Training of multidisciplinary greenhouse gas assurance engagement teams to improve analytical procedures task performance

Author:
Koroy, Tri Ramaraya

Publication Date:
2015

DOI:
https://doi.org/10.26190/unsworks/2749

Training of Multidisciplinary Greenhouse Gas Assurance Engagement Teams to Improve Analytical Procedures Task Performance

Tri Ramaraya Koroy

A Thesis in fulfilment of the requirements of
the degree of Doctor of Philosophy

School of Accounting
UNSW Business School

January 2015

PLEASE TYPE

THE UNIVERSITY OF NEW SOUTH WALES
Thesis/Dissertation Sheet

Surname or Family name: KOROY

First name: TRI RAMARAYA
Other name/s: RAY

Abbreviation for degree as given in the University calendar: PhD

School: School of Accounting
Faculty: UNSW Business School

Title:
Training of multidisciplinary greenhouse gas assurance engagement teams to improve analytical procedures task performance

Abstract 350 words maximum: (PLEASE TYPE)

The demand for assurance on greenhouse gas (GHG) emissions has increased due to growing concerns about climate change and the introduction of new legislation and emissions trading schemes in many countries. GHG assurance engagements necessitate the involvement of practitioners from accounting and non-accounting disciplines to form multidisciplinary teams (MDTs). Focusing on training intervention, this thesis investigates whether two training techniques drawn from the educational and cognitive psychology literature, analogical encoding and collaborative learning, are effective in improving individual and MDT performance in conducting a complex analytical procedures task commonly completed in GHG assurance engagements. Analogical encoding is a technique that facilitates encoding of knowledge by comparing two worked examples simultaneously whereas collaborative learning refers to a technique that encourages learners to work together to facilitate discussion and understanding when learning new tasks.

The thesis employs a between-subjects experiment using postgraduate students (as surrogates for novice practitioners) to examine the research hypotheses. The study finds that for complex tasks such as the analytical procedures task, a combination of analogical encoding and collaborative learning techniques leads to the highest learning outcomes for individuals and teams. At the individual level, these results suggest that the combination of the two techniques allows simultaneously the reduction in cognitive load, facilitation of deep processing, and development of knowledge structures during learning thereby facilitating improved performance. At the team level, the combined techniques facilitate team member familiarity and sharing of workload, resulting in enhanced process gains. These processes enable team members to perform effective and efficient hypothesis generation and objective evaluation of hypotheses (i.e., less biased towards the inherited hypothesis), which in turn increases the likelihood that they will select the correct causal hypothesis. An analysis was also conducted on the role of team member cognitive structures (i.e., the manner in which knowledge that is important to team functioning is mentally organised, represented, and distributed within the team) and reveals that the two training techniques do not affect all measures of team member cognitive structures and these constructs do not mediate all the relationships between team training inputs and team performance.

Declaration relating to disposition of project thesis/dissertation

I hereby grant to the University of New South Wales or its agents the right to archive and to make available my thesis or dissertation in whole or in part in the University libraries in all forms of media, now or here after known, subject to the provisions of the Copyright Act 1968. I retain all property rights, such as patent rights. I also retain the right to use in future works (such as articles or books) all or part of this thesis or dissertation.

I also authorise University Microfilms to use the 350 word abstract of my thesis in Dissertation Abstracts International (this is applicable to doctoral theses only).

05 February 2015

Signature
Witness
Date

The University recognises that there may be exceptional circumstances requiring restrictions on copying or conditions on use. Requests for restriction for a period of up to 2 years must be made in writing. Requests for a longer period of restriction may be considered in exceptional circumstances and require the approval of the Dean of Graduate Research.

FOR OFFICE USE ONLY
Date of completion of requirements for Award:

THIS SHEET IS TO BE GLUED TO THE INSIDE FRONT COVER OF THE THESIS

ORIGINALITY STATEMENT

‘I hereby declare that this submission is my own work and to the best of my knowledge it contains no materials previously published or written by another person, or substantial proportions of material which have been accepted for the award of any other degree or diploma at UNSW or any other educational institution, except where due acknowledgement is made in the thesis. Any contribution made to the research by others, with whom I have worked at UNSW or elsewhere, is explicitly acknowledged in the thesis. I also declare that the intellectual content of this thesis is the product of my own work, except to the extent that assistance from others in the project's design and conception or in style, presentation and linguistic expression is acknowledged.’

Signed......................................

05 February 2015

Date..

COPYRIGHT STATEMENT

'I hereby grant the University of New South Wales or its agents the right to archive and to make available my thesis or dissertation in whole or part in the University libraries in all forms of media, now or here after known, subject to the provisions of the Copyright Act 1968. I retain all proprietary rights, such as patent rights. I also retain the right to use in future works (such as articles or books) all or part of this thesis or dissertation. I also authorise University Microfilms to use the 350 word abstract of my thesis in Dissertation Abstract International (this is applicable to doctoral theses only). I have either used no substantial portions of copyright material in my thesis or I have obtained permission to use copyright material; where permission has not been granted I have applied/will apply for a partial restriction of the digital copy of my thesis or dissertation.'

Signed ……………………………………………………………………

Date 05 February 2015 ……………………………………………………………………

AUTHENTICIY STATEMENT

'I certify that the Library deposit digital copy is a direct equivalent of the final officially approved version of my thesis. No emendation of content has occurred and if there are any minor variations in formatting, they are the result of the conversion to digital format.'

Signed ……………………………………………………………………

Date 05 February 2015 ……………………………………………………………………

ABSTRACT

The demand for assurance on greenhouse gas (GHG) emissions has increased due to growing concerns about climate change and the introduction of new legislation and emissions trading schemes in many countries. GHG assurance engagements necessitate the involvement of practitioners from accounting and non-accounting disciplines to form multidisciplinary teams (MDTs). Focusing on training intervention, this thesis investigates whether two training techniques drawn from the educational and cognitive psychology literature, analogical encoding and collaborative learning, are effective in improving individual and MDT performance in conducting a complex analytical procedures task commonly completed in GHG assurance engagements. Analogical encoding is a technique that facilitates encoding of knowledge by comparing two worked examples simultaneously whereas collaborative learning refers to a technique that encourages learners to work together to facilitate discussion and understanding when learning new tasks.

The thesis employs a between-subjects experiment using postgraduate students (as surrogates for novice practitioners) to examine the research hypotheses. The study finds that for complex tasks such as the analytical procedures task, a combination of analogical encoding and collaborative learning techniques leads to the highest learning outcomes for individuals and teams. At the individual level, these results suggest that the combination of the two techniques allows simultaneously the reduction in cognitive load, facilitation of deep processing, and development of knowledge structures during learning thereby facilitating improved performance. At the team level, the combined techniques facilitate team member familiarity and sharing of workload, resulting in enhanced process gains. These processes enable team members to perform effective and efficient hypothesis generation and objective evaluation of hypotheses (i.e., less biased towards the inherited hypothesis), which in turn increases the likelihood that they will select the correct causal hypothesis. An analysis was also conducted on the role of team member cognitive structures (i.e., the manner in which knowledge that is important to team functioning is mentally organised, represented, and distributed within the team) and reveals that the two training techniques do not affect all measures of team member cognitive structures and these constructs do not mediate all the relationships between team training inputs and team performance.

ACKNOWLEDGEMENT

I would like to thank my supervisors, Associate Professor Wendy Green and Professor Gary Monroe, for their invaluable advice, comments, suggestions, dedication and support. Without them, this thesis would not have been possible.

I would like to thank the School of Accounting staff, who provided feedback when I was developing my experimental instruments, and when I presented the results of my thesis at the review panel. In particular, I wish to thank Professor Mandy Cheng, Associate Professors Noel Harding, Peter Roebuck, and Jane Baxter, Dr Radzi Jidin, and Dr Sarah Kim for their comments and suggestions.

The completion of this thesis would not have been possible without the financial assistance from Indonesia's Dikti Scholarship. I would also like to thank the ASB Experimental Lab for small project funding and Professors Ken Trotman and Roger Simnett for additional funding for the experiment from their ARC Discovery Grant. I also wish to thank Jenny Merkley for assisting in the development of the research instrument and Jim Park for developing the computer program used to control the experiment, as well as Rob Morley for his assistance in coding the experimental data. I would also like to thank the students who participated in the experiment. A special thanks to my friends and fellow PhD students for helping me run the pilot project and the experiment and their continuous support and friendship, especially Erboon 'Noom' Ekasingh, Skip Zhou, Ashna Prasad, Shan Zhou, Jahanzeb Khan, Tanya Fiedler and Yolanda Tobing.

Finally, but most importantly, I would not have been able to complete this thesis without the love, support, and encouragement from my wife, Sophia. I also wish to apologize to my children, Nathan, Kenneth and Evangeline and thank them for their patience and sacrifices while I concentrated on completing this thesis. To my non-academic friends, especially the Indonesian community in Sydney, thank you for helping me and my family through the toughest times. I am truly grateful for all your help.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION, AIMS, MOTIVATION AND CONTRIBUTIONS OF THE RESEARCH

1.1. Introduction

An increased focus on the link between greenhouse gas (GHG) emissions and climate change has led many organisations to quantifying these emissions. These figures are used for internal management purposes, for the preparation of a GHG statement as part of a regulatory disclosure regime or an emissions trading scheme, or to inform investors and others on a voluntary basis. Data from company responses to the Carbon Disclosure Project (CDP) shows that a growing number of the world's largest companies are publicly reporting their quantified GHG emissions. (CDP 2003, 2013).[1] There is also a large impetus for reporting GHG emissions in countries that have introduced mandatory reporting as part of their implementation of emissions reporting schemes or emissions trading schemes. By 2013, 34 countries (Australia, New Zealand, Switzerland and 28 EU member states as well as Iceland, Liechtenstein and Norway) and 18 subnational jurisdictions had implemented emissions trading schemes (EU 2013; Talberg and Swoboda 2013). In addition, there has been significant growth in the global carbon market, which has grown from $11 billion in 2005 to $30 billion in 2013; there are eight carbon markets in the United States, Canada, Kazakhstan and China joined the world's emissions trading schemes in 2013 alone, according to the World Bank (WorldBank 2012, 2014).[2]

Concurrent with this increase in GHG reporting, there has also been a growth in independent assurance of GHG reporting to enhance the degree of confidence of the intended users (Simnett et al. 2009; ICAA 2013). This growth in the number of companies voluntarily assuring

---

[1] The Carbon Disclosure Project (CDP), based in the United Kingdom, is an organisation that works with shareholders and corporations to disclose the GHG emissions of major corporations. CDP has established a repository of GHG emissions and energy-use data (CDP 2013).

[2] The size of the global carbon market reached the highest value of $176 billion in 2011 but decreased due to the major economic downturn in recent years. Global carbon markets have shrunk in value since 2011, but are expected to rise again in 2014 (WorldBank 2012, 2014).

their publicly-available GHG emissions disclosures is demonstrated by company responses to CDP, where the number has increased from 41.0 per cent in 2009 to 45.6 per cent in 2013 (CDP 2009, 2013) and is consistent with assurance acting as a signal to the market in terms of the increased credibility of publicly-available GHG information (Zhou et al. 2013). While little is currently known about the benefits that GHG assurance may provide to the companies issuing GHG reports, recent research suggests that the benefits noted for sustainability assurance may also accrue to companies that obtain assurance of their GHG information.[3] The limited number of prior studies suggest that assurance of sustainability information leads to benefits such as lower cost of capital (Dhaliwal et al. 2011) and improved perceived credibility and reliability of the information (Hodge et al. 2009; Pflugrath et al. 2011). Similarly, Bose et al. (2014) find that assurance of GHG emissions reduces the negative market impact of reporting GHG emissions.

The importance of the assurance of GHG emissions worldwide is further highlighted by the June 2012 release of an international GHG emissions assurance standard by the International Auditing and Assurance Standards Board (IAASB), ISAE 3410 *Assurance Engagement on Greenhouse Gas Statements* (IAASB 2012). This assurance standard provides international guidance for assurance practitioners in conducting GHG emissions assurance engagements, with many jurisdictions (e.g., Australia, Canada and New Zealand) have issued national GHG assurance standards that are compatible with ISAE 3410.

While GHG assurance engagements are an emerging assurance area outside the traditional financial assurance services, assurance practitioners from accounting backgrounds have the necessary assurance competencies to undertake these engagements, such as those developed from the audit methodologies commonly used for audits of financial statements (Nugent 2008; Huggins et al. 2011). For example, as discussed in ISAE 3410, the GHG statement is a statement of GHG emissions for a particular period; it is therefore similar in nature to an income statement. As a result, the use of the audit risk model for audits of

---

[3] GHG information is commonly included as part of a sustainability report that covers a broader set of environmental accountabilities. GHG assurance is a more defined and confined subject matter within the overall sustainability assurance area. As reported by a recent worldwide survey, the proportion of sustainability reports that include assurance statements prepared by third parties has increased in recent years (KPMG 2011, 2013). This report documents an increase in the percentage of the largest 250 companies worldwide producing sustainability reports from approximately 64 percent in 2005 to 83 percent in 2008 and 93 percent in 2013. The formal third party assurance of these reports also increased from 30 percent in 2005, 40 percent in 2008, to 59 percent in 2013. The accounting profession was engaged to provide assurance for approximately 67 per cent of these reports in 2013 (KPMG 2011, 2013).

financial statements can be transferred into this domain. The audit risk model allows practitioners to understand the entity, to assess the risk of material misstatements and to respond appropriately to the assessed risks. Practitioners can assess the risk of material misstatement at the GHG statement level. An assessment at the assertion level is also possible for each GHG statement line item.[4]

Despite the ability to draw on audit risk methodology, the complex scientific nature of a GHG assurance engagement means that assurers from the accounting profession are unlikely to have the necessary task-specific or subject matter (i.e., scientific) knowledge to properly complete these engagements (Huggins et al. 2011; IAASB 2012). Providing these complex services requires diverse expertise. Therefore, as recognised by ISAE 3410, assurers with competencies in both assurance and the related subject matter are required to undertake these assurance engagements. In particular, besides assurance expertise, multiple types of knowledge relating to the environmental aspects of an organisation's activities are needed. The extensive involvement by practitioners from non-accounting disciplines (or specialists) requires the formation of multidisciplinary teams (MDTs) (Simnett et al. 2009; Huggins et al. 2011; O'Dwyer 2011). In these MDTs, experts from environmental engineering or science provide expertise in relation to the subject matter (GHG emissions) and professional accountants provide the expertise in undertaking assurance engagements (Nugent 2008; Huggins et al. 2011).

The increasing involvement of MDTs in GHG assurance is consistent with the trend in auditing where MDTs have become the norm; non-accounting specialists are now treated as an integral part of the audit team (Selley 1999; Boritz et al. 2014). In the past, when obtaining knowledge of the business, non-accounting experts were usually informally involved for consultation purposes and they played only a minor role and their suggestions were not heavily depended on (Selley 1999). However, in recent years, specialist involvement has expanded to include roles in selecting the engagement team, establishing the appropriate

---

[4] As discussed in ISAE 3410, similar assertions to those used for financial audits can be used in GHG assurance. Because the GHG statement is similar in nature to an income statement, assertions concerning events for the period under audit can be used (e.g., occurrence, completeness, accuracy, cut-off, classification) as well as assertions concerning presentation and disclosure of the GHG emission inventory (e.g., occurrence and responsibility, completeness, classification and understandability, accuracy and quantification, and consistency)(IAASB 2012).

materiality level, assessing risk, designing audit procedures, and even participating in the evidence-gathering stage (Selley 1999; Boritz et al. 2014).

The use of MDTs for complex tasks is well recognised in the management and psychology literature (Van der Vegt et al. 2003; Mannix and Neale 2005). The formation of MDTs, which have diverse expertise by their nature, is motivated by the premise that team decisions and actions are more likely to be effective when representatives from all the relevant areas of expertise are brought together to work on a task (Van der Vegt and Bunderson 2005). The need for diverse expertise in these teams is highlighted when the task involves solving a complex problem or issue and/or performing actions (Van der Vegt et al. 2003). The solving of complex tasks frequently requires the search for and evaluation of alternatives. In such cases, diverse expertise enables teams to encompass the full range of perspectives and issues through access to the broader range of information and capabilities possessed by team members compared to individuals on their own (Mannix and Neale 2005). It is therefore expected that the performance of MDTs should benefit from the combination of the abilities, knowledge, and different viewpoints of its members (van Knippenberg et al. 2004).

However, while MDTs provide the benefit of team diversity, they also introduce a number of challenges. Research in the psychology field provides evidence that simply bringing together a group of professionals with diverse backgrounds does not necessarily ensure that they will function effectively as a team and make appropriate decisions (Milliken and Martins 1996; Williams and O'Reilly 1998; Mannix and Neale 2005). In fact, some studies report that group performance is higher when groups are homogeneous rather than heterogeneous (Murnighan and Conlon 1991; Jehn et al. 1999; Simons et al. 1999). Although team diversity brings beneficial effects for performance, this diversity may also create difficulties in realising the team’s potential value because differences in the background of the different team members make it difficult for members to relate to one another, thereby increasing the likelihood of poor communication, misunderstanding and interpersonal friction (Milliken and Martins 1996; Williams and O'Reilly 1998; Jackson et al. 2003; van Knippenberg et al. 2004).

The evidence that MDTs are not working well in audit firms is provided by a prior study (O’Dwyer 2011). This in-depth, interview-based study on sustainability assurers reported that when accountants and non-accountants commenced working together on assignments, difficulties emerged due to the different perspectives the two groups had surrounding the assurance practice. This led to both a lack of understanding and misunderstanding, and less cooperation among team members. As a result, growing frustration within the team impaired its effectiveness (O'Dwyer 2011).

If the potential problems resulting from the use of such teams are not properly addressed, the quality of judgments and decision-making, and the quality of the assurance provided may be affected in MDTs providing GHG assurance services. Prior studies in management and organizational psychology (Kozlowski and Ilgen 2006; Mathieu et al. 2008)_and accounting (Bonner 2008) suggest that training can be used as an intervention to improve the performance of teams that facing these problems.

Therefore, this thesis examines training techniques that may improve the quality of judgments and decision-making when MDTs are involved in providing GHG assurance services. In particular, this thesis provides evidence relating to potential improvements in the performance of GHG assurance by MDTs through the use of two training interventions: analogical encoding and collaborative learning. These techniques have previously been found to be useful in less complex settings. Analogical encoding is a technique that facilitates encoding of knowledge by comparing two worked examples simultaneously (Gentner et al. 2003). Collaborative learning or group learning refers to instructional methods that encourage learners to work together to facilitate discussion and understanding when learning tasks (Dillenbourg 1999; Kirschner et al. 2009a; Kirschner, Paas, Kirschner, et al. 2011). This research is consistent with the aim of applied accounting research, which is to contribute to best practice through improving the quality of judgments and decision-making (Libby and Luft 1993; Libby 1995; Nelson and Tan 2005; Bonner 2008).

1.2. Research Aim

Due to the multidisciplinary nature of the area to be investigated in this study, the theoretical foundation of the study is also multidisciplinary in nature. The theories and variables that are examined by the thesis come from diverse areas including organisational psychology, educational and cognitive psychology, and the auditing literature relating to judgments made in analytical procedures tasks. In particular, the two training techniques evaluated in this study with regard to their efficacy in enhancing MDT performance (i.e., analogical encoding and collaborative learning) are drawn from the educational and cognitive psychology literature. This thesis reports the results of an experiment that tests the usefulness of these two techniques in improving the performance of MDTs in an analytical procedures task in a

GHG setting. The two training techniques have previously been examined in settings to test individual learning performance for relatively simple learning tasks. However, this study extends their use and proposes using the two techniques as potential team-training interventions. Accordingly, this thesis has three aims, which are outlined in the subsections below.

1.2.1. Training Interventions to Improve Individual Performance

The first aim of this thesis is to examine the use of two training techniques (analogical encoding and collaborative learning) to improve the abilities of individual team members in an analytical procedures task. As noted by prior studies (Simnett et al. 2009; Huggins et al. 2011), the accountant members of teams have no subject-matter knowledge in this area. On the other hand, scientist members of teams have no knowledge in assurance concepts. Both of these types of knowledge are required to conduct GHG assurance. The abilities of individual members are investigated because these variables are viewed as important inputs into team performance (van Knippenberg et al. 2004). The effective use of these training techniques is determined by the individual's ability to address the three learning principles outlined in prior research for effective learning and transfer: the optimisation of cognitive resources in learning processes (Sweller et al. 1998; Clark et al. 2006), the facilitation of deep learning processing (Chi 2009), and the development of knowledge structures (Gentner et al. 2003). These two techniques have been investigated by researchers in separate lines of research in the educational psychology literature, where the research studies either examined the impact on cognitive resources, the impact on deep processing or the impact on knowledge structure. This prior research shows that analogical encoding improves knowledge structure (Gentner and Markman 1997), which is thereby expected to improve performance (Gentner et al. 2003). However it does this in a manner that imposes a significant cognitive resource load that may impair performance (Renkl 2011). Collaborative learning, on the other hand, decreases cognitive resource load (Kirschner et al. 2009a, 2009b; Kirschner, Paas, Kirschner, et al. 2011) and encourages deep processing (Chi 2009; Fonseca and Chi 2011). However, it does not facilitate the development of knowledge structures; this may impair performance (Rajaram and Pereira-Pasarin 2010; Rajaram 2011). This study attempts to address all three learning principles simultaneously in order to provide a comprehensive understanding of the way in which these techniques can improve individual learning performance.

1.2.2. Training Interventions to Improve Team Performance

The second aim of this thesis is to determine whether the use of these two techniques affects team performance in an analytical procedures task. As suggested by prior studies (Kozlowski and Ilgen 2006; Mathieu et al. 2008), team training is required to improve team performance. Specifically, the use of a combination of the two training techniques is examined as a potential team-training intervention. Although individual team members may exhibit ability in a task, when they are required to work in a team, performance is either diminished (i.e., process losses (Steiner 1972)) or improved (i.e., process gains (Hill 1982)) as a result of various team processes. In the case of MDTs, process losses may occur due to relations between team members who have different functional and/or educational backgrounds. As suggested in prior studies, individuals who are dissimilar to others in more heterogeneous teams are less likely to communicate. This leads to lower levels of member commitment and group cohesion, and higher levels of relational conflict (Wagner et al. 1984; O'Reilly et al. 1989; Tsui et al. 1992; Riordan and Shore 1997; Pelled et al. 1999). Social categorisation (Tajfel and Turner 1986) and lack of familiarity between team members and their disciplines (Gruenfeld et al. 1996) in diverse teams also make it difficult for team members to cooperate and perform better. This thesis therefore examines the extent to which these two training techniques are not only beneficial in improving individual members' abilities, but also their ability to overcome the problems that occur in MDTs.

1.2.3. The Role of Cognitive Structures

The third aim of this thesis is to extend prior research by investigating the role of cognitive structures in the functioning of MDTs when performing a conceptual task. Cognitive structures are defined as the manner in which knowledge that is important to team functioning is mentally organised, represented, and distributed within the team. This enables team members to anticipate and execute actions (Kozlowski and Ilgen 2006). Prior research generally finds that cognitive structure is the key to superior team performance and that it shapes coordination processes relevant to the accomplishment of team goals (Kozlowski and Ilgen 2006; Mathieu et al. 2008; DeChurch and Mesmer-Magnus 2010). On other hand, prior studies also found that heterogeneous teams such as MDTs have problems in developing effective TMM and TMS (Murnighan and Conlon 1991; Milliken and Martins 1996; Williams and O'Reilly 1998; Jehn et al. 1999; Simons et al. 1999; Jackson et al. 2003; van Knippenberg et al. 2004).

This thesis explores whether training interventions, which can be viewed as one of the team inputs, are effective in enhancing two constructs of cognitive structure: team mental models (TMMs) and transactive memory systems (TMSs). The thesis also explores whether these enhanced cognitive structures improve MDT performance. TMMs are defined as the organised mental representations of knowledge about key elements of the team's relevant environment that are shared across the team members (Klimoski and Mohammed 1994; Mohammed et al. 2010). TMSs are referred to as a form of cognitive structure that encompasses both the knowledge uniquely held by particular group members as well as a collective awareness of who knows what (Kozlowski and Ilgen 2006).

To achieve its three main aims, the thesis uses a between-subjects experiment in which the use of two training techniques is manipulated. Participants in the experiment are postgraduate students, who are considered to be an appropriate surrogate for novice practitioners for training research purposes (Bonner and Walker 1994; Bonner et al. 1997). It is predicted that a training intervention using a single technique may not lead to better learning outcomes both at the individual and team level due to either increased cognitive load or lack of familiarity. However, it is predicted that performance of individuals and teams in performing an analytical procedures task will be highest when the individuals are trained using a combined analogical encoding and collaborative learning technique as these two techniques complement each other in overcoming cognitive load and familiarity problems. It is also predicted that cognitive structures (i.e., TMMs and TMSs) will mediate the relationships between training interventions and team performance.

1.3. Motivation

The growing demand for GHG reporting and its assurance means that determining ways to assist auditors to improve quality for this assurance function is important. Assurance firms are currently at an early stage of development and experience with these types of engagements (Olson 2010; O'Dwyer 2011; O'Dwyer et al. 2011). The necessity for having MDTs undertake assurance on GHG statements brings potential benefits as well as problems. The diversity of expertise, knowledge and background inherent in MDTs brings benefits in providing a broader range of task-relevant knowledge, skills and abilities with which to perform the task. However, there are also some potential problems faced by diverse teams that may impede team performance (Mannix and Neale 2005). These problems, which include lack of understanding or misunderstanding, miscommunication, and less cooperation between team members, relate to intragroup relational aspects between team members who have different functional and/or educational backgrounds. Accordingly, this thesis is first motivated by the need to provide evidence relating to the potential for training interventions to improve MDT performance by realising the benefits and overcoming some of the problems associated with the use of MDTs.

In prior research, in order to improve team effectiveness, organisational psychologists have suggested a number of general interventions such as structuring team composition, training, and leadership (Kozlowski and Ilgen 2006; Mathieu et al. 2008). The current study focuses on *training* as a team intervention to improve team effectiveness. There are two key reasons for focusing on team training. First, in the GHG assurance setting, although team members with subject matter knowledge are experts in their own domain, they have limited or no knowledge relating to performing GHG assurance, i.e., they have limited general domain and/or task-specific knowledge needed for such tasks.[5] Thus, training is needed in order to improve team member competencies and abilities in the GHG assurance task, which in turn is expected to improve team effectiveness. Second, as suggested by the psychology literature, team performance will be improved if team members possess teamwork skills or those skills focused on the behaviours and attitudes necessary for effective team functioning such as how to effectively interact, maintain relationships, cooperate, and coordinate with other members of the team. This training is expected to improve the ability of team members to communicate, coordinate and interact; this should lead to better team performance (Dyer 1984; Morgan et al. 1986; Ellis et al. 2005).

Organisational psychologists have examined several team-training techniques that can be used to improve team performance. However, prior studies in organisational psychology provide little insight on team-training interventions for teams performing tasks such as those involved in undertaking GHG assurance tasks. Prior studies primarily focus on interventions

---

[5] At least three types of knowledge appear to be potential determinants of expertise in various auditing tasks as suggested by Bonner and Lewis (1990): (1) general domain knowledge, a basic level of accounting and auditing knowledge (as well as environmental science knowledge in the GHG assurance) gained by most persons through formal training and general experience as an auditor (or an environmental scientist); (2) task-specific knowledge that refers to the knowledge necessary to complete the task and considered as subspecialty knowledge related to specialised industries, clients and engagements acquired by people who have experience with specific audit clients, with certain industries (or engagements) and/or firm training in those specialised areas; and (3) general business knowledge, such as an understanding of management incentives in a variety of contractual situations, which can be acquired through formal instruction and various personal experiences such as reading. In the context of GHG engagement, members of MDTs do not have all this knowledge. This thesis focuses on the first two types of knowledge.

that emphasise practising in a way that approximates, simulates, or replicates the actual task and performance context, in order to acquire an understanding of the knowledge and skills required to improve task coordination and adaptation (Kozlowski and Ilgen 2006; Mathieu et al. 2008). These approaches have been developed for, and largely applied to teams performing action/psychomotor tasks (Kozlowski and Ilgen 2006). Performing an action/psychomotor task, such as sports, and military or commercial aviation tasks, requires team members to coordinate actions and perform physical tasks that generally possess high levels of behavioural interdependence (McGrath 1984; DeChurch and Mesmer-Magnus 2010). In these tasks, team members must respond effectively by integrating their physical joint actions in time-sensitive and emergency situations. Most applications of these team training techniques have tended to be limited to such teams (Kozlowski and Ilgen 2006). GHG assurance engagements, on the other hand primarily involve mental or conceptual tasks. Teams performing this type of task do knowledge work (i.e., work that mostly involves processing information and making decisions) and also possess a high level of informational interdependence (as opposed to behavioural interdependence) (McGrath 1984; DeChurch and Mesmer-Magnus 2010). Previous studies have examined team training approaches for teams performing action/psychomotor tasks (e.g., guided team self-correction training (Smith-Jentsch et al. 1998; Smith-Jentsch et al. 2008); team coordination and adaptation training (Entin and Serfaty 1999); and cross-training (Volpe et al. 1996; Blickensderfer et al. 1998; Cannon-Bowers et al. 1998; Marks et al. 2002). However, it is not known whether the team-training techniques that have been found to improve performance in action tasks will have the same potential for improving the effectiveness of teams performing conceptual tasks such as those encountered in performing GHG assurance engagements. In addition, little is known from prior studies about specific training interventions that may be effective in overcoming the problems faced in MDT settings. Thus, it is important to investigate training interventions that may assist MDTs providing GHG assurance to perform conceptual tasks more effectively, thus leading to higher quality and more credible GHG audits.

The second motivation of this thesis is to test the application of training techniques used in educational psychology as potential training techniques to improve both individual and team performance in a GHG assurance engagement. As outlined above, prior studies in organisational psychology provide little insight on team-training interventions for teams performing conceptual tasks such as those involved in undertaking GHG assurance tasks. On the other hand, prior studies in educational psychology suggest that analogical encoding and collaborative learning may aid performance of these tasks. Analogical encoding has the potential to facilitate deeper understanding and development of knowledge structures (Gentner et al. 2003), whereas collaborative learning has the ability to encourage interaction between team members, thereby improving the understanding of the concepts (Kirschner et al. 2009a; Kirschner, Paas, Kirschner, et al. 2011). However, in prior studies these techniques have been studied in separate lines of research in cognitive and educational psychology and have been investigated in isolation. As a result, the potential benefits of employing these techniques together have not been explored. In addition, little is known about the boundary conditions of these training techniques when they are applied in learning a complex task (such as an analytical procedures task) by a heterogeneous team (such as a MDT performing a GHG assurance engagement). To add to this limited knowledge, this thesis explores the effectiveness of these training techniques at both the individual and MDT level.

Third, this thesis is motivated by the limited understanding that exists with regard to the role of team member cognitive structures in team performance. Research in organisational psychology suggests that team cognitive structures are important drivers of team performance (Kozlowski and Ilgen 2006; Mathieu et al. 2008; DeChurch and Mesmer-Magnus 2010; Mohammed et al. 2010). The concept behind team cognitive structures refers to cognitive structures or knowledge representations that enable team members to organise and acquire the information necessary to anticipate and make decisions or execute actions (Kozlowski and Ilgen 2006). These structures represent mediating mechanisms that link inputs such as training and team composition to team outcomes (Mathieu et al. 2008). However, most empirical work relating to cognitive structures has been conducted in the context of performance/psychomotor tasks (Kozlowski and Ilgen 2006) and only a few have involved decision-making tasks (DeChurch and Mesmer-Magnus 2010). Little is known, therefore, about the importance of the cognitive structure construct for outcome performance. For example, it is not known whether the findings from action tasks extend to other types of tasks such as those that require divergent thinking, (i.e., such as the generate tasks required in generating hypotheses in an analytical procedures task).

Finally, this thesis is motivated by the need to provide further evidence relating to the effect of training interventions to improve the performance of analytical procedures tasks. Analytical procedures are performed during most assurance engagements and this task has been recognised as a complex task in the auditing literature (Bonner and Pennington 1991; Koonce 1993). The GHG assurance standard, ISAE 3410 (IAASB 2012), requires the use of analytical procedures that are considered to be effective and efficient for such engagements. ISAE 3410 (IAASB 2012) also requires that the GHG assurance engagements to be performed by MDTs, therefore it can be inferred that compliance with this standard would mean that this task is commonly completed by MDTs. This is because analytical procedures are based on considering relationships between information, and the nature of the physical or chemical relationship between particular emissions and other measurable phenomena are fixed, and predictable relationships also exist between emissions and financial information in GHG assurance engagements (IAASB 2012). However, prior audit studies have found that decision makers suffer deficiencies in all components of performing analytical procedures (e.g., Bedard and Biggs 1991; Heiman-Hoffman et al. 1995; Asare and Wright 2003). Despite this difficulty, a recent field study suggests that analytical procedures are currently used more than they have been in the past (Trompeter and Wright 2010).This study also suggest that there has been an increase in the tendency to assign analytical procedures tasks to less experienced staff. It is found that approximately a third of the total audit budget allocated to analytical procedures and auditors at all ranks conducting them. Audit firms are more comfortable in assigning this work to more junior staff, perhaps because they have increased their investments in training junior staffs (Trompeter and Wright 2010). Given the importance and difficulty of analytical procedures in the GHG setting where MDTs are the norm, there is a greater need to investigate and design training interventions that will assist these teams to improve their effectiveness in analytical procedures and, thereby, the quality of the GHG assurance. Consistent with the tendency to assign analytical procedures task to less experienced staff, in this thesis the improvement in performing this task is focused particularly on novice-level practitioners. Therefore, this thesis includes an empirical study to provide insights on methods to improve individual and team performance in conducting this task. In particular, this thesis attempts to provide empirical evidence relating to how to accelerate the acquisition of the specialized knowledge which is normally acquired through professional experience through training for less experienced staff (Bonner 2008).

1.4. Contributions

Investigating the effectiveness of training techniques in improving MDT performance in GHG assurance is important, given the growing importance of this assurance function in adding credibility to reported emissions. By testing training interventions in a setting where MDTs perform this complex task, this study makes a number of theoretical contributions to knowledge; it also provides evidence for a number of practical considerations. These contributions are discussed in the following sections.

1.4.1. Theoretical Contributions

The first two theoretical contributions of this study relate to providing evidence in relation to the effective use of analogical encoding and collaborative learning in improving the abilities of individuals in a GHG assurance analytical procedures task. Prior research has examined these training techniques individually, and these techniques have been found to be beneficial in enhancing individual and team performance in settings where team members are drawn from a homogeneous background to perform a simple learning task. This thesis aims to investigate the use of these two techniques in settings where individuals performing a complex task. By reviewing prior studies, this thesis highlights a number of potential problems related to each technique. This prior research suggests that one technique is superior in one aspect yet inferior in another, and this thesis demonstrates that employing these techniques concurrently is expected to include benefits from the best aspects of both techniques and lead to improved performance of the task in a complex setting. To date, no research has examined them in combination to determine if the potential benefits from one technique can improve performance by overcoming the potential problems from the other technique. In addition, while these two techniques have been found to be beneficial in enhancing individual and team performance in settings where team members drawn from a homogeneous background perform a simple learning task, no prior study has explored the benefits of combining these two techniques in order to reduce the inherent limitations of each technique. In particular, prior research has provided an understanding of the abilities of each training technique to address two primary cognitive factors that affect effective learning and knowledge transfer in a homogenous setting: the optimisation of cognitive resources in learning processes and better recall of relevant knowledge to solve new problems by developing accurate knowledge structures. However, no previous study has investigated the benefits of these two techniques in terms of using these two factors simultaneously. Nor has any prior research investigated the combined use of these techniques to improve individual performance. Given that prior research suggests that one technique is superior in one aspect yet inferior in another, employing these techniques concurrently is expected to include benefits from the best aspects of both techniques and lead to improved performance of the task. If evidence supporting the abilities of these techniques is found, this thesis will be the first to provide an understanding of the benefits provided by the analogical encoding technique as well as the disadvantages that need to be overcome in order to improve learning performance.

The second contribution relates to the benefits and disadvantages of the collaborative learning technique in improving learning outcomes. The results of this thesis will substantially contribute to the educational psychology literature as well as to accounting literature in relation to the effectiveness of training techniques for individual learners. While prior studies find that the use of the collaborative learning technique brings beneficial effects for homogeneous learners, i.e., those with similar knowledge and backgrounds (e.g., Kirschner, Paas, Kirschner, et al. 2011), this study provides insights as to whether this technique is also beneficial for heterogeneous learners (i.e., those who do not have similar knowledge or backgrounds) when learning a complex task. This thesis will demonstrate that in understanding a complex task that involves knowledge from a variety of fields, the use of collaborative learning enables individuals to achieve better learning outcomes.

The third theoretical contribution of this thesis relates to the combined use of these two techniques as a team-training intervention in improving team performance. The results of this study contribute to the organisational psychology literature as well the accounting literature by furthering our knowledge on the team-training technique that has the greatest potential for improving MDT effectiveness when performing conceptual tasks such as an analytical procedures task. As noted earlier, prior studies have examined team-training approaches for teams performing action/psychomotor tasks (e.g., guided team self-correction training (Smith-Jentsch et al. 1998; Smith-Jentsch et al. 2008); team coordination and adaptation training (Entin and Serfaty 1999); and cross-training (Cannon-Bowers et al. 1998)) within homogeneous teams (i.e., teams from similar educational backgrounds). This study extends the prior literature in two ways: first, the training techniques are applied to a conceptual task rather than an action task; and second, the training techniques are applied to MDTs rather than homogenous teams. The thesis will demonstrate that analogical encoding and collaborative learning, due to their potential benefits in enhancing team process, are suitable for MDTs.

The results of this thesis also make a contribution to the organisational psychology and accounting literatures in relation to the role of cognitive structures in the functioning of MDTs when performing a conceptual task. No previous study has examined the role of cognitive structures in MDTs and most previous studies in organisational psychology have focused on action tasks (Kozlowski and Ilgen 2006; Mathieu et al. 2008). The results of this study therefore extend knowledge relating to the importance of this construct to MDTs as well as to other types of tasks such as conceptual tasks that require divergent thinking, including generate tasks (e.g., generating hypotheses) and decision-making tasks (e.g., evaluating and nominating the most likely causes of an observed fluctuation) as in an analytical procedures task.

By investigating specific training interventions that are appropriate to overcome deficiencies in performing analytical procedures, this thesis makes a fifth contribution by extending current research relating to training in the performance of analytical procedures tasks. Only a few prior studies (e.g., Bonner and Walker 1994; Moreno et al. 2007) have examined training techniques to improve the performance of individuals in this task. This thesis will provide evidence on the effectiveness of analogical encoding and collaborative learning in improving performance in two important stages of an analytical procedures task: hypothesis generation and hypothesis evaluation.

1.4.2. Practical Contributions

The importance of the results of this study to the practice of assurance lies in the identification of possible training interventions to improve the performance of both individual members and MDTs. To the extent that the interventions are found to be effective in improving individual and team performance, the results will provide a significant practical contribution on the use of appropriate training interventions that can be recommended for use in the training of multidisciplinary practitioners in audit firms as well as in higher education institutions. The results of this study provide further evidence on: (1) the usefulness as an appropriate training design of the analogical encoding and collaborative learning techniques by addressing the important learning principles that should be considered when improving learning performance; (2) team-training interventions that facilitate improved team process and in turn improved team performance; (3) team interventions that facilitate improved TMMs and TMSs for heterogeneous teams such as MDTs; and (4) training techniques that facilitate improved individual and team performance in conducting an analytical procedures task.

1.5. Structure of the Thesis

The structure of this thesis is as follows. Chapter 2 provides a review of the relevant areas of literature that are important in understanding the study. The literature is multidisciplinary in nature and includes diverse research; therefore, this chapter draws on the relevant literature from educational and organisational psychology as well as accounting to generate hypotheses about the impact of the two training techniques on improving individual abilities in completing the task, as well as team processes and team performance. Particular research hypotheses on the role of cognitive structures and transactive memory in effective team functioning are also outlined in this chapter.

Chapter 3 outlines the research methods, including the design employed to test the hypotheses, the experimental task, and the definitions and measurement of variables used in this thesis. Chapter 4 presents the results of the analyses relating to the hypotheses and discusses these results. Finally, Chapter 5 summarises the main findings arising from the thesis, discusses the theoretical and practical contributions of the results, outlines some of the limitations of the study, and presents some potential areas for future research.

CHAPTER 2

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1. Introduction

This chapter reviews existing research literature to provide a theoretical foundation for identifying the problems faced by multidisciplinary teams (MDTs) and the possible training interventions that can be used to enhance the performance of MDTs. Due to the multidisciplinary nature of this study, a broad range of literature is reviewed including social psychology, management and organisational psychology, cognitive and educational psychology, and accounting literature.

Section 2.2 reviews the training interventions used to enhance the ability of individual team members to perform analytical procedures tasks. The section develops research hypotheses related to the first aim of this thesis. The section first examines the use of analogical encoding and its positive effects on individual performance. It provides arguments as to why these benefits may not occur for MDTs completing complex tasks. This is followed by a subsection discussing research into the effects of collaborative learning on individual performance and a discussion of the interactive effects of the two techniques.

Section 2.3 looks at the effects of the two training techniques on team performance. Given that GHG assurance is conducted by MDTs, it is important to understand not only how individual members of a team can best acquire the knowledge needed to complete relevant tasks, but also how these teams are best able to combine the knowledge of individual members to enable high quality performance of the task. This section reviews the literature relating to the team effectiveness of MDTs and develops research hypotheses on training interventions to improve team processes and performance in a GHG assurance analytical procedures task.

Finally, the effects of the training techniques on cognitive structures are discussed in Section 2.4. The section also explores the role of cognitive structures (Kozlowski and Ilgen, 2006; Mathieu et al. 2008) as potential mediating variables between training interventions and team performance. This section reviews the literature relating to two types of cognitive structure: team mental models (TMMs) and transactive memory systems (TMSs). It includes research hypotheses related to how these cognitive structures may affect team performance in a GHG assurance analytical procedures task.

2.2. Enhancing Individual Multidisciplinary Team Member Performance in an Analytical Procedures Task

In this section, literature from educational and cognitive psychology is reviewed in order to demonstrate the use of two training techniques to improve individual performance. This section also includes the proposed research hypotheses for team member performance in an analytical procedures task setting, based on the literature review. In this thesis, training refers to 'a systematic acquisition of skills, rules, concepts, or attitudes that result in improved performance in another environment' (Goldstein and Ford 2002, 1). Training includes both formal classroom activities that are carried out in a university, a firm or a professional organisation, and on-the-job activities that involve practice and feedback (Bonner 2008). This thesis focuses primarily on formal classroom activities, which are called instructional activities.

2.2.1. Individual Learning Processes and Principles

Any examination of effective training techniques requires an understanding of the cognitive processes and the principles involved in knowledge acquisition or learning. From an information processing perspective (Mayer 1996; Mayer 2008), learning involves the acquisition of mental representations of knowledge from processed information (Mayer 1996). In learning new information, individuals must first focus their attention on the relevant pieces of the information presented and then select and transfer them to working memory. Working memory is a central and conscious element of human cognition responsible for active processing of information during thinking, problem solving and learning (Sweller et al. 1998; Clark et al. 2006). Next, information entering working memory must be organised by constructing internal connections between the incoming elements (Mayer 2008). The incoming information must then be integrated with prior knowledge by constructing external connections between the newly-organised knowledge in working memory and existing relevant knowledge that individuals retrieve from long-term memory. The next process is encoding, which is defined as the process of placing knowledge constructed in working memory into long-term memory. Long-term memory is a relatively permanent storage of knowledge (Sweller et al. 1998). Encoding has a major impact on other cognitive processes, such as storage (how information is kept in memory) and retrieval (how information is retrieved from memory) because there is an interactive relationship between these processes. Thus, problems in one area lead to problems in another (Bruning et al. 2004). Studies have shown that the accessibility of information from long-term memory at a later point in time depends primarily on the way it was originally encoded. The more ways a learner encodes information, the greater the chances of later retrieval (Greidler 2009).

Prior studies from separate lines of research in cognitive and educational psychology reveal that there are three basic principles of learning that must be in place in order for the learning processes described above to be successful (Gentner et al. 2003; Mayer 2008; Chi 2009). These principles include the limited capacity principle, the deep processing principle and the memory organisation principle. These principles are discussed below.

2.2.1.1. Limited Capacity Principle

The limited capacity principle (Mayer 2008) suggests that, to make learning efficient, it is important to optimise cognitive resources in the learning processes. This is because working memory, as one of the cognitive resources, has a limited capacity (Miller 1956; Cowan 2001, 2010). Individuals are able to actively process only a limited amount of material at one time (Baddeley 1999). During learning activities the amount of information and the number of interactions that must be processed simultaneously can either under or overload the finite amount of working memory everyone possesses (Sweller et al. 1998). Cognitive load theory, which is developed based on this principle, suggests that in order to improve learning, it is important that learning instruction should be carefully designed by optimising the cognitive load during learning (Sweller et al. 1998; Clark et al. 2006). Optimising cognitive load means that irrelevant loads are managed and minimised, whereas the necessary load that is required in learning is promoted (Clark et al. 2006; Mayer 2008).

Educational psychologists suggest that appropriate ways to optimise the cognitive capacity depend on the sources of cognitive load during learning (Sweller et al. 1998). Three sources of cognitive load have been identified in prior studies: intrinsic load, extraneous load, and germane load (Sweller et al. 1998; Clark et al. 2006; Mayer 2008).

Intrinsic load refers to the amount of cognitive processing required to comprehend the learning material and depends on its conceptual complexity (Sweller et al. 1998). Intrinsic load cannot be eliminated, but it can be managed through deconstructing the task by segmenting or giving pre-training that provides the name and characteristics of each major element (Sweller et al. 1998; Mayer 2008).

The second type of cognitive load, *extraneous load*, refers to the amount of cognitive capacity used for cognitive processing that is not relevant to the goals of the instruction (Sweller et al. 1998). Extraneous load can be reduced by cutting out extraneous material, using headings to signal organisation, placing words near corresponding pictures or studying worked examples (Mayer 2008).

The third source, *germane load,* refers to the capacity of the working memory to deal with intrinsic load; this is the load that leads to learning (Sweller et al. 1998). Germane load is 'mental work imposed by activities that benefit the instructional goal' (Clark et al. 2006, 11). Because germane load is required and relevant to learning, this load should be promoted and working memory capacity should be freed up for it. The manner in which information is presented to individuals and the learning activities required of individuals are factors relevant to levels of this load (Sweller et al. 1998; Clark et al. 2006).

The training techniques examined in this thesis are designed to optimise cognitive load for learners. Specifically, analogical encoding techniques should promote germane load (albeit it also increases intrinsic load) (Renkl 2011); whereas collaborative learning should reduce intrinsic and extraneous load (e.g., Kirschner et al. 2009a; Kirschner, Paas, and Kirschner 2011). The cognitive loads imposed by these techniques are taken into account when examining the impact of these training techniques on learning performance.

2.2.1.2. Deep Processing Principle

The second principle of learning is the deep processing principle. This principle suggests that meaningful learning occurs when individuals are asked to conduct each process deeply or intensively (i.e., selecting, organising, integrating and encoding) by requiring them to engage in overt activities (Chi 2009). Although an individual can learn by carrying out a passive activity such as listening to a lecture or reading a text, research shows that people are more likely to learn if they are forced to do something overtly because overt behavioural activity corresponds to the minimum underlying cognitive processes required to produce the behaviour (Chi 2009; Williams and Lombrozo 2010; Fonseca and Chi 2011). Overt activities include note-taking, highlighting or underlining, making one's own explanations, comparing and contrasting, and interacting with other individuals (Chi 2009). The implication of this principle is that individuals must be engaged in an appropriate learning activity in order to conduct deep processing while learning (Chi 2009).

Educational psychologists differentiate student learning activities according to the observable, overt actions on the part of the learner and categorise them into four types: passive, active, constructive, and interactive. They suggest that different types of learning activities lead to different learning outcomes (Chi 2009; Fonseca and Chi 2011).[6] Interactive activities are thought to be superior for learning compared with constructive activities; constructive activities are superior to active activities. Educational psychologists argue that, in a passive learning situation, learning outcomes are impaired because the learner is essentially not engaging in any overt activity related to the learning task. In contrast, better learning outcomes are associated with active learning situations where the learner is engaged in doing something physical while learning (Chi 2009).

The explanation for the superiority of certain learning activities is based on their underlying cognitive processes. The underlying cognitive processes of active learning as argued by Chi (2009) are *assimilating processes* where the presented materials are attended to and parts of the materials are selected. As a result, relevant knowledge is activated and strengthened and related knowledge is searched. These processes allow new information to be encoded in the context of the relevant activated knowledge. The new information is thereby instantiated in the context of an existing knowledge set (Chi 2009). On the other hand, when doing constructive activities, a learner goes one step further by producing additional output that contains information beyond that provided in the original material. These activities allow a

---

[6] According to Chi (2009) and Fonseca and Chi (2011), learners are in a passive learning situation when they are essentially not engaging in any overt activity related to the learning task. In an active learning situation, however, the learners must be engaged in doing something physical while learning. An example of this is that rather than passively reading a text, the learner is also highlighting or underlining the text while reading. An activity is called a constructive learning activity when a learner goes one step further by producing some additional output that contains information beyond that provided in the original material. Examples of these activities are generating one's own explanations, creating a concept map, asking questions, drawing a diagram, and comparing and contrasting cases. Lastly, an activity can be classified as an interactive learning activity when a learner interacts with a peer, an expert, or a system as when responding to instructional prompts, responding to an expert's questions, challenging a partner's statement, and asking and answering questions of each other.

learner to conduct *creating processes* as the mechanisms of inference generation and mental model repair (Chi 2000). In this case, a learner can enrich his or her existing knowledge and repair existing knowledge to make it coherent, accurate or better structured (Chi 2009). Interactive activities lead to the best learning outcomes because in these learning situations the cognitive mechanisms of *both creating and assimilating* are included. Therefore, the techniques examined in this thesis use both creating and assimilating processes in order to enhance learning.

2.2.1.3. Memory Organisation Principle

The third principle of learning is the memory organisation principle, in which the knowledge that is processed must be encoded in a specific organisation in the memory to make it easier to retrieve when the learner encounters a new problem (Gentner and Markman 1997; Markman and Gentner 2001).[7] This principle is important to consider because learning is successful if new knowledge stored in long-term memory that is brought back into working memory through retrieval processes is available for use later when needed in a novel situation on the job. However, studies by Gick and Holyoak (1980, 1983) find that most individuals fail to access prior knowledge that would be highly useful when performing far transfer tasks (i.e., tasks that require performers to adapt their skills to new situations (Clark et al. 2006). This problem, which is referred to as the *inert knowledge problem* (Gentner et al. 2003), can be resolved by asking individuals to abstract the knowledge in a specific organisation in the memory during the encoding process. Based on prior studies, which show that experts organise their knowledge hierarchically (Anderson 1993), an individual’s acquisition of expertise is more likely to be accelerated if the novice learns to organise his or her knowledge hierarchically like the experts (Day et al. 2001). Therefore, when learning, it is important that individuals organise the instructional information in a breadth-first, hierarchically-organised manner (Eylon and Reif 1984; Zeitz and Spoehr 1989). Breadth-first organisation involves generating an explanation at the highest level of the domain and then recursively decomposing the representation one level at time (Zeitz and Spoehr 1989).

The memory organisation principle (Clark et al. 2006) can be facilitated by using particular training techniques, such as the analogical encoding technique (Gick and Holyoak 1983;

---

[7] In addition to the term ’memory organization‘, several other labels have been attached to the construct of knowledge organization, including knowledge structures and mental models (Dorsey et al. 1999; Day et al. 2001). In this thesis, these terms are used interchangeably.

Gentner et al. 2003). This thesis examines whether improvements in memory organisation enhance learning performance.

2.2.1.4. Summary of Individual Learning Processes and Principles

As outlined in this section, three basic principles of learning must be in place in order for learning processes to be successful: the limited capacity principle, the deep processing principle, and the memory organisation principle (Gentner et al. 2003; Mayer 2008; Chi 2009). These principles have been studied in separate lines of research in cognitive and educational psychology and have been investigated in isolation. Therefore, an important contribution of this thesis is that the training techniques examined in this thesis address all three principles simultaneously, as outlined in the following sections.

2.2.2. The Use of the Analogical Encoding Technique as an Individual Training Intervention

As noted in Section 2.2.1, training techniques should be designed to facilitate the three learning principles in order to improve learning performance. This thesis investigates two training techniques that may achieve this goal: analogical encoding and collaborative learning. The section discusses how the analogical encoding technique addresses the three learning principles. The section also develops research hypotheses relating to the use of this technique in learning a complex task such as an analytical procedures task.

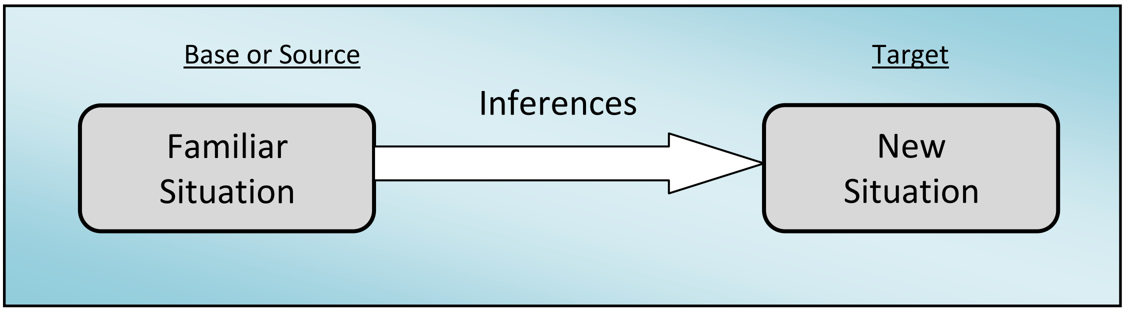
2.2.2.1. Worked Examples

Some educational psychology studies have suggested using worked examples as a training method to bring the three learning principles into play (Renkl 2011). A worked example is a step-by-step demonstration of how to perform a task or solve a problem (Mayer 2008). The use of this method has consistently been shown to be more effective and efficient for learning compared to conventional learning tasks (Atkinson et al. 2000) because it allows individuals to devote all their available cognitive capacity to studying the worked-out solution procedure and prevents the use of problem-solving strategies that are cognitively demanding (Sweller et al. 1998). This method takes the limited capacity principle into account. With regard to the deep processing principle, the use of worked examples, along with other learning activities, has been shown to lead to better learning outcomes (Chi 2009; Fonseca and Chi 2011). Worked examples have also been used as analogues where the learner abstracts the principles behind the examples and encodes them in a particular knowledge structure in the memory.

2.2.2.2. Analogical Encoding

The use of familiar worked examples that can serve as models or analogies to new situations has been investigated by studies in psychology and accounting. Consistent with psychology literature which posits that analogical transfer is an ability of mapping knowledge from a prior stored situation to a current situation (Gentner 1983; Ross 1987, 1989; Holyoak et al. 2001), in accounting literature, analogical reasoning is frequently focused on as a method by which individuals transfer knowledge from previous tasks, problems or experiences to a current task (Marchant 1989). Knowledge transfer here refers to 'the situation in which knowledge developed for one task will assist an individual's judgment performance in another task' (Thibodeau 2003). The idea is that individuals can readily learn specific examples (from tasks, problems, experience), which then can serve as models or analogies for future situations. Analogical reasoning is helpful because it could allow individuals to transfer their knowledge from a related familiar problem to a new situation. An individual uses this existing knowledge of similar situations and compares the features of each problem in order to solve a new problem (Gick and Holyoak 1980; Novick 1988; Marchant et al. 1991). Figure 2.1 depicts this cognitive mechanism which is called standard analogical reasoning.

Figure 2.1. Standard Analogical Reasoning



Source: Adapted from Gick and Holyoak (1983) and Gentner et al. (2003).

There is considerable evidence in psychology that analogical transfer can lead to powerful insights when it occurs. If individuals notice a similarity between a new problem and one of their previously learned examples (i.e., a familiar situation) they can use the prior example to inform the current problem (e.g., Ross 1984; Pirolli and Anderson 1985). When individuals succeed in accessing an appropriate prior example, they typically perform well in mapping the solution to the current problem (Pirolli and Anderson 1985; Reed 1987; Ross 1989).

However, a review of the prior literature in psychology reveals that people often fail to access prior cases in new contexts (Gick and Holyoak 1980, 1983; Ross 1987, 1989; Reeves and Weisberg 1994). Although people do show some degree of spontaneous relational transfer (Johnson and Seifert 1992; Gentner, Ratterman, et al. 1993), people are unlikely to use an analogous problem to solve a new problem unless they are given a hint that the problems are similar (Gentner, Rattermann, et al. 1993). In addition, most hints or reminders relating to prior situations appear to be driven largely by surface similarities, such as similar characters and settings, rather than by similarities in relational structure (Gick and Holyoak 1980, 1983; Ross 1984; Brooks 1987; Ross 1987, 1989; Brooks et al. 1991; Gentner, Ratterman, et al. 1993; Catrambone 2002). This means that people often fail to apply past learning to new situations that share the same causal or mathematical principles. Psychological studies suggest that the reason for the failure to use knowledge gained in one setting to solve problems in new settings is that the knowledge people learn is tied to the context of learning (Ross 1987; Gentner, Ratterman, et al. 1993). Learners often focus on surface aspects and are generally poor at noticing structural similarities, even within a single context (Ross 1987; Novick 1988).

Consistent with these findings, a review of prior literature in accounting shows it is not easy to identify situations when knowledge will transfer between tasks using analogical reasoning, with studies producing mixed results (Gick and Holyoak 1980, 1983; Marchant 1989; Marchant et al. 1991; Salterio 1996; Salterio and Koonce 1997). For example, although Marchant (1989) argues that auditors use analogical reasoning to generate a potential hypothesis in an unusual situation, a closer examination of his study reveals that providing information relevant for hypothesis generation prior to the hypothesis generation task as a source analogue did not significantly alter subjects' selection of the analogous hypothesis.[8]

---

[8] Marchant (1989) argues that auditors use analogical reasoning to generate a potential hypothesis based on the subject's estimate of the probability of two target errors they generated as potential hypotheses. As argued by Marchant (1989), the target of knowledge from the source analogue would increase the information suggesting the analogous hypothesis thereby increasing the estimated likelihood of occurrence of that hypothesis. However, he also uses another measure, the subject's response to the forced choice selection of hypotheses, the measure that is consistent with prior analogical reasoning studies (e.g., Gick and Holyoak 1980, 1983) which usually asked participants to solve the problem (or to generate hypotheses as in his study). Testing the research hypotheses using this measure, the results shows that there was no significant treatment effect for the source analogue

This means that auditors fail to apply past learning to a new situation. A more recent study (Kozloski 2011) indicates that auditors' being reminded of prior situations appears to be driven largely by surface similarities. He finds that auditors transfer knowledge regarding the assessment of the overall risk of fraudulent financial reporting from a surface-similar source fraud risk assessment to a target fraud risk assessment. Furthermore, it is found that auditors did not exhibit transfer relating to the overall risk of fraudulent financial reporting when provided with a structurally similar source analogue. These findings confirm that individuals often fail to recall relevant and useful examples to which they have been exposed when conducting relational retrieval using a standard analogical reasoning.[9]

Because of the importance of analogical (or relational) transfer, much research in psychology has been conducted to answer what kinds of learning experiences promote relational retrieval. Prior research suggests that the best-established way of promoting relational transfer is for the learner to compare analogous examples during learning (Gick and Holyoak 1983; Catrambone and Holyoak 1989; Loewenstein et al. 1999; Thompson et al. 2000; Kurtz et al. 2001; Gentner et al. 2003; Loewenstein et al. 2003). Such technique, which is called analogical encoding, involves encoding the knowledge that results from comparing and contrasting two analogues or examples (Gentner and Markman 1997; Gentner et al. 2003). The comparison used in this technique entails a structural alignment and mapping process that highlights the similar aspects of two examples (Gentner and Markman 1997). Focusing on shared (or divergent) aspects between examples promotes the abstraction of a common relational structure that can be stored as a particular structure in long-term memory. Thus, drawing a comparison can lead individuals to focus on structural commonalities rather than on idiosyncratic surface features (Gentner and Markman 1997; Gentner et al. 2003).

Furthermore, unlike standard analogical learning, in which knowledge is mapped from a well-understood (or familiar) example to a target problem, in analogical encoding, the mapping can occur in both directions – whatever is understood about one example can serve to shed

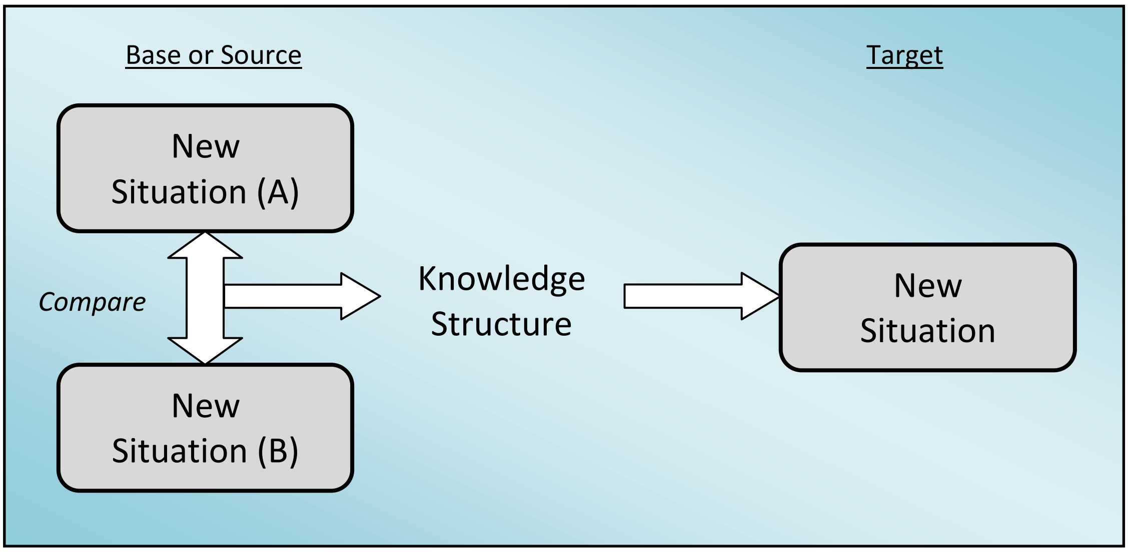
---

and the interaction of source analogue and expertise (Table 1, page 508). Therefore, the results suggest that the use of the source analogue fails to promote the hypothesised analogical transfer.

[9] As noted by two accounting studies (Thibodeau 2003; Joe and Vandervelde 2007), transfer of knowledge using standard analogical reasoning may occur if three conditions are met: (a) a common element of the tasks must exist and an individual must recognize the similarities between the two tasks; (b) the individual must understand the base task domain well and be capable of abstracting the general principles or strategies learned from the base task domain that can be applied to the target task; and (c) the base task knowledge must be organized in a manner that will allow such knowledge to be transferred to the target task.

light on another (Gentner et al. 2003). As shown in Figure 2.1, in standard analogical learning, the base or source description which is a familiar situation is matched with the target description, a less familiar situation. Analogical learning, which involves structural mapping by aligning the two situations, requires learners to find the correspondences between the two representations and to project inferences from the base to the target (Gentner 1983). In contrast, in analogical encoding, individuals compare two examples (Problem A and B in Figure 2.2) and, on the basis of highlighting the similar (and/or divergent) aspects of the two examples, they conduct a structural alignment and mapping process and derive an abstraction as a particular knowledge structure, which in turn can facilitate transfer to a structurally similar problem (Gentner and Markman 1997). As illustrated in Figure 2.2, each corresponding element of two analogous worked examples can be mapped, highlighted and encoded into a particular structure.

Figure 2.2. Analogical Encoding



Source: Adapted from Gentner et al. (2003).

Studies have also found that when worked examples are studied with a compare-and-contrast activity such as that used in the analogical encoding technique, the worked examples should be more easily retrieved when the learner encounters a new case with the same structure (Gentner et al. 2003). This is because the abstracted knowledge structure will have fewer idiosyncratic details and therefore will conflict less with the surface features of the current or target case (Gentner and Markman 1997). Thus, when solving problems in new contexts, individuals should be able to recall and apply knowledge structures derived through analogical encoding better than with previously-reviewed individual examples (Catrambone and Holyoak 1989; Reeves and Weisberg 1994).

On the other hand, when worked examples are studied separately (i.e., without comparison as in standard analogical reasoning), individuals focus mainly on the surface features of the presented material (Gentner et al. 2003) when conducting cognitive processes prior to memory retrieval. They tend to encode them in a more concrete, context-specific manner. In the next process – the retrieval process – individuals retrieve items from long-term memory on the basis of feature surface similarities between the target problem and stored items (Gentner et al., 1993; Gick and Holyoak, 1980; 1983; Ross, 1984, 1987, 1989; Mayer 2008). In other words, individuals fail to organise knowledge by not appreciating structural features in the presented material that would be highly useful when resolving a new problem with similar structural features (Gentner and Markman 1997). This superficial structure process explains the inert knowledge problem, in which individuals appear to have difficulty in applying relevant, previously-learned knowledge to new situations that are different in their surface features, although sharing similar structural features (Gentner 1989; Medin and Ross 1989).

For complex learning tasks, such as the GHG analytical procedures task explored in this thesis, research in educational psychology suggests that the use of more advanced techniques, such as analogical encoding, is needed when using worked examples (Kirschner et al. 2009a). However, it is important to note that in the studies outlined above, the analogical encoding technique has been investigated in isolation. In addition, although these studies address the memory organisation principle (Gentner et al. 2003), they do not address the other two learning principles: limited capacity and deep processing. Although positive effects of analogical encoding have been found in studies where individuals studied simple learning tasks, several studies saw no positive effects when the individuals studied complex learning tasks (Cummins 1992; VanderStoep and Seifert 1994). Little is known about how the use of analogical encoding affects individual cognitive load and deep processing, which in turn affect learning outcomes. This thesis extends prior research by addressing all three learning principles: limited capacity, deep processing, and memory organisation. The thesis also examines the technique in a complex task setting.

2.2.2.2.1. Impact of Analogical Encoding on the Limited Capacity Principle

It has been argued that the analogical encoding technique imposes high cognitive load on working memory (Renkl 2011). As a result, consistent with the limited capacity principle, the use of the analogical encoding technique may hinder learning, particularly when this technique is used to perform complex tasks. The explicit prompt to compare and contrast the worked examples impose too great a processing demand (i.e., cognitive overload) in the organising process (i.e., constructing internal connections between many incoming elements from the worked examples to be compared). As a result, limited working memory capacity is available for the encoding process (i.e., placing knowledge constructed in working memory into long-term memory) (Sweller et al. 1998; Clark et al. 2006; Renkl 2011). This higher cognitive load may explain why prior studies in psychology have found that the use of analogical encoding did not improve performance in solving the target problem (Cummins 1992; VanderStoep and Seifert 1994).

2.2.2.2.2. Impact of Analogical Encoding on the Deep Processing Principle

The analogical encoding technique can be classified as a constructive learning activity that is expected to encourage deep learning processes (Chi 2009; Fonseca and Chi 2011). However, the use of this technique may not lead to superior learning outcomes for individuals who have existing knowledge structures that are incompatible with the training material. As noted above, the underlying cognitive mechanisms in constructive learning activities are the creating processes in which individuals generate inferences and repair their mental model (Chi 2000, 2009). Through these mechanisms, existing knowledge is enriched and repaired in order to make it more coherent, accurate and better-structured. However, studies in educational psychology investigating the deep processing principle have generally used homogeneous participants with similar backgrounds and knowledge (i.e., students who have either similar or no knowledge or who have no pre-existing mental models in a particular domain). To date, no study has investigated training for diverse-background MDTs whose members have different pre-existing knowledge structures or mental models. In this thesis, it is argued that an individual's pre-existing mental models have an influence on the cognitive mechanisms in the creating processes. In particular, research suggests that the creating processes are facilitated when a learner's pre-existing mental models before training are compatible with training material structures (or implied mental models) (Nelson et al. 1995; Bonner et al. 1996; Bonner et al. 1997; Vera-Munoz 1998; Vera-Munoz et al. 2001; Borthick et al. 2006). In contrast, when the pre-existing knowledge structures that are activated during learning do not match or are not compatible with the structure of the training material, studies have found that individuals often restructure the task or the learning material to create a problem representation that matches their pre-existing knowledge structures (Nelson et al. 1995; Bonner et al. 1996; Bonner et al. 1997; Vera-Munoz 1998; Vera-Munoz et al. 2001; Borthick et al. 2006). Where this is the case, the creating processes that use the mechanisms of inference generation and mental model repair may not occur, thus hindering the learning process.

2.2.2.2.3. Impact of Analogical Encoding on the Memory Organization Principle

The beneficial effect of the analogical encoding technique in facilitating memory organisation is only realised when the individual's pre-existing knowledge structure is compatible with the structure of the training material in terms of the development of accurate knowledge structures (where there is no pre-existing knowledge structure). As noted above, according to the memory organisation principle, the development of a particular knowledge structure is beneficial because it makes the knowledge more easily retrieved when the learner encounters a new problem (Gentner and Markman 1997). However, as argued above, for individuals who have an incompatible pre-existing knowledge structure, the new organisation or structure according to the training material does not match or is in conflict with their pre-existing structures. When this happens, individuals often restructure the task or the learning material to create a problem representation that matches their pre-existing knowledge structures (Nelson et al. 1995; Bonner et al. 1996; Bonner et al. 1997; Vera-Munoz 1998; Vera-Munoz et al. 2001; Borthick et al. 2006). These individuals find it difficult to retrieve new knowledge structures and to transfer the knowledge to a new problem. In this situation, the use of this technique may not be effective in helping to develop a particular knowledge structure and may not improve learning outcomes.

2.2.2.2.4. Impact of Analogical Encoding for Complex Tasks

Although previous studies have found that the analogical encoding technique leads to superior learning outcomes in simple learning tasks, the use of this technique by individuals in learning a complex task (such as that performed by MDTs in analytical procedures for GHG assurance) may not lead to higher learning outcomes. In this thesis, this prediction is examined in the setting where individual members perform an analytical procedures task – a complex learning task used in the GHG assurance setting. The analytical procedures task is a complex multi-stage task that involves multiple cognitive processes including mental representation, hypothesis generation, information search, hypothesis evaluation and the final judgment (Elstein et al. 1978; Koonce 1993). This task is characterised as a diagnostic, sequential and iterative process (Koonce 1993). First, mental representation contains the current formulation or understanding of the problem situation. The mental representation guides and constrains the cognitive processes in every other stage of the analytical procedures task (Koonce 1993). In the hypothesis generation stage, individuals access their organised mental representation, which contains knowledge about the causes of the problem (i.e., hypotheses), and generate the potential hypotheses. This stage is a cognitive process that is characterised as a construction process since an auditor must explain unexpected fluctuations by generating potential causes as hypotheses (Bonner and Pennington 1991). Next, in the information search stage, information is acquired to test those hypotheses and, based on the evidence from the available information, the hypotheses are evaluated to achieve a diagnosis (Koonce 1993; Solomon and Shields 1995). In the final judgment stage, the most likely cause for an unexpected fluctuation is determined. These two latter stages are labelled as a reduction process where an auditor must rule out unsupported hypotheses and choose from among appropriate hypotheses (Bonner and Pennington 1991).

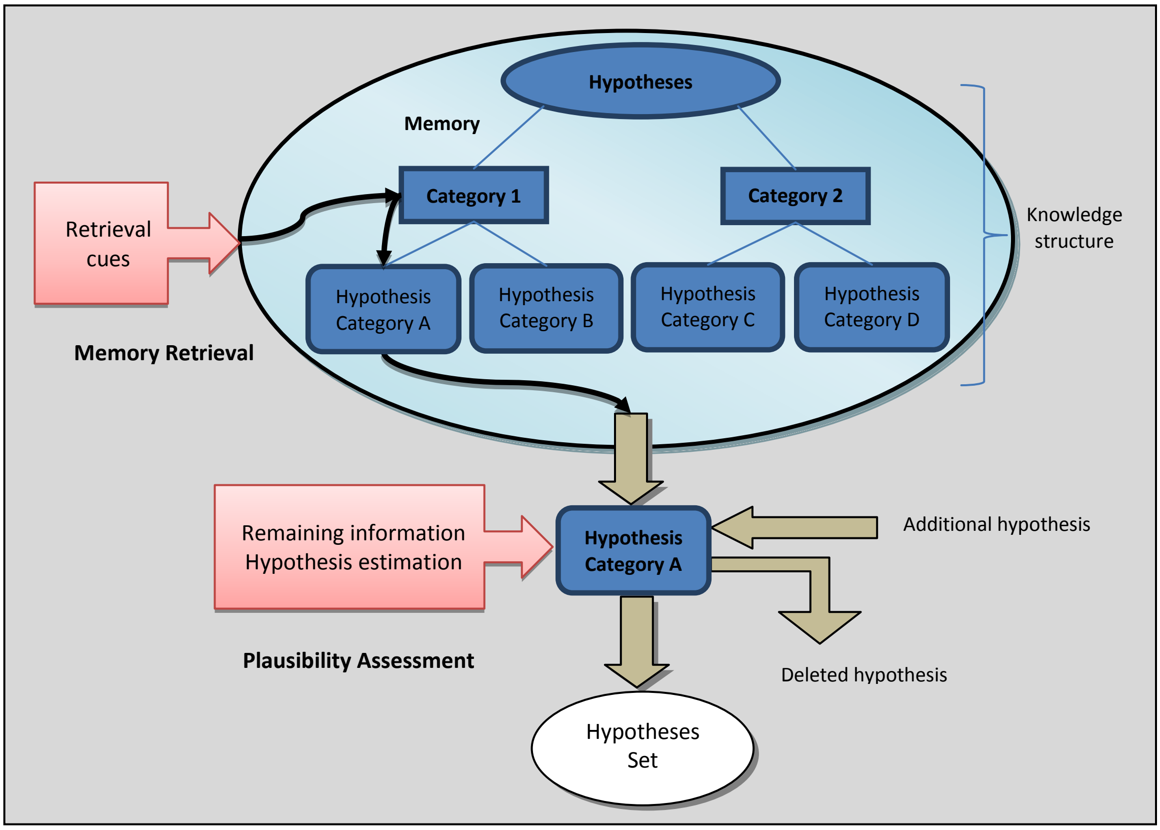
Focusing only on the hypothesis generation stage at the individual level, a review of the analytical procedures studies reveals that in order to improve an individual’s ability in generating hypotheses, the individual must: (1) be able to retrieve hypotheses from memory efficiently and effectively; (2) be able to verify relationships in an hypothesis; and (3) verify information that is already active in memory in order to check the consistency of the retrieved hypotheses (Fisher et al. 1983; Bonner 2008). These two cognitive processes can be facilitated by acquisition of knowledge content and development of appropriate knowledge structures in the individual’s mental representations (Bonner 2008). Knowledge content includes knowledge on possible causes of misstated reports based on an understanding of the client’s environment. The knowledge structures are the organisation of these causes according to a particular categorisation (Frederick et al. 1994). In the case of auditors, in financial statement auditing, error hypotheses are usually categorised based on either audit objectives/assertions or transaction cycles (Frederick et al. 1994; Coyne et al. 2010).[10]

The existence of a well-developed knowledge structure in long-term memory is important because it improves the ability of the individual to generate better hypotheses (Bonner 2008). This occurs because of the ease of retrieval of hypotheses related to the cues provided (Libby and Frederick 1990; Tubbs 1992; Frederick et al. 1994). In particular, if causal hypotheses are structured according to a certain categorisation in memory, the retrieval process will be more efficient and effective because only a subset of hypotheses or a category that is consistent with relevant retrieval cues is retrieved (Bonner 2008) (see Figure 2.3). Assessing the plausibility of generated hypotheses can also be conducted optimally and efficiently because the hypotheses generated will be more focused on a specific category of hypotheses, meaning that the number to be checked and estimated is moderate (Bhattacharjee et al. 1999).

---

[10] Audit errors can be categorised based on audit assertions that provide a framework for developing specific audit objectives. For example, assertions about classes of transactions and events for the period under audit are occurrence (i.e., transactions and events that have been recorded have occurred and pertain to entity); completeness (i.e., all transactions and events that should have been recorded have been recorded); accuracy (i.e., amounts and other data relating to recorded transactions and events have been recorded appropriately); cut-off (i.e., transactions and events have been recorded in the correct accounting period); and classification (i.e., transactions and events have been recorded in the proper accounts (IAASB 2009). Audit errors can also be categorised on the basis of transaction cycles which focus on a small number of cycles through which a large number of transactions are processed into a larger number of accounts. From many categorisations, the five main transaction cycles found in most industrial and commercial enterprises are: (1) revenue and receipt; (2) purchase and payment; (3) human resource (payroll); (4) inventory; and (5) financing/investing (Eilifsen et al. 2013).

Figure 2.3. Effective and Efficient Hypothesis Generation



Source: Modified by the author from Fisher et al. (1983) and Bonner (2008)

Studies have suggested that the use of analogical encoding, which involves comparing examples of different problem categories with regard to the distinguishing features of each category, can help individuals learn to better distinguish these problem categories (Cummins 1992; VanderStoep and Seifert 1994; Day et al. 2010). This can be achieved by employing *problem-category comparison,* an analogical encoding technique that involves comparing examples of two (or more) different problem categories (Rittle-Johnson and Star 2011). By using this technique, the knowledge of causal hypotheses can be structured in the form of a hierarchical network, also referred to as a *taxonomic structure* (Markman 1999; Anderson 2010). In this structure, the category at the highest level of abstraction is at the top of the network; beneath it are categories at the next most detailed level of abstraction. Membership in categories is based on similarity along some dimension(s). Beneath these categories are further categories, if applicable, or individual members of categories (Bonner 2008).

In the context used in this thesis, MDTs learn to categorise causal hypotheses in an analytical procedures task. However, due to their differing education and experience, each team member possesses a different pre-existing knowledge structure (or way of organising information in memory) which may not match or be compatible with the other team member's knowledge structure. For example, the knowledge structure of an auditor, which is developed from prior education or experience in auditing will be different to, or have little similarity with, the knowledge structure of a scientist who has no prior knowledge in categorising this type of information. As outlined previously, when pre-existing knowledge structures that are activated during learning do not match or are not compatible with the structure of the training material, individuals will restructure the task or the learning to create a problem representation that matches their pre-existing knowledge structures. This has an influence on learning as the creating processes that use mechanisms of inference generation and mental model repair may not occur in these cases.

2.2.2.3. Summary of the Analogical Encoding Training Technique and Development of Hypothesis 1

In summary, while prior research has found that the performance of individuals trained using analogical encoding improves under certain circumstances (e.g., for simple tasks), the use of the analogical encoding technique (i.e., problem-category comparison) may not be effective as a training intervention in improving the performance of individual members of MDTs in a complex task such as an analytical procedures task. This prediction is formally proposed, stated in null form, as follows:

Hypothesis 1: *Performance in generating hypotheses will not differ between individuals trained using the analogical encoding technique and those trained without this technique.*

2.2.3. The Use of the Collaborative Learning Technique as an Individual Training Intervention

The second training technique, collaborative learning, refers to an instruction method in which individuals work together in small groups towards a common goal on academic tasks (Dillenbourg 1999). This technique can be used as an advanced technique when using worked examples. As with the analogical encoding technique, the collaborative learning technique has been investigated in isolation in previous studies; each technique has been examined for a particular learning principle. In particular, the collaborative learning technique has been examined in the context of optimising cognitive resources (Kirschner et al. 2009a; Kirschner, Paas, and Kirschner 2011; Kirschner, Paas, Kirschner, et al. 2011). Although some studies have conceptualised the advantages of this technique as a beneficial learning activity that facilitates deep processing (Chi 2009; Fonseca and Chi 2011), there are very few studies examining this technique in relation to the deep processing principle. A notable exception is the study by Hausmann et al. (2008), which found that in solving physics problems, student participants assigned to a joint-explain group (i.e., an interactive situation where a participant generates joint explanations with another participant on how to solve the problems) outperformed self-explain groups (i.e., a constructive situation where participants generated explanations on how to solve the problems on their own). To date, little is known about the impact of collaborative learning on the development of knowledge structure, nor how this affects learning outcomes. This thesis extends this research by examining collaborative learning with reference to all three learning principles: limited capacity, deep processing and memory organisation.

2.2.3.1. Collaborative Learning and the Limited Capacity Principle

First, from the limited capacity principle perspective, use of the collaborative learning technique is beneficial to learning because the processing of information necessary for carrying out a learning task can be distributed to group members, creating a large reservoir of cognitive capacity (Kirschner et al. 2009a). The expanded capacity of working memory allows the information within the task and the cognitive load to be divided across multiple collaborating working memories. By sharing the cognitive load among the members of the group, the remaining processing capacity can be freed up at the individual level for relevant load (i.e., germane load) that is necessary in learning (Kirschner et al. 2009a; Kirschner, Paas, and Kirschner 2011; Kirschner, Paas, Kirschner, et al. 2011). The use of this technique is suitable for complex tasks because it shares the additional cognitive loads associated with initiating and maintaining communication and coordination (called *transactional activities*) among the group members (Kirschner et al. 2009a; Kirschner, Paas, and Kirschner 2011; Kirschner, Paas, Kirschner, et al. 2011).[11] These activities impose either intrinsic load (i.e., via the communication and coordination that are inherent in a collaborative learning environment), or germane load (i.e., through fostering shared understanding, trust, mutual

---

[11] According to Kirschner et al. (2009a, 37), group communication is 'a process in which members of a group share and discuss the learning task, the relevant information elements, and the task solution as well as communication intended to reach common ground' and group coordination is 'a process that manages the interdependencies between group members so that every member knows exactly which activities other members are carrying out or will carry out, in order to effectively determine what an individual's own activities at the moment and in the future entail.'

performance monitoring, common ground, argumentation, coordination, and positive cognitive conflicts), or extraneous load (i.e., through fostering errors, conflicts or unnecessary duplication) (Kirschner et al. 2009a). However, for highly complex tasks, the additional cognitive load, as argued by Kirschner et al. (2009a), is relatively low compared to the load distribution advantage.

2.2.3.2. Collaborative Learning and the Deep Processing Principle

From the deep processing principle perspective, the use of collaborative learning as an interactive learning environment may facilitate not only creating processes (i.e., cognitive mechanisms of inference generation and mental model repair (Chi 2000)) but also assimilating processes (i.e., the processes of selection of relevant information, activation of relevant knowledge, and encoding new information in the context of the relevant activated knowledge) through a joint dialogue (Chi 2009; Fonseca and Chi 2011). Furthermore, the use of this technique may result in more effective and efficient learning because collaborating with other team members facilitates the encoding process in terms of the added advantage of the other learners' contributions when learning together (Chi 2009). The other individual can provide additional information, a new perspective, corrective feedback, and a new path or line of reasoning that strengthens the encoding process (Chi 2009). The interaction in dialogues between team members can contribute to learning through the discussion of issues that neither of the group members may have been able to come up with on his or her own (Chi 2009).

Prior studies in educational psychology suggest that when learning collaboratively with a partner, individuals produce a shared understanding or representation of the information (Jeong and Chi 2007). This shared understanding can be achieved by joint dialogues, in which each partner can change their joint understanding in a dynamic way that may result in a more innovative and novel mental model (Jeong and Chi 2007; Chi 2009).[12] In other words, when working in groups of two (dyads) (Jeong and Chi 2007), the potential outcome of this joint

---

[12] According to Chi (2009), joint dialogues occur when an individual interacts with other individuals and makes substantive contributions to the topic or concept under discussion. The substantive contributions in joint dialogues can be made either sequentially (i.e., individuals take it in turn) or in a more overlapping way (i.e., individuals build on or expand upon each other's line of reasoning). In addition, individuals in joint dialogues can participate in self-construction (i.e., each individual incorporates the contributions of the partner and extends his or her own understanding).

dialogue is the development of a new problem conception that was not initially available to the dyad (Fonseca and Chi 2011).[13]

2.2.3.3. Collaborative Learning and the Memory Organization Principle

The use of collaborative learning may not facilitate the development of knowledge structure. Research in collaborative memory (Basden et al. 1997; Barber et al. 2010) suggests that collaboration may inhibit the development of knowledge structure and appropriate retrieval. Research has found that when an individual develops his or her own idiosyncratic way of organising information in memory, working collaboratively with a partner to recall the information will disrupt his or her recall performance (Andersson and Rönnberg 1995; Weldon and Bellinger 1997; Rajaram and Pereira-Pasarin 2010; Rajaram 2011). This phenomenon, which is called *collaborative inhibition,* occurs because at the point of retrieval, when information is provided in a different structure (as part of someone else's recall), it disrupts the individual's organisational structure and lowers their recall performance (Basden et al. 1997). In addition, Barber et al. (2010) find that compared to individually encoded items, collaboratively encoded items were not more idiosyncratically meaningful and were not better recalled.

2.2.3.4. Impact of Collaborative Learning for Complex Tasks

The analytical procedures task, as suggested by prior studies, is characterized as a complex multi-stage diagnostic reasoning task that involves multiple cognitive processes (Elstein et al. 1978; Koonce 1993). The complexity of analytical procedures can be attributed to: (1) the need to uncover inconsistencies between actual and expected decision cues (i.e., year-to year differences); and (2) the number of possible decision alternatives (i.e., potential causes for the unexpected changes) that must be considered (Bonner 1994; O'Donnell and Johnson 2001). Because the number of information elements that should be processed is higher, this task requires substantial cognitive resources (Bettman et al. 1990). In learning complex tasks such as an analytical procedures task, as noted in Section 2.2.3.1, optimisation of cognitive resources is facilitated by using the collaborative learning technique. Although tasks that involve the need to uncover inconsistencies and identify the many decision alternatives (and related information elements) impose high cognitive load, collaborative learning allows the

---

[13] Prior educational psychology studies have also demonstrated the beneficial effects of collaborative learning as group learning in which several learners (more than two individuals) learn together. See Slavin (2011) for a review.

cognitive load to be divided and shared among the members of the group. In turn, the remaining processing capacity can be utilised optimally for necessary learning processes. Consequently, the use of this technique is expected to lead to better learning outcomes.

In understanding a complex task that involves knowledge from a variety of fields, such as analytical procedures in GHG assurance engagement, strengthening the encoding process through deep processing is required. As noted in Section 2.2.3.2, the use of collaborative learning enables the interaction in joint dialogues between members of learning groups. When interacting, each individual can provide required additional information, a new perspective, corrective feedback, and a new path or line of reasoning. In the context of MDTs, because each member has different knowledge and background, team members can contribute significantly to learning by providing relevant information and perspectives from their respective domains. Therefore, the use of collaborative learning allows deep processing and thereby enables individuals to achieve better learning outcomes in learning a complex task.

As noted previously, the existence of a well-developed knowledge structure is important in generating better hypotheses (Bonner 2008). However, as outlined in Section 2.2.3.3, the development of knowledge structure may not be facilitated by collaborative learning. In the context used in this thesis, where MDTs learn to categorise causal hypotheses in an analytical procedures task, due to their differing education and experience, each team member possesses a different pre-existing knowledge structure (i.e., way of organising information in memory). This may not match or be compatible with the knowledge structure of other team members. For example, the knowledge structure of an auditor, which develops from prior education or experience in auditing will be different to or have little similarity with the knowledge structure of a scientist who has no prior knowledge in categorising this type of information. When these individuals learn collaboratively, the other team member's organisation structure (which is incompatible) may disrupt the individual's organisation structure; therefore, it may impair the encoding process for learning the knowledge structure supplied in the training material.

2.2.3.5. Summary of the Collaborative Learning Technique and Development of Hypothesis 2

As outlined above, the collaborative learning technique includes benefits in terms of reduced cognitive load as well as substantial deep processing resulting from a joint dialogue. At the same time, disruption from other group members may inhibit memory organisation around the provided structure. Because this technique includes more facilitating factors in learning (i.e., reduced cognitive load and deeper processing) than inhibiting factors (i.e., disruptions from collaboration that inhibit the development of knowledge structure), it is argued that the use of this technique leads to better individual learning outcomes. Following from this argument, a research hypothesis, stated in alternative form, is proposed as follows:

Hypothesis 2: *Performance in generating hypotheses will be better for those individuals trained using the collaborative learning technique than those trained without this technique.*

2.2.4. The Interaction between Analogical Encoding and the Collaborative Learning Techniques as an Individual Training Intervention and Development of Hypothesis 3

One aim of this research is to examine whether analogical encoding and collaborative learning can improve the performance of MDTs in the GHG assurance setting. As outlined in Sections 2.2.2 and 2.2.3, although both analogical encoding and collaborative learning have been found to enhance individual learning, these training techniques have also been found to be ineffective in certain situations. In particular, analogical encoding increases cognitive load when this technique is used in a complex learning task and collaborative learning inhibits the development of knowledge structure. However, in a complex setting, such as the analytical procedures in the assurance of GHG emissions, the use of these two techniques concurrently is still expected to lead to include benefits from the best aspects of both techniques, leading to overall improved performance of the task in a complex setting. In particular, this thesis examines whether the advantage of decreased cognitive load when using collaborative learning can combine with the deeper understanding of the task gained from analogical encoding and thereby improve individual and MDT performance.

Moreno et al. (2007) suggest that in analytical procedures task training, because of the complex nature of analytical procedures, a combination of training interventions may be necessary and may overcome the limitations of a single technique. Specifically, Moreno et al.

(2007) test the combination of worked examples and problem-solving training groups with self-explanation (i.e., individuals actively explaining the solution to themselves, a type of constructive learning activity). They found that student participants who received a combination of these training techniques performed as well as the benchmark group of practicing auditors and outperformed participants in all other groups (i.e., those that received a single training technique). The results of Moreno et al.'s (2007) study demonstrate that complex analytical procedures require a combination of interventions in both the hypothesis generation and hypothesis evaluation stages.

A single intervention training technique may have potential limitations in improving individual ability when performing a complex task such as an analytical procedures task. Consistent with this notion of benefits from combined training interventions, this thesis argues that combining analogical encoding with collaborative learning will lead to better learning outcomes. The rationales for this prediction are summarised in Table 2.1. The following discussion provides a specific explanation for this expected improvement based on the three learning principles.

As argued in Section 2.2.2, using the analogical encoding technique when learning a complex task such as an analytical procedures task may not lead to superior learning outcomes due to its limitations in addressing the three learning principles. As shown in the second row of Table 2.1, high cognitive load and the beneficial effect of this technique can only occur when individuals have compatible pre-existing knowledge structures. This prevents single interventions using this technique from leading to better learning outcomes. As indicated by the positive effects in the second row in Table 2.1, when compared to the first row as a baseline, where individuals train with no such techniques, there is no improvement when this technique is used as a single intervention.[14]

Using the collaborative learning technique (relative to the use of analogical encoding) as a single intervention may have more beneficial effects in learning an analytical procedures task. As argued in Section 2.2.3, the use of this technique leads to better individual learning outcomes. The third row of Table 2.1 indicates that two positive effects due to more optimal use of cognitive resources and deep processing allow the improvement of individual learning

---

[14] Due to an average effect that occurs when some participants may have one type of knowledge structure and others another type of knowledge structure, with randomization it is expected that the benefits of deep processing and memory organization are not realised. Therefore there are no differences between Condition 1 and 2.

outcomes. In the context of learning to generate hypotheses, this technique allows individuals to acquire knowledge content that includes knowledge on possible causes of misstated reports based on an understanding of the client's environment.

Table 2.1. The Effects of Training Techniques for Complex Tasks Performed by MDTs

No.	Training Techniques	**Principle 1**: Optimising cognitive resources	**Principle 2**: Facilitate deep processing		**Principle 3**: Facilitate memory organization	
1.	No Analogical Encoding and No Collaborative Learning	✓	✗		✗	
2.	Analogical Encoding and No Collaborative Learning	✗	✗	for individuals who have incompatible knowledge structure	✗	for individuals who have incompatible knowledge structure
			✓	for individuals who have compatible knowledge structure	✓	for individuals who have compatible knowledge structure
3.	No Analogical Encoding and Collaborative Learning	✓	✓		✗	
4.	Analogical Encoding and Collaborative Learning	✓	✓		✗	for individuals who have incompatible knowledge structure
					✓	for individuals who have compatible knowledge structure

Source: Developed by the author based on Gentner et al. (2003), Clark et al. (2006), Chi (2009) and Renkl (2011).

The use of the analogical encoding technique combined with collaborative learning may lead to better retrieval and transfer of knowledge of causal hypotheses in the hypothesis generation stage. Individuals who train using a combination of training techniques are predicted to outperform individuals who train using only the collaborative learning technique. As indicated by the fourth row in Table 2.1, similar to using collaborative learning as a single intervention, there are two positive effects from using a combined technique: reduced cognitive load and deep processing when learning.

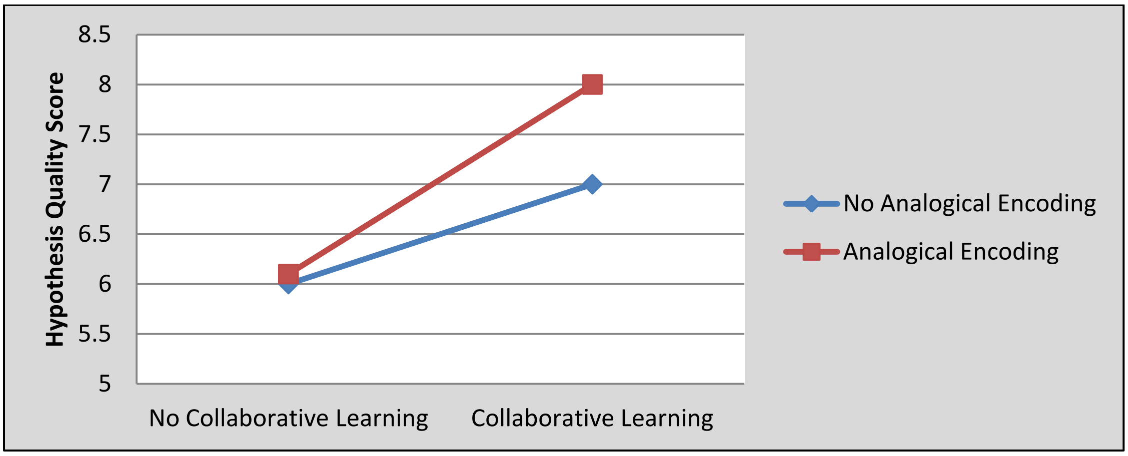
The addition of collaborative learning to the analogical encoding technique is advantageous in reducing cognitive load. Learning together with other individuals may reduce cognitive overload in the organising process (i.e., constructing internal connections between many incoming elements from the worked examples to be compared). By sharing the cognitive load among the members of the group, capacity of working memory can be expanded and allows the information processing to be divided across multiple collaborating working memories. As a result, the remaining processing capacity is available for relevant load (i.e., germane load) that is necessary in the encoding process (i.e., placing knowledge constructed in working memory into long-term memory) (Sweller et al. 1998; Clark et al. 2006; Renkl 2011). Although the cognitive load may be higher than learning without analogical encoding, the use of combined techniques may reduce cognitive load significantly compared to using analogical encoding on its own.

The addition of collaborative learning to the analogical encoding technique also may be beneficial in facilitating deep processing. When analogical encoding is used on its own, the knowledge creating processes via the mechanisms of inference generation and mental model repair may not occur due to the learning inhibition that stems from the incompatibility between pre-existing knowledge structures (or mental model) and the structure of the training material. The addition of collaborative learning allows interaction in dialogues between team members, which contributes to learning through the discussion of issues that individual group members may not have been able to come up with on their own (Chi 2009). In addition, the difficulty that individuals face when they have pre-existing incompatible knowledge structures may be reduced because learning collaboratively with a partner enables individuals to produce a shared understanding or representation of the information (Jeong and Chi 2007). The other member's contribution through additional information, a new perspective, corrective feedback, and a new path or line of reasoning also may strengthen the encoding process (Chi 2009).

In addition to the two positive effects of collaborative learning, the use of analogical encoding is beneficial in facilitating the development of knowledge structure particularly when the individual's pre-existing knowledge structure is compatible with the training structures. Although, this positive effect may not occur when an individual's pre-existing knowledge structure is incompatible with the training structures, in general, there are more positive effects of using a combined technique compared to using collaborative learning alone as shown in the third and fourth row of Table 2.1. Therefore, it is expected that the use of a combination of analogical encoding and collaborative learning will lead to the highest learning outcomes relative to using a single training technique or no such techniques.

Figure 2.4 illustrates the suggested ordinal interaction. When individuals train without collaborative learning, there is no individual performance improvement when they train using an analogical encoding technique. However, when collaborative learning is used, there is an improvement in individual performance due to collaboration. More improvement can be obtained when analogical encoding is combined with collaboration learning. This combination facilitates individuals to generate hypotheses efficiently and effectively.

Figure 2.4. Expected Results for the Effect of Training Techniques on Individual Hypothesis Generation



Source: Developed by the author based on arguments in Sections 2.2.2, 2.2.3, and 2.2.4.

This pattern of expected individual performance leads to the following interaction hypothesis, stated in alternative form: [15]

Hypothesis 3: *Individual performance in generating hypotheses will be highest when the individuals train using a combination of analogical encoding and collaborative learning techniques; lower when the individuals train with only the collaborative learning technique; and lowest when they train without the collaborative learning technique, regardless of whether they train with or without the analogical encoding technique.*

---

[15] The determination of the expected means in Figure 2.3 can be explained as follows. Prior studies in hypothesis generation suggest that novices had difficulty in generating complete sets of hypotheses and the mean number of hypotheses generated was only 3.4 hypotheses and seemed to be much less specific than those generated by experts (Mehle 1982). Using the hypothesis generation quality score (as explained later in Chapter 3), with 3 less-specific hypotheses, the score that can be assigned is 6. If the individuals train with a training technique, it is expected that the hypothesis quality score will be higher due to more hypotheses to be generated and/or more specification of these hypotheses. There will be no difference between Condition 1 and 2 and the scores for collaborative learning conditions will be higher than no collaborative learning (i.e., 7 for Condition 3 and 8 for Condition 4).

2.3. Improving Multidisciplinary Team Performance in an Analytical Procedures Task

The foregoing discussion has focused on individual performance after training. In this section, literature from management and organisational psychology is reviewed in order to understand the performance of teams and MDTs.[16] The benefits from using the two training techniques in improving team performance in an analytical procedures task setting are examined. This section also includes research hypotheses relating to team performance.

2.3.1. Team Effectiveness in Multidisciplinary Teams (MDTs)

An understanding of the factors that affect team performance is required to improve the performance of diverse-background MDTs. Team-related research in the organisational psychology literature suggests that the aggregation of both team input and processes (and other mediational factors) is important for team performance (Faraj and Sproull 2000; Kozlowski and Ilgen 2006; Mathieu et al. 2008). Inputs refer to the composition of the team in terms of individual characteristics and resources at multiple levels (individual, team, and organisation) (Kozlowski and Ilgen 2006; Mathieu et al. 2008). The inputs affect mediators, which consist of team processes and other mediators. Team processes refer to activities that team members engage in while combining their resources to resolve task demands (Marks et al. 2001). Previous studies have identified several activities involved in team processes including planning, information sharing, critical evaluation, monitoring, cooperation, coordination, morale-building communication and commitment (Weingart and Weldon 1991; Jehn and Shah 1997; Marks et al. 2001). The other mediators are factors that are not classified as team processes. These may include the cognitive, motivational and affective states of teams (Marks et al. 2001).

2.3.1.1. Effect of Team Diversity – Intergroup Bias

In the context of MDTs, the inputs include the diversity of expertise, knowledge and background of a team. The literature on team diversity suggests that although diversity in teams provides benefits such as a broader range of task-relevant knowledge, skills and abilities needed in performing the task, there are also some serious problems faced by

---

[16] In prior studies, researchers have distinguished between groups and teams, with the different terms reflecting different research traditions. However, because the distinction between groups and teams is a rather artificial one that does not reflect their fundamental differences (Kerr and Tindale 2004; Forsyth 2010), in this thesis the terms teams and groups are used interchangeably.

diverse teams that may impede team process (Mannix and Neale 2005). These problems relate to intragroup relational aspects between team members who have different functional and/or educational backgrounds. The social categorisation perspective (Tajfel and Turner 1986) suggests that individuals tend to categorise themselves and others into groups based on their similarities (i.e., the in-group) and differences (i.e., the out-group). According to this categorisation, team members who are perceived as out-group members are less likely to be liked, trusted or preferred as team members compared with in-group members. This problem is called the *intergroup bias* and refers to more favourable perceptions of and attitudes and behaviour towards the in-group than the out-group (Brewer 1979; van Knippenberg et al. 2004). As found in some team diversity studies, the more heterogeneous the team (i.e., the more diverse the teams), the worse the team process and the lower the team performance (Murnighan and Conlon 1991; Jehn et al. 1999; Simons et al. 1999). This occurs because individuals who are dissimilar to others in more heterogeneous teams are less likely to communicate due to intergroup bias, resulting in lower levels of member commitment and group cohesion, and higher levels of relational conflicts (Wagner et al. 1984; O'Reilly et al. 1989; Tsui et al. 1992; Riordan and Shore 1997; Pelled et al. 1999).

In the studies cited above, intergroup bias has been investigated in the group setting (i.e., more than two people). However, it is argued that this phenomenon can also occur in dyads in the context of the MDTs that are examined in this thesis. As argued by Brown and Turner (1981), group size is by no means a necessary or even important criterion for the establishment of an intergroup situation. Consistent with this argument, intergroup attitudes have been examined in a dyadic setting (González and Brown 2003).

2.3.1.2. Effect of Team Diversity – Elaboration

Previous studies suggest that if intergroup bias is not properly prevented or managed, it may disrupt elaboration of task-relevant information in the teams (van Knippenberg et al. 2004). Elaboration is argued to be the core team process underlying the positive effects of diversity on performance and is defined as ‘the exchange, discussion, and integration of ideas, knowledge, and insights relevant to the team’s task’ (van Knippenberg et al. 2004, 1011).

In order to realize the benefits of diversity in MDTs, it is suggested that interventions should be undertaken to foster elaboration and to prevent intergroup biases disrupting elaboration of task-relevant information (van Knippenberg et al. 2004). Among several specific interventions for fostering elaboration, one is to improve task ability to elaborate diverse information by providing a more extended start-up phase to allow this ability to be developed over time as team members become familiar with each other's perspectives (van Knippenberg et al. 2004).

Another suggestion for fostering elaboration and preventing intergroup bias is to find ways to 'bridge' diverse team members through connections such as social ties, common values, team identity, superordinate goals or culture within the team (Mannix and Neale 2005). Studies have suggested that there are at least two ways to bridge diverse team members: (1) the development of social ties or familiarity between team members (Gruenfeld et al. 1996), and (2) the development of a collective team identification (Van der Vegt and Bunderson 2005). While both of these techniques have been useful in obtaining the full benefits of a diverse team, only the first technique is feasible for examination in the context of this thesis.[17]

Creating social ties by improving familiarity between members has been shown by prior studies to have beneficial effects in group functioning (Gruenfeld et al. 1996). Social ties or connections enable a team to create an environment that is tolerant of divergent perspectives (Mannix and Neale 2005). This environment possesses 'constructive confrontation norms' (Kellermanns et al. 2008) and is characterised by group norms of open expression, disagreement and the avoidance of negative affect. The existence of such an environment encourages team members to share their perspectives or viewpoints by reducing the social and psychological barriers (or costs) due to diversity (Gruenfeld et al. 1996; van Knippenberg et al. 2004). In the teams whose members are familiar with each other, those with divergent perspectives can be heard as legitimate group members (Mannix and Neale 2005). If a team cannot create such an environment, individuals with unique

---

[17] The second technique of bridging is to create a motivational force that can enable interaction in the face of diversity using *collective team identification* (Van der Vegt and Bunderson 2005). This construct is defined as 'the emotional significance that members of a given group attach to their membership in that group' (Van der Vegt and Bunderson 2005, 533). The point is to emphasise what is similar between team members rather than simply what is different (Mannix and Neale 2005). For example, studies have demonstrated the importance of a superordinate identity to resolve seemingly intractable differences between subgroups (Harrison et al. 2002). Similarly, Van der Vegt and Bunderson (2005) found that for teams working in the oil and gas industry, which had a low collective identification, expertise diversity was negatively related to team learning and performance. In contrast, for teams with high collective identification, expertise diversity was positively related to team learning and performance. However, creating a collective team identification by allowing teams to develop shared history together takes substantial time (Van der Vegt and Bunderson 2005); therefore, it is not feasible to examine this in the experimental setting used in the current study.

perspectives may be unwilling to pay the social and psychological costs necessary to share their viewpoints (Asch 1952; Festinger 1957; Edmondson 1999). As demonstrated by Gruenfeld et al. (1996), the security of diverse teammates who had social connections with each other led to their greater willingness to take the risks necessary to share their unique information. In contrast, teams composed of strangers were unwilling to risk the discomfort, potential conflict and ostracism that might result from behaviour that deviated from the group norms. Connectedness, through social ties or familiarity, between members is thus a key factor allowing diverse teams to experience trust and social cohesion, and to communicate effectively.

The divergent perspectives that are generated and shared by members promote the constructive process of information elaboration (van Knippenberg et al. 2004). Social psychology studies have shown that the presence of alternative perspectives tends to generate divergent thinking in which the issue is considered from multiple perspectives and results in debate and constructive conflict (Nemeth 1992). Gruenfeld et al. (1996) suggest that when an alternative perspective has been generated, members respond with increased cognitive flexibility. Ironically, this seems to occur because of the desire of the team to converge on a single outcome or decision (Forsyth 2010). As members attempt to explain away or somehow incorporate alternative perspectives, they must typically reconceptualise their own perspective on the task; as a result, they may recognise aspects of problems that had been hidden until then (Nemeth 1986). They are then more likely to detect novel solutions or come to new decisions (Nemeth and Wachtler 1983; Nemeth and Kwan 1985, 1987). The need to reconcile conflicting viewpoints may force the team to more thoroughly process task-relevant information elaboration and may prevent the team from opting too easily or prematurely for a course of action on which there seems to be consensus (van Knippenberg et al. 2004).

On the other hand, if a team cannot create an environment that is tolerant of divergent perspectives, the constructive process of information elaboration may be less likely to take place because the individuals that engage in interactions with out-group members (i.e., those with different background and expertise) may actually strive to avoid conflict in an effort to avoid upsetting interpersonal dynamics, appearing prejudiced or confirming negative stereotypes about their in-group (Tajfel and Turner 1986). Instead of engaging in conflict or expressing divergent opinions, members of heterogeneous groups (i.e., those who are unfamiliar with out-group members) may attempt to behave like other group members, regardless of the nature of their private beliefs (Gruenfeld et al. 1996). Unfamiliar group members may therefore be reluctant to discuss information that is inconsistent with, or irrelevant with regards to, what others have mentioned or seem to believe. They may tend to repress disagreement or to conform to some behavioural pattern (Janis 1982; Nemeth and Staw 1989). Gruenfeld et al. (1996) demonstrate that groups of strangers (i.e., with no social ties) are more likely to adopt the majority preference or to aggregate their individual choices than to conduct sufficient information elaboration by pooling their unique information to discover the correct choice. In contrast, familiar group members were more comfortable disagreeing with one another than groups whose members were unacquainted.

The importance of an environment that is tolerant of divergent perspectives has been investigated in groups where more than two individuals work together. This thesis argues that this condition is also important in the dyadic teams that are examined in the thesis. For example, a number of phenomena that can occur in groups cannot occur in dyads due to the fact that dyads are too small. These phenomena include coalition formation and majority/minority influence (Moreland 2010). Other group phenomena occur in dyadic as well as in group settings (Williams 2010). In a dyadic setting, team members, who are unfamiliar with out-group members and may tend to repress disagreement, might not adopt the majority preference to reconcile conflicting viewpoints as in a group setting (Gruenfeld et al. 1996). Instead of adopting the majority preference, team members in dyads may tend to aggregate their individual choices or may attempt to conform to some behavioural pattern like other group members. Regardless of the setting (i.e., dyadic or group), both tendencies lead to insufficient information elaboration.

2.3.1.3. Summary of Team Effectiveness in Multidisciplinary Teams

As shown by prior studies in group decision making, disagreement in the form of diverse judgments among group members is typically associated with superior decision-making quality (e.g., Sniezek and Henry 1989). Disagreement is beneficial to the extent that it may help focus on evidence inconsistent with tentative or preliminary conclusions (Favere-Marchesi 2006). Elaboration (van Knippenberg et al. 2004) is an important means of allowing different viewpoints to be heard. It is therefore important to create an environment that is tolerant of divergent perspectives and disagreement in order to improve MDTs.

2.3.2. Training Interventions to Improve Multidisciplinary Team Performance

Prior research in organisational psychology suggests that team training is a key means to enhance team effectiveness. The success of team-training intervention depends on identifying and improving the competencies that are needed (Salas and Cannon-Bowers 2001; Kozlowski and Ilgen 2006). Team-related literature categorises competencies required for the effective teams in terms of knowledge, skills and attitudes that are either specific or generic to the task (i.e., task work) and specific or generic to the team (i.e., teamwork) (Stevens and Campion 1994; Cannon-Bowers and Salas 1997; Stevens and Campion 1999). The competencies are specific when they are contextually grounded in the team or its task and generic when these competencies are more generally transportable across teams or tasks (Cannon-Bowers et al. 1995; Cannon-Bowers and Salas 1997). Enhancing taskwork and teamwork competencies requires different training activities (Morgan et al. 1986). Taskwork training includes training to improve the interactions of the team members with equipment, the technical aspects of the job, and other task-related activities. The activities in this training include understanding the task requirements, discovering the 'rules' by which the tasks are to be performed, establishing patterns of interaction with equipment, exchanging patterns of interaction with equipment, exchanging task-related information, and developing team solutions to problems (Morgan et al. 1986).[18] On the other hand, teamwork training activities are focused on the behaviours and attitudes necessary for effective team functioning through enhancing the quality of the interactions, relationships, affects, cooperation, and coordination of teams. This training is expected to improve the ability of team members to communicate, coordinate and interact, and leads to better team performance (Morgan et al. 1986; Ellis et al. 2005).

The distinction between specific and generic taskwork and teamwork competencies has implications on the design of team training in terms of whether team members can be trained as individuals or whether they need to be trained together as an intact team (Kozlowski and Ilgen 2006). The literature generally advises that while training for generic taskwork and teamwork, competencies should be directed at the individual level to develop proficiency (Dyer 1984; Cannon-Bowers and Salas 1997), while for specific taskwork and teamwork competencies, training design should focus on training intact teams in real or synthetic representations of their performance environment (Cannon-Bowers and Salas

---

[18] The generic and specific taskwork competencies are essentially the same concept as general domain and task-specific knowledge as suggested by Bonner and Lewis (1990).

1997). In addition, training design should also consider the form of task or workflow interdependence inherent in the team task. As suggested by the literature, team members should be trained together as an intact team when member contributions to performance include more complex patterns of workflow or are highly interdependent (Kozlowski et al. 2000). Training intact teams is seen to provide opportunities for members to integrate their teamwork skills and to jointly carry out complex coordinated actions (Kozlowski et al. 2000; Kozlowski and Ilgen 2006).

Performing an analytical procedures task requires specific and generic taskwork and teamwork competencies (Bonner and Pennington 1991). In the context of MDTs performing this task in a GHG assurance setting, team members have relevant generic task work competencies related to their backgrounds or expertise that are transportable to or be applied to. For example, team members who have competency to perform an analytical procedures task in financial auditing can transfer this skill to the GHG assurance setting; conversely, team members who have knowledge of GHG emission quantifications can apply the knowledge in the new setting. However, because these competencies should be possessed by all MDT members, training intervention for these competencies is not needed. As a result, this thesis focuses on how training can improve specific taskwork and teamwork competencies.[19]

Studies in team training have suggested various team-training approaches to improve specific taskwork and teamwork competencies. A review of the team training literature reveals little insight on team-training interventions that are suitable for teams performing tasks such as those involved in undertaking GHG assurance tasks. A common theme that cuts across many team-training techniques is that these training techniques rely on the learning-by-doing method to improve specific taskwork and teamwork (Dyer 1984; Kozlowski and Ilgen 2006). By practising in a way that approximates, simulates or replicates their task and performance context, team members are expected to acquire taskwork knowledge, share and integrate the knowledge, and coordinate effectively, based on this knowledge (Kozlowski and Ilgen 2006). For example, after performing the task, through guided team self-correction training

---

[19] Generic (i.e., transportable) teamwork competencies include conflict resolution, collaborative problem solving, communication, goal setting and performance management, planning and task coordination (Stevens and Campion 1994). Improving these competencies requires a particular training program that is beyond the scope of this thesis. Experimental evidence shows that these competencies can be enhanced through training targeted on the individual level (e.g., Chen et al. 2004; Ellis et al. 2005; Rapp and Mathieu 2007).

(Smith-Jentsch et al. 1998; Smith-Jentsch et al. 2008), team members are asked to reflect on prior performance, to diagnose the team's problems, to discuss errors and provide constructive feedback, and to plan for future learning and improvement. These activities are assumed to foster correct expectations among team members. Using simulations with scripted scenarios that allow team members to carry out a set of synthetic experiences important to their effectiveness is an important feature of Crew Resource Management (CRM) training. In this technique, which is also known as team coordination and adaptation training (e.g., Entin and Serfaty 1999), team members are trained to alter their coordination strategy and to reduce the amount of communication necessary for successful task performance. Rotating the positions in a team during training is a component of cross-training (e.g., Cannon-Bowers et al. 1998). Through this rotation, team members are expected to develop an understanding of the knowledge and skills (i.e., taskwork and teamwork competencies) necessary to successfully perform the tasks of other team members thereby improving coordination between them (Volpe et al. 1996; Blickensderfer et al. 1998; Cannon-Bowers et al. 1998; Marks et al. 2002). A meta-analytical study provides evidence that the use of these three team-training interventions leads to an increase in team performance (Salas et al. 2007).

However, it is important to note that these team-training approaches have been developed for, and largely applied in, the military sector and in commercial aviation (Kozlowski and Ilgen 2006). That is, they have been developed to improve specific taskwork and teamwork competencies for teams performing *action or psychomotor tasks* (McGrath 1984) that involve performing time-sensitive tasks, which require members to coordinate actions and perform physical tasks that generally possess high levels of behavioural interdependence (DeChurch and Mesmer-Magnus 2010).[20] In these tasks, team members must respond effectively by

---

[20] Group or team tasks, according to McGrath (1984), can be divided into several categories. One dimension of these categories is the degree to which the tasks involve activity that is primarily *mental or conceptual*, as opposed to being primarily *physical or behavioural*. Along with another dimension which concerns the degree to which the tasks involve conflict as opposed to cooperation among group members, group tasks can be further divided into four more categories: (1) generating tasks; (2) choosing tasks; (3) negotiating tasks; and (4) executing tasks (McGrath 1984; Forsyth 2010). These four categories can be further divided into eight distinct categories: (1) planning tasks; (2) creativity tasks (generating tasks); (3) intellective tasks; (4) decision-making tasks (choosing tasks); (5) cognitive conflict tasks; (6) mixed motive tasks (negotiating tasks); (7) contests/battles/competitive tasks; and (8) performance/psychomotor tasks (executing tasks). These eight categories are intended to be mutually exclusive and exhaustive. While most studies in team research have been conducted on teams performing action or performance/psychomotor tasks (Type 8), this thesis examines MDTs performing an analytical procedures task, a task that can be categorised as a *conceptual task* according to McGrath's (1984) typology. Because an analytical procedures task is composed of a multi-stage

integrating their physical joint actions in time-sensitive and emergency situations. The instructional objective of team training emphasises improving implicit coordination between team members because they must anticipate and initiate the exchange of information and required resources when there is not enough time for explicit communication (Kozlowski and Ilgen 2006).

In contrast to teams performing action or psychomotor tasks, this thesis focuses on MDTs performing tasks that can be categorised as *mental or conceptual tasks.* Teams performing these types of tasks carry out knowledge work by processing information and making decisions and possess a high level of informational interdependence (DeChurch and Mesmer-Magnus 2010). In these teams, knowledge, expertise, opinions and the perspectives possessed by team members need to be integrated to make a decision or solve a problem. It is therefore unclear whether the team-training interventions described above have the same potential for improving team effectiveness in less critical, though no less important, team contexts such as that examined in this thesis.

This thesis extends prior research by examining team-training interventions that can be applied for MDTs performing a conceptual task. The instructional objective of team training for these teams is to improve the elaboration of task-relevant information. In particular, this thesis proposes that the two training techniques, analogical encoding and collaborative learning, that have been examined as individual training interventions in educational psychology as outlined in Section 2.3.1, can be used as team-training interventions to improve MDT performance in an analytical procedures task. The improvement is expected in two stages of the analytical procedures process (i.e., hypothesis generation and evaluation). Because these stages have different cognitive processes (Moreno et al. 2007), the thesis looks at them in two stages. The following sections provide the rationale behind the use of these techniques followed by the proposed research hypotheses.

---

process (Koonce 1993), each stage is categorised differently according to the nature of the stage. While hypothesis generation can be categorised as a *creativity task* (Type 2), hypothesis evaluation can be classified as a *decision-making task* (Type 4).

2.3.2.1. Analogical Encoding as a Team-Training Intervention to Improve MDT Performance in Hypothesis Generation and Development of Hypothesis 4

As outlined above, improving specific taskwork and teamwork competencies through training as an intact team is important in team training. This thesis focuses on MDTs performing a conceptual task by processing information and making decisions. Such teams possess a high level of informational interdependence. This thesis explores potential training techniques that may enable MDT members to elaborate task-relevant information effectively. In order to promote elaboration of task-relevant information and perspectives, it is important that MDT members have excellent task ability (Libby and Luft 1993; Libby 1995; van Knippenberg et al. 2004). Task ability may be enhanced via training interventions such as analogical encoding. However, as discussed in Section 2.2, the analogical encoding technique has been shown in prior studies to improve individual learning performance, particularly for simple tasks. This training technique has also been seen as training that is targeted on individual learners rather than training for an intact team. It remains an empirical question as to whether this technique has the potential to enhance specific taskwork and teamwork competencies that allow MDT members to conduct effective elaboration.

Prior research examining the use of analogical encoding shows that analogical encoding has benefits in improving the ability of the individual to solve problems (Gentner et al. 2003). However, as outlined in Section 2.2.2, the positive effects of analogical encoding are found when individuals study simple learning tasks. In fact, several studies found no positive effects when individuals studied complex learning tasks (Cummins 1992; VanderStoep and Seifert 1994). As discussed in Section 2.2.2, the use of this technique on its own may not lead to better individual performance in a complex learning task because of the cognitive load it imposes. Specifically, the use of analogical encoding (i.e., problem-category comparison), which involves the use of an explicit comparison prompt to construct internal connections among many elements from the worked examples, may impose too great a processing demand and may leave limited available working memory capacity to be allocated for the necessary learning process (Sweller et al. 1998; Clark et al. 2006; Renkl 2011). As suggested by educational psychologists (DeLeeuw and Mayer 2008), increasing levels of cognitive overload can be indicated by the higher levels of perceived difficulty when using this training technique.

At the team level, previous studies suggest that increasing levels of difficulty (i.e., perceptions of the mental effort necessary for task execution) lead to decreased team performance (Funke and Galster 2009). This happens because tasks characterised as mentally difficult use resources, leaving individuals (and teams) with a reduction in available resources (e.g., information-processing capacity) for additional team task demands (Funke and Galster 2009; Funke et al. 2012; Bedwell et al. 2014). Consequently, use of the analogical encoding technique (i.e., problem-category comparison), which is more likely to be perceived as difficult, may not be effective as a team-training intervention for improving MDT performance in a complex task. In this thesis, this prediction is tested at each stage of the analytical procedures process, i.e., hypothesis generation, hypothesis evaluation and final judgment.

In relation to hypothesis generation, the levels of difficulty are even higher due to the fact that this task is a cognitively demanding activity. In the hypothesis generation stage, which is characterised as a construction process, the individuals must construct explanations for the observed unexpected fluctuations by generating potential causes as hypotheses (Bonner and Pennington 1991). However, a substantial number of studies provide insights that in order to construct the explanations individuals (particularly novices) demonstrate deficiencies in retrieving hypotheses from memory and often produce sets of hypotheses which are insufficient, both in terms of quantity and quality, to allow an optimal or nearly optimal choice to be made (Gettys and Fisher 1979; Gettys et al. 1980; Manning et al. 1980; Mehle et al. 1981; Mehle 1982; Fisher et al. 1983; Biggs et al. 1988; Bonner and Lewis 1990; Joseph and Patel 1990; Libby and Frederick 1990; Bedard and Biggs 1991; Knapp and Knapp 2001). Therefore, it is predicted that the use of a mentally difficult learning task to apply to an intrinsically difficult task may not lead to an effective team performance. This prediction is formally proposed, stated in null form, as follows:

Hypothesis 4: *MDTs whose members train using the analogical encoding technique will not perform hypothesis generation better than those MDTs whose members train without the analogical encoding technique.*

2.3.2.2. Collaborative Learning as a Team-Training Intervention to Improve MDT Performance

As noted above, team-training research generally suggests that team members should be trained together as an intact team to improve specific taskwork and teamwork competencies rather than being trained individually because team members acquire the knowledge necessary for effective team functioning when they are trained together (Liang et al. 1995; Moreland et al. 1996, 1998; Moreland 1999; Moreland and Myaskovsky 2000; Kozlowski and Ilgen 2006). Training as a group is conceptually similar to collaborative learning. Both methods require team members to work together interactively in understanding the task. However, there are some features that distinguish the collaborative learning technique used in this thesis from those in prior studies of team training, as explained below.

First, prior studies in educational psychology (Kirschner et al. 2009a; Kirschner, Paas, Kirschner, et al. 2011) investigate the collaborative learning technique in order to understand how to improve individual learning performance; however, in this thesis this technique is also used to understand how to improve MDT performance. Second, prior team training studies (e.g., Smith-Jentsch et al. 1998; Entin and Serfaty 1999) and organizational psychology (e.g., Liang et al. 1995; Moreland et al. 1996, 1998; Moreland 1999; Moreland and Myaskovsky 2000) have examined group training accompanied with a learning-by-doing method. As a result of the method used, the researchers attribute the benefit of group training to the development of transactive memory systems (i.e., a form of cognitive structure that encompasses both the knowledge uniquely held by particular group members with a collective awareness of who knows what (Kozlowski and Ilgen 2006)). This finding was possible because, by using the learning-by-doing method, group members have the opportunity to obtain direct knowledge and feedback on their performance when conducting real tasks (Lewis and Herndon 2011). In contrast, the group training used in this thesis is used in order to facilitate learning from worked examples.

The beneficial effects on learning that the use of worked examples brings are important to support the current practice of training in several domains. This method, which is usually delivered via case-based instruction, is widely used in business, law and medicine (Kolodner 1997). In these domains, the principles are taught through discussion of rich examples that embody key points (Bonner 2008). By demonstrating how to solve the problems in the cases, instructors are able to facilitate the learners in using specific examples as models or analogies for future situations (Reeves and Weisberg 1994). In addition, examples in these domains are generally presented as specific and concrete cases drawn from real cases and they are therefore more engaging and more easily understood than abstract, domain-general principles (Kolodner 1997). In the accounting domain, the use of the worked example method is seen to have advantages in making the training more effective and efficient (Bonner 2008). The use of this type of instruction may speed up knowledge acquisition when compared with practice (such as learning by experience) and it also lowers the training cost substantially. Because of these benefits, Bonner (2008) argued that reading worked examples appears to be a substitute for practice.

Because of the difference in the methods used in operationalising collaborative learning, this thesis focuses on the other benefit of group training: learning worked examples together in a group to create an environment where it is possible to develop social integration or social ties among team members. As discussed previously in Section 2.3.1, connecting the MDT through social ties may be a key factor in allowing diverse teams to experience trust and social cohesion, to communicate effectively, and to achieve high performance levels (Mannix and Neale 2005; Larson 2010). The existence of social ties is one way to provide a bridge to diverse team members in MDTs (Mannix and Neale 2005). The advantage of bridging is that it creates a powerful and multifaceted link between MDT members that leads to other benefits. As noted above, MDTs are able to capitalise on team diversity when they are able to invite alternative perspectives. One way that this may occur is through team familiarity. As members become socially connected or familiar with one another through group training, their interpersonal relationships are improved and they experience less uncertainty, and therefore less anxiety, than members of newly formed groups (Shah and Jehn 1993; Gruenfeld et al. 1996). This reduced anxiety alleviates cognitive constraint, thereby increasing the fluency and flexibility of group members' thoughts (Nemeth 1986). Group members who are familiar with each other and who have already achieved social acceptance, are prone towards conformity and less prone to social categorisation. These members are more comfortable disagreeing with one another than groups not trained together and as a result they will be less likely to suppress alternative perspectives and judgments (Shah and Jehn 1993; Gruenfeld et al. 1996).

Member familiarity developed during group training also affects how members resolve cognitive conflicts between themselves (Gruenfeld et al. 1996). As members become familiar with one another, they become more cohesive, which enables them to deal with conflict effectively (Gruenfeld et al. 1996). In contrast, groups of strangers do not have social ties between them, and therefore they will be less proficient at resolving conflicts (Shah and Jehn 1993). The ability to cope with conflict is manifested in the group norms (or behaviour patterns) including open expression, disagreement, constructive confrontation and the avoidance of negative affect (Kellermanns et al. 2008). When such strong norms of constructive confrontation are in place, teams are in a better position to realise the benefits of more diverse input without experiencing the negative consequences caused by some forms of conflict (Kellermanns et al. 2008). Training techniques, such as collaborative learning, that foster constructive confrontation norms, assist MDT performance because conflict is necessary for diligent and thorough information processing (Nemeth 1986; van Knippenberg et al. 2004).

On the other hand, as explained above, performance does not benefit from the presence of diverse perspectives (or conflicts) per se, but from the process it is assumed to promote i.e., the deep-level and creative processing of diverse information and viewpoints, which is called elaboration of task-relevant information (van Knippenberg et al. 2004). In conducting such elaboration, team members are required to engage in deeper information processing. This is likely to be related to task performance when team members are high in task ability (van Knippenberg et al. 2004); this is important in order to promote elaboration of task-relevant information and perspectives. As outlined in Section 2.2.3, given that the collaborative learning technique brings added benefits in terms of reduced cognitive load as well as substantial deep processing from a joint dialogue, and given that the inhibiting factor of collaboration is relatively low, this technique is predicted to lead to superior learning outcomes (i.e., improving individual task ability). It is therefore proposed that this technique can be used as a team-training intervention not only to improve individual task ability but also to improve social ties, which in turn improve the ability of MDT members to perform elaboration of task-relevant information. In the next paragraphs, the arguments on the benefits of this training intervention are outlined in an analytical procedures task setting.

2.3.2.2.1. Collaborative Learning as a Team-Training Intervention to Improve MDT Performance in Hypothesis Generation and Development of Hypothesis 5

A review of analytical procedures studies reveals that if hypothesis generation is performed by groups or teams, the processes may involve either or both of two stages: group memory retrieval processes and group consistency-checking processes (Casey et al. 1984). The consistency-checking process (Fisher et al. 1983) is included in the plausibility assessment stage of hypothesis generation.[21] The elaboration of task-relevant information is necessary to conduct this process. If group members engage in deeper information processing through elaboration, they contribute to the MDT by exchanging the information and perspectives required to assess the consistency of retrieved hypotheses (van Knippenberg et al. 2004). In exchanging information, team members may provide cognitive interstimulation in remembering the information contained in their mental representations. Cognitive interstimulation contributes to synergistic memory retrieval on the receipt of cues or prompts from other group members (Hill 1982; Larson 2010). Team members then process the information and perspectives at the individual level and feed the results of this individual-level processing back into the group. During this process, team members can correct each other's errors if necessary (Bedard et al. 1998). Discussion and integration of the implications of the hypotheses are performed by the teams in order to retain consistent hypotheses and discard inconsistent hypotheses from their combined list (Fisher et al. 1983; Fisher 1987).

In contrast, if the team fails to conduct elaboration, team performance may suffer. In such teams, the exchange of diverse information, ideas, and viewpoints is less likely to be realised. Because members of such teams tend to avoid rather than confront any conflict of opinions, conflict and dissent are likely to disrupt rather than stimulate in-depth processing (Gruenfeld et al. 1996). Team members who do not use elaboration have been found to opt for a quick compromise to avoid conflict and are less likely to correct each other's errors because they are reluctant to criticise or embarrass other members of the team (Gruenfeld et al. 1996; Jehn and Shah 1997). As a result, members of these teams tend to select hypotheses based on aggregation (i.e., combining the individual's hypotheses) without sufficient consistency checking.

In addition, by using collaborative learning, social ties between members enhance process gains in elaboration. Group-related studies have suggested that group process gains are a beneficial effect of working in groups. They occur when the dynamics of group interaction increase the total performance of that group and move the group towards better choices or decisions (Hill 1982; Forsyth 2010; Larson 2010). In the context of hypothesis generation for

---

[21] The team experiment in this thesis, as explained in Chapter 3, Section 3.4.3.2, does not focus on the group memory retrieval process during hypothesis generation but rather on the group consistency-checking process. To allow this focus, individuals generated hypotheses individually prior to group discussion of the hypotheses.

such groups, there are process gains such as cognitive interstimulation during information exchange as well as error correction when discussing and integrating the processed information on the consistency of hypotheses (Bedard et al. 1998; van Knippenberg et al. 2004; Mannix and Neale 2005). The existence of a bridge to diverse MDT members from the more extended start-up phase during training also enables teams to reduce process losses such as the tendency to conform and suppress alternative perspectives in teams (Gruenfeld et al. 1996). Group process losses refer to the inhibiting effects that occur when the group fails to realise its potential productivity (Kerr and Tindale 2004; Tindale and Starkel 2010). These process losses occur when the dynamics of working together decrease the total performance of a group and move the group away from better choices or decisions (Steiner 1972).

Another beneficial effect of collaborative learning is that this technique enables a reduction in cognitive load (as discussed in Section 2.2.3) and allows individuals (and MDTs) to utilize the available resources (e.g., information-processing capacity) for additional team task demands (Funke and Galster 2009; Funke et al. 2012; Bedwell et al. 2014). The additional team task demands include the elaboration of task-relevant information as described above. Although a hypothesis generation task is a cognitively demanding activity, the reduced cognitive load through collaborative learning allows team members to conduct important task demands such as elaboration.

In summary, the use of collaborative learning brings beneficial effects through bridging diversity, reducing the levels of difficulties and enhancing elaboration. This helps MDTs perform better. The following research hypothesis is offered, stated in alternative form:

Hypothesis 5: *MDTs whose members train using the collaborative learning technique will have a higher performance in hypothesis generation than MDTs s whose members train without the collaborative learning technique.*

2.3.2.3. The Interaction between Analogical Encoding and Collaborative Learning as a Team-Training Intervention in Improving MDT Performance in Hypothesis Generation

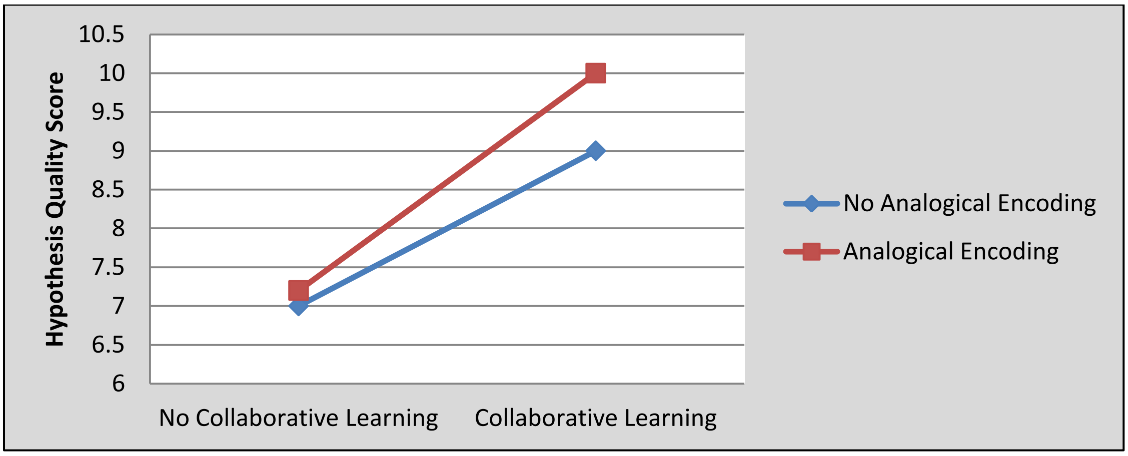
When a MDT performs a complex task, the use of two training techniques concurrently may lead to benefits from the best aspects of both techniques resulting in team processes that lead to improved MDT performance of the task. Although the use of collaborative learning as a single training intervention may lead to superior learning outcomes as proposed by Hypothesis 5, the addition of analogical encoding may help in developing constructive elaboration. When learning the worked examples collaboratively, the interaction in dialogues between team members can contribute to learning through the discussion of issues that neither of the group members may have been able to come up with on his or her own (Chi 2009). In the context of MDTs, each member can contribute significantly to learning by providing relevant information and perspectives from their respective domains. When the use of collaborative learning is combined with analogical encoding, according to the educational psychology perspective, individuals conduct a constructive activity in which the individuals produce some additional output that contains information beyond that provided in the original material (Chi 2009). It is therefore anticipated that they will be able to produce more knowledge. These additional benefits may lead to improved task ability for the individuals, which will better equip them in elaborating the task-relevant information (van Knippenberg et al. 2004). In addition, discussion from different perspectives in order to compare and contrast and develop common relational and distinguished features between the worked examples in the analogical encoding technique may enable team members to practice elaboration (Chi 2009; Fonseca and Chi 2011). This also provides the opportunity for team members to create an environment that is conducive to elaboration where the exchange of diverse information, ideas and viewpoints is likely to be realised (van Knippenberg et al. 2004).

The positive effects of analogical encoding, as noted above, may only be realised when combined with collaborative learning. This is because it is predicted that when analogical encoding is used without collaborative learning, it may lead to lower MDT performance than when MDT members train without either technique. When MDT members learn using analogical encoding without collaboration with other members of the team, they may have a higher cognitive load when learning (Renkl 2011), which in turn affects their perception of the difficulty of the actual task. As suggested by previous team studies (Funke and Galster 2009; Funke et al. 2012; Bedwell et al. 2014), higher levels of difficulty (i.e., perceptions of the mental effort necessary for task execution) lead to decreased MDT performance. This happens because tasks characterised as mentally difficult use cognitive resources, leaving individuals (and MDTs) with a reduction in available resources (e.g., information processing capacity) for additional team task demands such as elaboration of task-relevant information.

As discussed previously in Section 2.3.2.2, collaborative learning creates an environment where it is possible to develop social integration or social ties among MDT members and allows diverse teams to experience trust and social cohesion, to communicate effectively, and to achieve high performance levels. In addition, by using collaborative learning, social ties between members enhance elaboration of task-relevant information. In the context of hypothesis generation for such groups, this learning environment allows in the enhancement of process gains and a reduction of process losses when generating hypotheses. Combining the positive effects of this technique with those of the analogical encoding technique is expected to lead to effective team processes and in turn higher performance levels.

Figure 2.5 illustrates the suggested ordinal interaction. When MDTs train without collaborative learning, there is no MDT performance improvement when using an analogical encoding technique. However, when collaborative learning is employed there is an improvement in MDT performance due to collaboration. More improvement can be obtained when analogical encoding is combined with collaborative learning.

Figure 2.5. Expected Results for the Effect of Training Techniques on Teams' Hypothesis Generation



Source: Developed by the author based on arguments in Sections 2.3.2.1, 2.3.2.2, and 2.3.2.3.

This pattern leads to the following ordinal interaction hypothesis:[22]

---

[22] The determination of the expected means in Figure 2.4 can be explained as follows. Prior studies in hypothesis generation suggest that individual novices had difficulty in generating complete sets of hypotheses and the mean number of hypotheses generated was only 3.4 hypotheses and seemed to be much less specific than those generated by experts (Mehle 1982). Using the hypothesis generation quality score (as explained later in Chapter 3), with three less-specific hypotheses, the score that can be assigned is 6. However, due to positive effects of group, the team's score is expected to be higher

Hypothesis 6: *MDT performance will be highest when team members train using a combination of analogical encoding and collaborative learning techniques; lower when team members train with only the collaborative learning technique; and lowest when team members train without the collaborative learning technique, regardless of whether they train with or without the analogical encoding technique.*

2.3.2.4. Use of Analogical Encoding and Collaborative Learning as Team Training Interventions to Improve MDT Performance in Hypothesis Evaluation and Final Judgment

The foregoing sections have outlined the expected impact of analogical encoding on the first stage of the analytical procedures process. The use of the two training techniques is also examined in the next stages of the analytical procedures process: hypothesis evaluation and final judgment. In hypothesis evaluation carried out by groups or teams, elaboration should be emphasised in such a way that alternative perspectives or judgments are exchanged, discussed and integrated (Koehler 1991). A review of the hypothesis evaluation literature in psychology and accounting suggests that individuals are frequently poor at evaluating hypotheses because they seem to be relatively insensitive to other ways in which the problem might have been framed or interpreted, particularly once they have inherited an hypothesis (i.e., received a suggestion from another party) (Koehler 1991; Koonce 1992). When inheriting a hypothesis, attention is brought to a single, specified hypothesis. As argued by Koehler (1991), if an individual also implicitly or explicitly provides an explanation for this hypothesis when they include this hypothesis in the hypothesis set, they establish a focal hypothesis that is temporarily accepted as true. The focal hypothesis, adopted as a conditional reference frame, affects how relevant evidence is interpreted. In interpreting the evidence, an individual mentally reorganises the relevant evidence in an attempt to improve the fit between the focal hypothesis and the evidence at hand (Koehler 1991). The plausibility of the hypothesis is assessed by the coherence and the ease of the fit that is established between the focal hypothesis and the relevant evidence. Evidence that is consistent with the focal hypothesis tends to be more comprehensible and viewed as more relevant, leading individuals to neglect possible flaws in the evidence. Inconsistent evidence, on the other hand, is more difficult to evaluate and is likely to be discounted or ignored (Koehler 1991;

---

than individual's score. Due to more hypotheses to be generated and/or more specification of these hypotheses it is expected that the score is 7. If the teams train with a training technique, it is expected that the hypothesis quality score will be higher than 7 (i.e., 9 for Condition 3 and 10 for Condition 4).

Koonce and Phillips 1996). To mitigate this tendency, it is necessary to create an environment that encourages alternative ways of thinking, enables different perspectives or interpretations to be exchanged, and allows for these ideas to be discussed and integrated (Nemeth 1986; van Knippenberg et al. 2004). Effective elaboration of task-relevant information is therefore seen as likely to make alternative hypotheses more prominent so that the individuals become less biased in favour of an inherited explanation (Koehler 1991; Brodbeck et al. 2007).

Furthermore, prior studies have suggested two strategies that can be used to mitigate this tendency: counterexplanation (Koonce 1992) and a sufficiency check (Anderson and Koonce 1998). The former involves consideration of why an inherited hypothesis may not be correct, whereas the latter involves consideration of the completeness of each hypothesis in terms of how much the hypothesis is able to explain the unexpected fluctuation. Conducting these two strategies is argued to bring the same benefits: it is likely to make an alternative hypothesis more prominent so that individuals are less biased in favour of the inherited explanation (Koehler 1991).

As suggested by prior studies (Asare and Wright 2003; Green and Trotman 2003), it is important to note that the components of an analytical procedures task are interdependent with other components through the iterative sequential process (Koonce 1993). Accordingly, better performance in this task depends not only on better performance in the hypothesis generation stage (i.e., by having a correct hypothesis set) but also on the effectiveness of the ensuing stages (i.e., an effective information search and correct hypothesis evaluation). Because poor performance in one cognitive process is not offset or compensated by better performance in another component, Bonner and Pennington (1991) suggest that specific training may be required for each cognitive process. Consequently, the method used in the analogical encoding technique in this thesis is designed specifically for the hypothesis evaluation stage. However, collaborative learning is also used in this stage because this technique brings beneficial effects for team processes in all stages of the analytical procedures task.

2.3.2.4.1. Impact of Analogical Encoding on Team Hypothesis Evaluation Performance

The use of the analogical encoding technique can improve team performance in the hypothesis evaluation stage by encouraging MDT members to be less biased in favour of an inherited explanation. Use of the analogical encoding technique can facilitate MDT members to counterexplain (Koonce 1992) and perform sufficiency checks (Anderson and Koonce 1998) when learning. The underlying basis of the analogical encoding technique is the use of worked examples to aid the understanding of the underlying principles of balanced hypothesis evaluation (Koehler 1991). This process assists MDT members to encode these principles in their memory so as to be available for retrieval when evaluating hypotheses in new situations (Gentner et al. 2003). The analogical encoding training method that is proposed to achieve this objective is a *problem comparison technique* (Gentner et al. 2003; Rittle-Johnson and Star 2011). In this technique, a comparison is made between two different problems that can be solved with the same method. The goal of analogical encoding in this type of comparison is to support learning of a general solution method (Rittle-Johnson and Star 2011). Unlike the problem-category comparison as used in the hypothesis generation stage, the comparison in the problem comparison method is simpler and the elements that are needed to be mapped in the two analogs are few. As such, the use of this method may be less likely to impose high cognitive load. Studies in the analogical learning literature have demonstrated that this method of comparison leads to positive effects when the learners use this method (Gick and Holyoak 1983; Catrambone and Holyoak 1989; Loewenstein et al. 1999; Thompson et al. 2000; Kurtz et al. 2001; Gentner et al. 2003; Loewenstein et al. 2003).

In the hypothesis evaluation setting, counterexplanation (Koonce 1992) and sufficiency checks (Anderson and Koonce 1998) can be conducted by comparing two problems with their respective possible causes: the correct cause and an explanation of the causes. These activities encourage team members to make alternative hypotheses more prominent (Koehler 1991) and to infer a general solution method (Rittle-Johnson and Star 2011) that contains a balanced evaluation of hypotheses. Subsequently, when they perform this stage in the test task, because of the inferred general solution that was encoded in long-term memory during the training phase, it is expected that MDT members will be less biased in favour of an inherited explanation because more hypotheses are available to them. They are therefore more likely to accurately evaluate the evidence relating to the correct hypothesis.

In addition, the use of the problem comparison technique which imposes lower cognitive load allows MDTs to utilize the available information-processing capacity for additional team task demands such as elaboration of task-relevant information (Funke and Galster 2009; Funke et al. 2012; Bedwell et al. 2014). In evaluating hypotheses, which involves a reduction process (choosing among possibilities), large amounts of information are processed through elaboration to form an evaluation (Bonner and Pennington 1991). Effective hypothesis evaluation can be attained by properly conducting the elaboration of task-relevant information that encourages alternative ways of thinking, enables different perspectives or interpretations to be exchanged, and allows for these ideas to be discussed and integrated. In turn, this process enables MDT members to accurately evaluate hypotheses.

The effect of analogical encoding on MDT performance in the hypothesis evaluation stage is different from the expected effect of this technique on MDT performance in the hypothesis generation stage as indicated by Hypothesis 4. The complete description why these expectations are different is summarised in Table 2.2.

Based on above expectations the following hypotheses are proposed, which are divided into two parts: evaluating the inherited hypothesis (Hypothesis 7a) and evaluating the correct hypothesis (Hypothesis 7b):

Hypothesis 7a: *Performance in evaluating the inherited hypothesis will be higher for MDTs where team members trained using the analogical encoding technique than those trained without the analogical encoding technique.*

Hypothesis 7b: *Performance in evaluating the correct hypothesis will be higher for MDTs where team members trained using the analogical encoding technique than those trained without the analogical encoding technique.*

Table 2.2. Comparison of the Logic for the Directional Effects of Analogical Encoding on MDT Performance

	Analytical Procedures Stage	
	Hypothesis Generation	**Hypothesis Evaluation**
Nature of this stage	A construction process (i.e., the individuals must construct explanations for the observed unexpected fluctuations)	A reduction process (i.e., individuals must choose among possibilities of explanations for the observed unexpected fluctuations)
Individuals' deficiencies in performing this stage	Individuals have difficulties in retrieving hypotheses from memory and produce sets of hypotheses which are insufficient, both in terms of quantity and quality.	Individuals are frequently poor at evaluating hypotheses because they seem to be relatively insensitive to other ways in which the problem might have been framed or interpreted, particularly once they have inherited an hypothesis.
Suggested improvements in individual level	Acquisition of knowledge content and development of appropriate knowledge structures in the individual's mental representations which enables the retrieval process will be more efficient and effective. It may occur because only a subset of hypotheses or a category that is consistent with relevant retrieval cues is retrieved.	An alternative hypothesis is made more prominent so that individuals are less biased in favour of the inherited explanation by using counterexplanation (i.e., consideration of why an inherited hypothesis may not be correct) and a sufficiency check (i.e., consideration of the completeness of each hypothesis in terms of to what extent the hypothesis is able to explain the unexpected fluctuation).
Suggested improvements in team level	Encourage team members to elaborate task-relevant information effectively in order to retrieve hypotheses and retain consistent hypotheses and discard inconsistent hypotheses from their combined list.	Encourage team members to elaborate task-relevant information effectively in order to to make alternative hypotheses more prominent and conduct a balanced evaluation of hypotheses.
Type of analogical encoding technique proposed for this stage	Problem-category comparison	Problem comparison
The effects of this type of analogical encoding technique on team functioning	This technique may enhance task ability in order to promote elaboration of task-relevant information. However, this technique also imposes higher cognitive load that may reduce information-processing capacity for additional team task demands such as elaboration.	This technique aids the understanding of the underlying principles of balanced hypothesis evaluation. Because this technique imposes lower cognitive load, it allows teams to utilize the available information-processing capacity for additional team task demands such as elaboration.
The directional effect of this type of analogical encoding on team performance	**Hypothesis 4**	**Hypothesis 7**
	No effect on team performance.	Positive effect on team performance.

2.3.2.4.2. Impact of Collaborative Learning on Team Hypothesis Evaluation Performance

The predicted benefits of collaborative learning as a technique that can be used for team training, as argued above, are also expected to be demonstrated in the hypothesis evaluation stage of analytical procedures tasks. Shared experience, when learning the worked examples, and through exchanging answers and points of view in order to understand the principles, are expected to facilitate the creation of social ties or an interpersonal relationship between MDT members that will bring beneficial effects when they work together to evaluate hypotheses (Gruenfeld et al. 1996). By using this technique, social integration or social ties between MDT members are created during the training phase, which creates a bridge between the diverse members (Mannix and Neale 2005). In addition, when learning collaboratively with other MDT members, MDT members gain the benefits of reduced cognitive load (Kirschner et al. 2009a) and deeper processing (Chi 2009) at the individual level (as outlined in Section 2.2). In turn, at the team level, these benefits enable MDT members to optimise the available resources (e.g., information-processing capacity) for additional team task demands (Bedwell et al. 2014) and to produce additional output that contains information beyond that provided in the original training material (Chi 2009; Fonseca and Chi 2011).

It is expected that training using this technique will lead to superior MDT performance. The reason for this expectation is that the social ties between MDT members that are developed during the training phase encourage the elaboration of task-relevant information and perspectives in the task performance phase. As noted previously, elaboration is important in order to realise the potential advantages of MDTs (van Knippenberg et al. 2004). The beneficial effect of reduced cognitive load also allows MDT members to optimise available team resources (e.g., information-processing capacity) for necessary team task demands such as elaboration (Funke and Galster 2009; Bedwell et al. 2014). Furthermore, the deep processing that is facilitated by using this technique also enables MDT members to develop a better understanding of the principles involved in the task (Chi 2009) and allows them to generate, discuss and integrate multiple perspectives when conducting elaboration. In hypothesis evaluation, the elaboration of these multiple perspectives is important to prevent biased hypothesis evaluation in favour of an inherited hypothesis (Koehler 1991; Brodbeck et al. 2007).

The following hypotheses are presented. They are divided into two parts: evaluating the inherited hypothesis (Hypothesis 8a) and evaluating the correct hypothesis (Hypothesis 8b):

Hypothesis 8a: *Performance in evaluating the inherited hypothesis will be higher for MDTs whose team members train using the collaborative learning technique than for MDTs whose members train without the collaborative learning technique.*

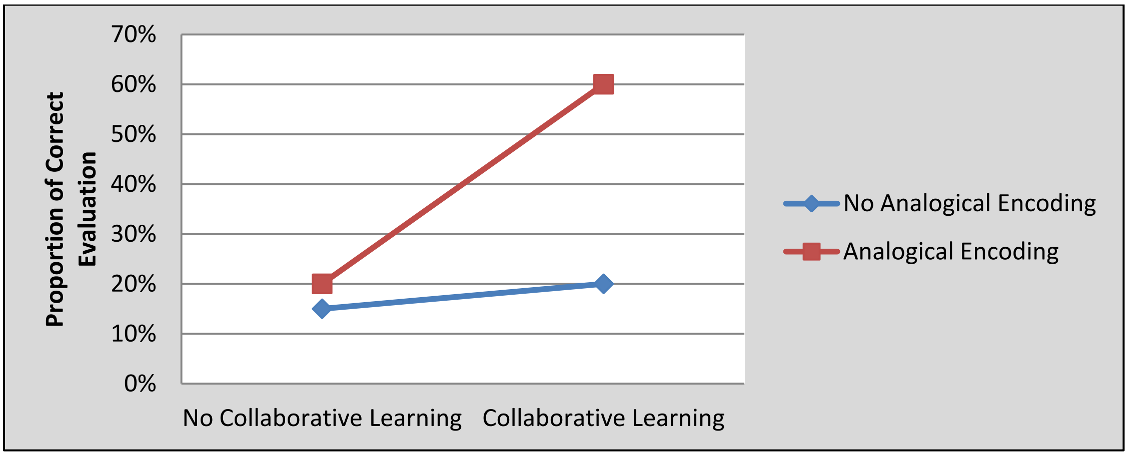
Hypothesis 8b: *Performance in evaluating the correct hypothesis will be higher for MDTs whose team members train using the collaborative learning technique than for MDTs whose members train without the collaborative learning technique.*

2.3.2.4.3. Impact of Analogical Encoding and Collaborative Learning on Team Hypothesis Evaluation Performance

When the collaborative learning technique is combined with the analogical encoding technique and used as a team-training intervention, it is expected that the team's ability to evaluate hypotheses will be more effective. This expectation is based on the fact that the use of collaborative learning provides the bridge or connection ties between diverse members and this bridge is expected to invite elaboration of task-relevant information and improve team processes when performing the task (van Knippenberg et al. 2004; Mannix and Neale 2005). Through this process, teams will be more critical of any individual hypothesis and the inherited hypothesis in particular. They will therefore increase their scrutiny of the evidence relating to the hypothesis. They will be less likely to accept it at face value. Teams are also less likely to overlook or discount alternative hypotheses and are more likely to properly evaluate the evidence to support it. As a result, the combined effects of these training techniques will make team members evaluate hypotheses objectively and be less biased toward the inherited hypothesis. By contrast, when team members learn collaboratively without the analogical encoding technique, although they obtain the benefits of improved elaboration, they are more likely to be biased toward the inherited hypothesis because, without analogical encoding, they lack the opportunity to infer a general solution method that contains a balanced evaluation of hypotheses. For the teams, whose members train without collaboration, the benefits of improved elaboration are not realised. Although the team members in these teams train using analogical encoding and can infer a general solution method that contains a balanced evaluation of hypotheses, the lack of social ties between members may disrupt the required elaboration. As noted above, MDT members may decide to avoid rather than confront any conflict of opinions, to opt for a quick compromise to avoid the conflict and are less likely to correct other member's errors because they are reluctant to criticise or embarrass other members of the team (Gruenfeld et al. 1996; Jehn and Shah 1997). As a result, when MDTs train without collaborative learning, the addition of the analogical encoding does not improve MDT performance.

Figure 2.6 illustrates the suggested ordinal interaction. It is predicted that when MDTs train without collaborative learning, MDT performance is no better than when they are trained using an analogical encoding technique due to increased cognitive load. However, when collaborative learning is employed, MDT performance is better due to collaboration reducing cognitive load as well as introducing additional perspectives. Better performance can be obtained when analogical encoding is combined with collaboration learning due to the deeper understanding developed.

Figure 2.6. Expected Results for the Effect of Training Techniques on Teams' Hypothesis Evaluation



Source: Developed by the author based on arguments in Sections 2.3.2.4.1, 2.3.2.4.2, and 2.3.2.4.3.

These arguments lead to the following ordinal interaction hypotheses which are divided into two parts: evaluating the inherited hypothesis (Hypothesis 9a) and evaluating the correct hypothesis (Hypothesis 9b):

Hypothesis 9a: *Performance in evaluating the inherited hypothesis will be higher for MDTs whose team members train using a combination of analogical encoding and collaborative learning techniques than for those MDTs whose members train with one or neither of these techniques.*

Hypothesis 9b: *Performance in evaluating the correct hypothesis will be higher for MDTs whose team members train using a combination of analogical encoding and collaborative learning techniques than for those MDTs whose members train with one or neither of these techniques.*

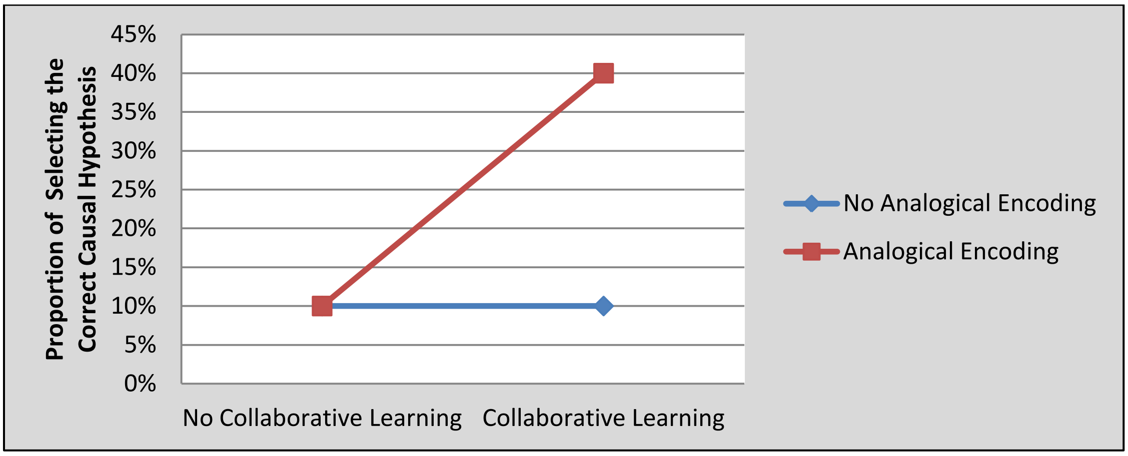
2.3.2.4.4. Impact of Analogical Encoding and Collaborative Learning on Teams' Final Judgment Performance

The final stage of the analytical procedures process is the final judgment as to the most likely cause of the noted fluctuation. After evaluating the evidence to support the hypotheses, team members have a discussion to determine the most likely cause of the difference between reported and expected amounts (Bedard et al. 1998). Teams select the most likely cause from the team's hypothesis set. If evidence does not support any of the hypotheses in the team's hypothesis set, they may generate other hypotheses in accordance with the iterative nature of analytical procedures (Koonce 1993). MDT performance in this final judgment is affected by their performance in the previous stages (i.e., hypothesis generation and evaluation) (Asare and Wright 2003; Green and Trotman 2003).

Therefore, MDTs whose members train with a combination of problem comparison through analogical encoding and collaborative learning techniques will also be expected to perform better in the final judgment. In this thesis, MDT performance is assessed in terms of the accuracy in selecting the most likely causal hypothesis. This expectation leads to the ordinal interaction as depicted in Figure 2.7. Thus, it is predicted that when MDTs train without collaborative learning, there is no MDT performance improvement in the final judgment stage when they train using an analogical encoding technique. However, when collaborative learning is employed there is an improvement in MDT performance in the final judgment stage due to collaboration. More improvement can be obtained when analogical encoding is combined with collaboration learning. The following hypothesis is proposed:

Hypothesis 10: *Performance in selecting the correct causal hypothesis will be higher for MDTs trained using a combination of analogical encoding and collaborative learning techniques than for those MDTs trained with one or neither of these techniques.*

Figure 2.7. Expected Results for the Effect of Training Techniques on Teams' Final Judgment



Source: Developed by the author based on arguments in Section 2.3.2.4.1.

2.4. The Effect of Training Interventions on Cognitive Structures and the Role of Cognitive Structures as the Mediator between Training Interventions and Team Performance in MDTs

The third aim of this thesis is explore the role of cognitive structures (Kozlowski and Ilgen 2006; Mathieu et al. 2008) as potential mediating variables between training interventions and team performance. Cognitive structures are defined as the manner in which knowledge important to team functioning is mentally organised, represented and distributed within the team. Cognitive structures also enable team members to anticipate and execute actions (Kozlowski and Ilgen 2006). This section presents a review of the literature relating to the two types of cognitive structures: team mental models (TMMs) and transactive memory systems (TMSs). This section reviews related research literature and develops the research hypotheses related to the effect of the proposed training interventions (i.e., the two training techniques: analogical encoding and collaborative learning) on cognitive structures. To examine the mediating mechanisms that link inputs such as training to team outcomes, this section also develops the research hypotheses related to the role of cognitive structures as mediating variables between training interventions and MDT performance.

Cognitive structures, in addition to team processes, have been recognised as one of the mediational factors that may intervene and transmit the influence of team inputs to outcomes (Ilgen et al. 2005; Mathieu et al. 2008). According to the input-process-outcome (IPO) model, team outputs are a function of various team processes, which are in turn influenced by numerous input variables (Mohammed and Hamilton 2007; Mathieu et al. 2008). Recently, this model has been modified to create an input-mediator-outcome (IMO) model (Ilgen et al. 2005) to reflect the importance of other factors in addition to team processes.

Studies have identified many types of mediating factors including cognitive structure (e.g., team climate, team mental models, and transactive memory) and motivational and affective factors (e.g., team cohesion, team efficacy, and potency, team affect, mood, and emotion, and team conflict) (Kozlowski and Ilgen 2006; Mathieu et al. 2008). This thesis focuses on cognitive structure as the variable of interest. Prior research generally finds that cognitive structure is the key to superior team performance. It shapes coordination processes relevant to team goals and their accomplishment (Kozlowski and Ilgen 2006; Mathieu et al. 2008; DeChurch and Mesmer-Magnus 2010). This thesis explores whether training interventions, which can be viewed as one of the team inputs, are effective in enhancing two constructs of cognitive structure: team mental models (TMMs) and transactive memory systems (TMSs) and also whether these enhanced cognitive structures improve performance.

The next three subsections provide a discussion on TMMs. Section 2.4.1 reviews research literature on TMMs and the interventions that are needed to develop them. Section 2.4.2 discusses the TMMs of MDTs. Section 2.4.3 proposes research hypotheses relating to the training interventions (i.e., analogical encoding and collaborative learning) that are used to enhance the development of the TMMs of MDTs in performing an analytical procedures task. TMSs are discussed in Section 2.4.4. Section 2.4.5 provides the research hypotheses relating to the training interventions (i.e., analogical encoding and collaborative learning) to be used to enhance the development of TMSs of MDTs.

2.4.1. Team Mental Models (TMMs) of MDTs

One type of cognitive structure that has received significant attention in team-related literature is the concept of TMMs (Kozlowski and Ilgen 2006; Mathieu et al. 2008; DeChurch and Mesmer-Magnus 2010). TMMs are defined as the organised mental representations of knowledge about key element of the team’s relevant environment that are shared across team members (Klimoski and Mohammed 1994; Mohammed and Dumville 2001; Mohammed et al. 2010). This concept is developed from the concept of mental models in individual cognition, which suggests that individuals understand the world by constructing working models or mental representations (Johnson-Laird 1983; Rouse and Morris 1986; Wilson and Rutherford 1989; Markman and Gentner 2001). A mental model in a person’s mind may contain a network of associations between relevant concepts (Mohammed and Ferzandi 2007) and the information stored in mental models. This helps individuals to describe, predict and explain events; to integrate new information; and to interact more efficiently with their environment (Rouse and Morris 1986).

From these individual-level studies, the mental model literature has been expanded to incorporate cognitive processes at the team level (Mohammed and Dumville 2001; Mohammed et al. 2010). Developed as a descriptive and prescriptive tool for team performance, TMMs derive from the idea that team effectiveness will improve if team members hold common or overlapping cognitive representations of equipment, procedures and performance requirement (task-focused representation) and interpersonal interaction requirement skills (team-focused representation) (Cannon-Bowers et al. 1993; Klimoski and Mohammed 1994).[23] Consistent with individual-level mental models, TMMs fulfil multiple purposes, including description (i.e., interpretation of information), prediction (i.e., expectations concerning future events), and explanation (i.e., developing causal accounts for a situation) (Rouse et al. 1992). The existence of well-developed TMMs (i.e., where team members have a common and accurate view of what is happening, what is likely to happen next, and why it is happening) allows team members to be 'on the same page' in knowing what to expect, anticipating what team members need, and explaining what is observed (Cannon-Bowers et al. 1993; Mohammed et al. 2010). In turn, this team cognition affects team effectiveness by enabling team members to coordinate actions and adapt behaviour to task demands, enabling effective interpersonal interactions and higher performance (Cannon-Bowers et al. 1993).

---

[23] In TMM research, TMMs are concerned with that portion of an individual's mental model that has relevance to the goals and mental models of the team (Cooke et al. 2000). TMMs are generally classified as either task or team models (Cannon-Bowers et al. 1993). While task models involve the various steps involved in the task and the resources (e.g., equipment) necessary to accomplish it, team models involve the information and skills of members that are relevant to the task and the ways in which their skills and behaviours must be coordinated in order to move efficiently toward task completion (Cannon-Bowers et al. 1993; Mohammed et al. 2010). The type of team has consequences for the type and content of mental model that should be studied (Webber et al. 2000). Whereas both task- and team-focused mental models are equally important for action teams (i.e., teams that conduct action or psychomotor tasks (McGrath 1984)), for decision-making teams (such as those examined in this thesis), a mental model related to the task at hand may be more important than a mental model that helps anticipate the actions of other team members (Jackson et al. 1995). Task-focused TMMs are especially relevant because decision-making is an information-intense activity (Jackson et al. 1995; DeChurch and Mesmer-Magnus 2010). The relevant types of TMMs investigated by this thesis are task-focused mental models.

The following subsections discuss the TMM properties, TMM similarity and TMM accuracy, that are relevant in relation to MDT performance.

2.4.1.1. Mental Model Similarity and MDT Performance

An important property of TMMs, which has received the most emphasis in the earliest work in TMM literature, is mental model similarity (Mohammed et al. 2010). This property refers to the degree to which the mental models of individual team members are consistent or converge with one another (e.g., Cannon-Bowers et al. 1993; Rentsch et al. 2008; Mohammed et al. 2010).[24] Prior empirical studies firmly support the importance of mental model similarity in influencing team performance (Marks et al. 2000; Mathieu et al. 2000; Cooke et al. 2001; Rentsch and Klimoski 2001; Marks et al. 2002; Cooke et al. 2003; Mathieu et al. 2005; Smith-Jentsch et al. 2005; Edwards et al. 2006; Ellis 2006; Lim and Klein 2006; Burtscher et al. 2011). Notably, however, most of the above empirical support for the importance of mental model similarity has been conducted in the context of action/psychomotor tasks (see Kozlowski and Ilgen 2006, for a review). In these tasks, team members must respond effectively in time-sensitive and emergency situations. The importance of this similarity of mental model is especially crucial in such settings because team members must anticipate and initiate the exchange of information and required resources when there is not enough time for explicit communication (Kozlowski and Ilgen 2006). In performing these tasks, which generally possess high levels of behavioural interdependence, mental model similarity enables team members to anticipate needs and actions and thereby implicitly coordinate their behaviour and improve team effectiveness (Cannon-Bowers et al. 1993).

The research outlined above supports the prediction that TMM similarity is more important for tasks that require a high level of behavioural integration, such as for action teams (Sundstrom et al. 1990), and less important for other types of teams, such as decision-making or project teams (Sundstrom et al. 1990; Sundstrom et al. 2000). However, a meta-analysis by DeChurch and Mesmer-Magnus (2010) found that TMMs are important for all types of teams including decision-making teams. According to DeChurch and Mesmer-Magnus (2010), this

---

[24] The TMM literature suggests that mental model similarity is generally measured along a continuum. At one end, team members hold incongruent mental models, in that their mental representations of people, places and things related to the task at hand are strikingly different from one another's. At the other end of the continuum, the mental models of each team member are seemingly identical (Mohammed and Ferzandi 2007).

construct is most predictive of processes and performance, suggesting that this type of cognition is important to performance in more than just action teams. Therefore, DeChurch and Mesmer-Magnus (2010) concluded that, while the majority of cognition research to date has been conducted on action teams, it can also be applied to other types of teams performing other tasks. Although DeChurch and Mesmer-Magnus (2010) conducted a meta-analysis of TMMs in decision-making tasks, it remains unclear from this meta-analysis study whether TMM similarity is important for all types of teams including MDTs.

Previous studies have suggested that the development of similar TMMs is dependent on team member characteristics, which include tenure and experience, educational and organisational-level, personality, race, gender, and general mental ability (Rentsch and Klimoski 2001; Edwards et al. 2006; Resick et al. 2010; Fisher et al. 2012). In general, these studies reveal that the homogeneity of these variables is likely to be related to TMM similarity. This is because homogeneity in these variables leads to similar language and similar interpretations of events that are related to team functioning (Rentsch and Klimoski 2001). In addition, homogeneity among team members is associated with increased communication within the team, increased ability to achieve consensus readily, increased cohesion, and decreased experience of intra-team conflict (e.g., Jackson et al. 1995). This provides an opportunity to develop further similar TMMs (Rentsch and Klimoski 2001). In summary, the TMM literature suggests that team effectiveness can be improved by developing highly similar TMMs and that this is more likely to occur when the team consists of members who have similar or homogeneous characteristics (Resick et al. 2010; Fisher et al. 2012).

One of the implications of these findings is that it may be difficult for heterogeneous teams, whose members have different characteristics, to develop a similar TMM. In heterogeneous teams such as MDTs, these characteristics can differ substantially between the individual members as each individual has their own background, knowledge, prior experience, expertise and aims (Badke-Schaub et al. 2007). Each member perceives reality according to his or her active perception, memory, prior knowledge, and needs (Rentsch and Klimoski 2001). Therefore, when heterogeneous team members exchange their mental models (which are different or may be in conflict with those of other members) in their communications, they may face difficulties in building up a similar TMM.

2.4.1.2. Potential Benefits of Mental Model Diversity to MDT Performance

Team researchers now recognise that the role of TMMs may be more complex in the sense that, for some tasks, members do not necessarily need to have similar (i.e., isomorphic or identical) mental models (Mohammed et al. 2010). The consensus in the team literature suggests that the degree of mental model similarity needed for effective team functioning depends on a number of factors including the nature of the task (Mohammed et al. 2010). Specifically, under normal circumstances that allow members to freely communicate with one another, additional similar TMMs may be less important, e.g., where team members have enough time to plan deliberately and are able to resolve any differences. Sufficient time also allows team members to conduct the necessary information processing such as elaborating the task-relevant information (Cannon-Bowers and Salas 1997). Therefore, for teams performing strong information-processing and decision-making components tasks, less similar TMMs may be viewed both as a problem or a potential advantage (Williams and O'Reilly 1998). As noted in Section 2.3.1, although diversity in information and perspectives (from different mental models) may have negative effects on MDT performance, it also provides a greater pool of task-relevant information and expertise, which in turn provides a potentially larger basis of support for decisions (Ancona and Caldwell 1992). As argued in the team literature (Larson 2010), generate tasks (i.e., tasks that plan strategies or create new ideas and approaches such as hypothesis generation (McGrath 1984)) are particularly likely to benefit from access to knowledge that is diverse, because that diversity can lead to a greater quantity of ideas. Specifically, although differences in information and viewpoints may give rise to task conflict and dissent (De Dreu and Weingart 2003), which may not always be conducive to information processing (e.g., it may disrupt this process when team members opt for a quick compromise to avoid conflict), prior studies argue that it may promote deep level and creative processing of diverse information and viewpoints by elaborating task-relevant information (van Knippenberg et al. 2004). Faced with the need to solve these conflicts and reconcile opposing views, team members may engage in more elaborate processing of task-relevant information and search for more creative solutions (Tjosvold 1998; De Dreu and Weingart 2003). As outlined in Section 2.3.1, particular team interventions (such as improving social ties and team training) are needed in order to realise the benefits of this diversity, (Mannix and Neale 2005). The collaborative learning intervention explored in this thesis may provide such a mechanism for developing TMMs, which will improve performance of MDTs while retaining diversity.

2.4.1.3. Mental Model Accuracy and MDT Performance

Another property of TMMs that has been examined in the TMM literature is mental model accuracy. This property is defined as the relationship between the team member representations and a target or ‘true score’ (Rentsch and Hall 1994). This construct assumes that there is an externally-verifiable correct definition of the mental model; it refers to the ‘degree to which members’ mental models adequately represent a given knowledge or skill domain’ (Edwards et al. 2006). In addition, accurate TMMs mirror the ‘true state of the world’ (Edwards et al. 2006, 728). The importance of accuracy is based on the rationale that although all team members can share identical mental models, these mental models may turn out to be erroneous, thus leading to a potentially poorer (rather than more successful) performance (Edwards et al. 2006). Therefore, team mental model similarity alone does not ensure success. If accuracy is not considered, the importance of similarity may be overestimated when accuracy is really driving relationships with team outcomes (Smith-Jentsch 2009). In response to this view, TMM studies increasingly assess accuracy. Although it makes sense conceptually that TMM similarity without accuracy will not yield high performance, empirical research has not uniformly supported this view with prior studies finding an inconsistent relationship between TMM accuracy and team performance. While many studies report a direct link between accuracy and performance (e.g., Marks et al. 2000; Cooke et al. 2001; Cooke et al. 2003; Edwards et al. 2006; Ellis 2006; Lim and Klein 2006; Burtscher et al. 2011), other studies have failed to find such a relationship (e.g., Webber et al. 2000; Mathieu et al. 2005). One explanation for these results, according to Edwards et al. (2006), is that TMM accuracy takes on increased importance when there is one best way or a limited number of successful strategies to perform the task.

In the context of teams performing strong information-processing and decision-making components tasks, mental model accuracy is an important TMM property because an accurate mental model possessed by at least one member enables the team as a whole to be effective in making the right decision (Mohammed et al. 2010). The existence of accurate mental models possessed by team members allows appropriate information and perspectives to be combined or integrated into the team’s decision when teams conduct elaboration. On the other hand, if team members share inappropriate, inaccurate, or biased mental models, the teams may be less effective (Tindale et al. 1996). Research on small decision-making groups in social psychology (Tindale 1993; Tindale et al. 1996) suggests that when members reach consensus, even if only a minority of the team have accurate mental models and have access to the truth (i.e., the correct solution), this minority can 'win out' if their position fits the shared cognitions of team members.

2.4.1.4. Relationship between Mental Model Similarity and Accuracy and MDT Performance

Although accuracy and similarity are related to each other, they are not redundant because they measure two different aspects of team mental models (Mohammed et al. 2010). Moreover, mental model similarity and accuracy may well interact to affect MDT performance. That is, if members share a common mental model that accurately captures their performance requirements for a given environment, it will enable them to respond effectively. Alternatively, should a shared model turn out to be inaccurate, it could prove quite detrimental for the team. Therefore, mental model similarity and accuracy have an interactive relationship with team processes and performance. The form of the interactions is disordinal, with the most effective processes and performance following from high-similarity, high-accuracy combinations and the least effective consequences stemming from high-similarity, low-accuracy instances (Mohammed et al. 2010).

Despite this, there is conflicting evidence as to whether mental model similarity and accuracy together predict team outcomes. Some studies have found significant interaction effects (e.g., Marks et al. 2000; Mathieu et al. 2005) indicating that teams exhibited the best processes and performance when they shared high-quality (i.e., similar and accurate) mental models, while others have not found such significant interaction effects (e.g., Lim and Klein 2006). Prior studies using homogeneous teams suggest that if team members share a common mental model that accurately captures their performance requirements for a given environment, it will enable them to respond effectively.

In the MDT setting, highly accurate and similar mental models may not occur. A high-similarity, high-accuracy combination is not feasible. For example, in the GHG assurance engagement context, a high-similarity, high-accuracy combination would mean that accountant team members would have subject-matter knowledge (i.e., environmental science knowledge) and the scientist members would have a comprehensive knowledge of auditing. In fact, as argued above, similar mental models would impair performance through leading to narrowed perspectives, failing to take advantage of the MDT members' diverse knowledge. In such cases, it may be important that some MDT members (but not necessarily all members) have highly accurate mental models. Therefore, in the MDT setting, the low-similarity, high-accuracy combination is likely to be more feasible and thereby likely to lead to more effective processes and performance compared to the low-similarity, low-accuracy combination.

2.4.2. Training Intervention to Enhance the Development of Team Mental Models of MDTs in Performing an Analytical Procedures Task

One team intervention that enhances the development of team mental models is training. In team studies, training has been the most frequently-investigated team intervention because it is viewed as a primary mechanism by which team members are motivated to effectively and efficiently converge their mental models (Cannon-Bowers 2007). In cases where individuals have dissimilar, faulty or inaccurate mental models in important team task areas, team researchers in the organisational psychology field suggest that it may be necessary to alter the structure and content of some team members' mental models (Converse et al. 1991; Rouse et al. 1992; Langan-Fox 2005). This research suggests that the establishment of methods to train or manipulate mental models is essential for attaining high performance in a task. In summary, the team-training goal should be to enable the development of relevant and accurate mental models that allow for greater understanding of the task and effective performance (Langan-Fox 2005).

Various types of team training have been found to increase TMM similarity and/or accuracy, including guided team self-correction (i.e., members are given the responsibility for diagnosing and solving their team's performance problems with guidance as to what topics they should discuss and how to do so constructively (Smith-Jentsch et al. 2008)), team interaction training (i.e., where teams are trained to coordinate their actions (Marks et al. 2000)), computer-based training (i.e., using a computer to focus on generic teamwork competencies (Smith-Jentsch et al. 2001)), and cross-training (i.e., each member is trained on the tasks, duties, and responsibilities of his or her fellow team members (Volpe et al. 1996; Blickensderfer et al. 1998; Cannon-Bowers et al. 1998; Marks et al. 2002)). However, it is important to note that these team-training approaches have been developed for, and largely applied in, the military sector and in commercial aviation (Kozlowski and Ilgen 2006). As outlined in Section 2.3.2, these training interventions are targeted on teams performing action or psychomotor tasks (McGrath 1984) which involve performing time-sensitive tasks requiring members to coordinate actions and perform physical tasks that generally possess high levels of behavioural interdependence in emergency situations (DeChurch and Mesmer-Magnus 2010). The instructional objective of team training is the improvement of implicit coordination between team members by developing a high-similarity, high-accuracy TMM because the existence of such a well-developed TMM enables team members to anticipate and initiate the exchange of information and required resources when there is not enough time for explicit communication (Kozlowski and Ilgen 2006). It is unclear whether these training techniques have the same potential for improving team effectiveness in less critical though no less important team contexts where tasks are not time-sensitive and where time is available for team members to communicate and elaborate task-relevant information.

It is also important to note that trainees involved in previous training research were homogeneous in terms of their background, knowledge, prior experiences and expertise. Participants recruited for the experiments usually consisted of undergraduate students who had no knowledge in the domain that they would be learning (Blickensderfer et al. 1998; Marks et al. 2002) or military personnel who have similar backgrounds, knowledge and experience (Cannon-Bowers et al. 1998; Smith-Jentsch et al. 2001; Smith-Jentsch et al. 2008). To date, there has been no study that specifically examines the use of training interventions in improving TMM development for heterogeneous teams whose members have diverse backgrounds, knowledge and experience. Thus, it remains an empirical question as to whether particular training interventions can affect the development of TMMs of diverse team members such as the MDTs examined in this thesis.

As outlined in Section 2.3.1, the use of two training techniques, analogical encoding and collaborative learning, is expected to improve MDT performance. This section examines how improvements gained using these training techniques are mediated by TMMs that are developed when MDT members learn with a particular training technique. The next two subsections provide a discussion of the effect of training interventions on TMMs and the mediating role of TMMs on MDT performance. The discussion is divided into two sections because the two stages of the analytical procedures process (i.e., hypothesis generation and hypothesis evaluation) have different cognitive processes (Moreno et al. 2007). Section 2.4.2.1 provides a review of the relevant literature and develops research hypotheses on training interventions to enhance the development of TMMs in the hypothesis generation stage. Section 2.4.2.2 provides the review and research hypotheses development for the hypothesis evaluation stage.

2.4.2.1. The Effect of Analogical Encoding on Team Mental Model Accuracy and Similarity in Team Hypothesis Generation

The discussion of the effect of analogical encoding on TMMs is divided into two subsections: the effect on TMM accuracy (Subsection 2.4.2.1.1) and TMM similarity (Subsection 2.4.2.1.2).

2.4.2.1.1. Analogical Encoding and TMM Accuracy

As noted above, TMM accuracy is normally defined as the degree to which the mental models of individual team members adequately represent a given knowledge or skill domain (Edwards et al., 2006). In the context of this thesis, TMM accuracy is referred to as the degree to which the mental models closely relate to the correct mental model according to the training material. TMM accuracy is also an important TMM property because the possession of an accurate mental model by at least one member enables team members to be effective in making the right decision (Mohammed et al. 2010). To develop a highly-accurate team mental model, the mental models of individual team members must also be highly accurate. This thesis examines the usefulness of the analogical encoding technique in achieving this goal. By using this technique, individuals are trained in a way that allows them to structure their knowledge in a particular way. As outlined below, accurate individual and team mental models can be developed using analogical encoding. Section 2.2.2 shows that, at the individual-level, the use of analogical encoding through problem-category comparison can help individuals learn to better distinguish problem categories (Cummins 1992; VanderStoep and Seifert 1994). Through this technique, the knowledge of causal hypotheses can be structured in a taxonomic structure in the individual's mental models (Markman 1999; Anderson 2010). Therefore, it is predicted that the use of analogical encoding leads to more accurate individual mental models. Theoretically, TMMs are related to and presume the existence of individual mental models (Langan-Fox 2005). Given that TMMs are by definition concerned with the interaction of the individual mental models of team members (Langan-Fox et al. 2000; Mohammed and Dumville 2001) and that TMMs are not held by any one individual but are a kind of aggregation of individual mental model accuracy (Cooke et al. 2000), it is predicted that the positive effect of analogical encoding also occurs with team-level mental models.[25]

---

[25] This thesis examines the task-focused mental model in the hypothesis generation stage. This TMM characteristic includes knowledge about causal hypotheses for the observed fluctuation.

The positive effect of analogical encoding on TMM accuracy is proposed despite this technique is beneficial only for team members who have no pre-existing mental models (i.e., in this thesis, team members who have no knowledge of auditing). This is because for these team members the use of analogical encoding leads to highly accurate mental models compared to those of team members who have pre-existing mental models. The resulted TMMs, which are aggregation of individual mental model, therefore, are not cancelled out by other team member's less accurate mental model. Therefore, on average, using the analogical encoding technique leads MDTs to have more accurate TMMs.

The above prediction leads to the following hypothesis, stated in the alternative form:

Hypothesis 11a: *MDTs that train using the analogical encoding technique have more accurate hypothesis generation TMMs than MDTs that train without the analogical encoding technique.*

2.4.2.1.2. Analogical Encoding and TMM Similarity

The propensity of each team member to develop a particular mental model (that is accurate) may differ. As outlined in Section 2.4.1.5, turning effective knowledge organisation into a particular mental model is more readily achieved when there is no incompatibility between the pre-existing knowledge structure or mental model that an individual has before training and the training structures at hand (Nelson et al. 1995; Bonner et al. 1996; Bonner et al. 1997; Vera-Munoz 1998; Vera-Munoz et al. 2001; Borthick et al. 2006). Compatibility between pre-existing mental models and the correct mental model (as developed according to the training material) may affect mental model development. In particular, when members train using analogical encoding, members who have compatible mental models (i.e., members who have no prior knowledge and experience in a particular domain, and thus a blank slate or no pre-existing mental models) are more likely to develop accurate mental models (in terms of the training material) than members who have incompatible pre-existing mental models.[26] By contrast, when pre-existing mental models and the training structure are

---

[26] In a MDT setting, each member has specialised expertise and knowledge and has little knowledge of the other member's area. Therefore each member has a blank slate for the other member's area. In this thesis, the focus of training is to improve individual and team performance in conducting an analytical procedures task, a task that an accountant member who has knowledge in auditing is already familiar with. In this setting the accountant members have a pre-existing mental model and the scientist members have a blank slate mental model. To investigate the effect of the incompatibility of the mental model, the training materials are deliberately designed in a structure that is incompatible

incompatible, as is the case in an MDT setting where each member may have different and incompatible mental models developed via discipline-specific knowledge and experience, a particular structure, according to instructions provided in the analogical encoding training material, may disrupt the individual's organisational structure as well as the development of this structure in his or her mental model (Bonner et al. 1996; Borthick et al. 2006). Because each member may have a propensity to develop a particular mental model, MDT members may develop different mental models after receiving particular structures through the training via analogical encoding. Therefore when trained with analogical encoding, similar TMMs are difficult to develop. Thus, this prediction can be formally hypothesised, stated in the null form, as follows:

Hypothesis 11b: *MDTs that train using the analogical encoding technique do not have more similar hypothesis generation TMMs than MDTs that train without the analogical encoding technique.*

2.4.2.1.3. The Effect of Collaborative Learning on Team Mental Model Accuracy and Similarity in Team Hypothesis Generation

Prior research suggests that the use of collaborative learning may bring beneficial effects for the development of both individual and team mental models (Jeong and Chi 2007; Chi 2009). As outlined in Section 2.2.3, one of these benefits is that the interaction in dialogues between team members produces a shared understanding or representation of the information (Jeong and Chi 2007; Chi 2009). This shared understanding can be achieved by each team member changing their joint understanding in a dynamic way that may result in a novel mental model (Jeong and Chi 2007; Chi 2009). In other words, the potential outcome of this construction is the development of a more similar and accurate mental model (Fonseca and Chi 2011).

However, it is important to note that the positive effect of collaborative learning has also been found to occur when there is no conflict when individuals organise the information in the learning material and integrate it with their prior knowledge in their working memories. As shown by studies in collaborative memory (Andersson and Rönnberg 1995; Weldon and Bellinger 1997; Rajaram and Pereira-Pasarin 2010; Rajaram 2011), the collaboration may inhibit the retrieval process because individuals organise the information elements

---

with the accountant's prior knowledge that is generally structured according to audit objectives or assertions (Frederick et al. 1994).

differently. When working collaboratively with a partner, the recall of information that is provided in a different organisation (as part of someone else's structure) may disrupt an individual's knowledge structure and his or her retrieval process.

In the MDT setting where MDT members are trained according to a particular structure, each MDT member may possess a different way to organise or structure the information elements and they may also have different prior knowledge which affects how the new information must be integrated. The pre-existing structure or mental model that an individual has acquired from prior education and experience plays an important role in organising and integrating the new information. In the MDT setting, the conflict of structure or mental models is likely to occur because the mental model of one MDT member may not match or be compatible with or similar to the other team member's mental model. As a result, learning collaboratively with other members may disrupt the learning process and thus may not facilitate the development of a similar mental model.

Therefore, although using the collaborative learning technique can have a positive effect when individuals have no pre-existing mental models (i.e., in this thesis, MDT members who have no knowledge of auditing), there may be no effect for MDT members who have pre-existing mental models (i.e., MDT members who have prior knowledge of auditing). In previous studies, TMM accuracy has been measured by aggregating individual mental models (e.g., Marks et al. 2000; Cooke et al. 2001; Cooke et al. 2003; Edwards et al. 2006). In general there is no effect from the use of this technique in terms of accurate TMM development. This is due to the effects being cancelled out by each team member's different mental model. In addition, because individual mental models are different from each other, TMMs will not be more similar compared to those of teams that train without this technique. These predictions lead to the following research hypotheses, stated in null form:

Hypothesis 12a: *MDTs that train using the collaborative learning technique do not have more accurate hypothesis generation TMMs than MDTs that train without the collaborative learning technique.*

Hypothesis 12b: *MDTs that train using the collaborative learning technique do not have more similar hypothesis generation TMMs than MDTs that train without the collaborative learning technique.*

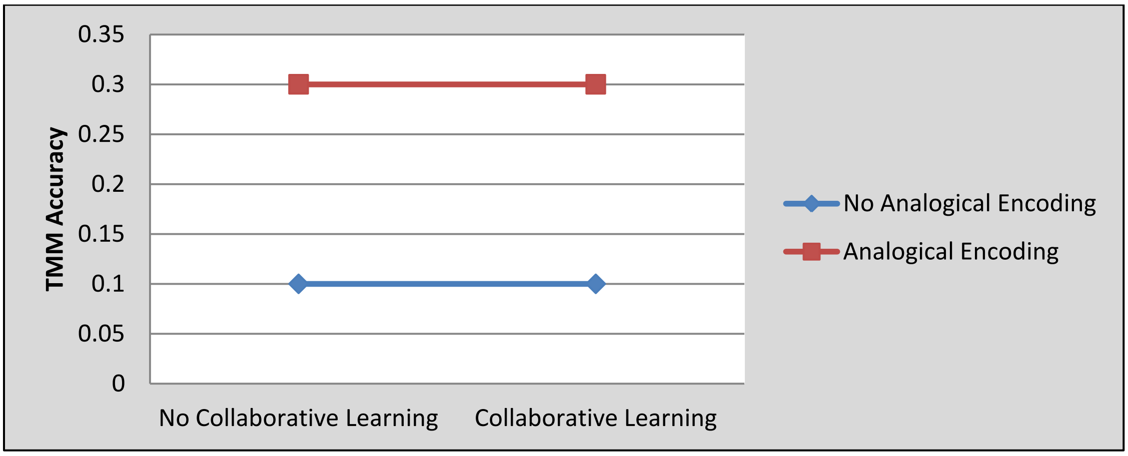
2.4.2.2. The Interactive Effect of Analogical Encoding and Collaborative Learning on Team Mental Model Accuracy and Similarity in Team Hypothesis Generation

In this section, the interaction effects of the two training techniques on TMM accuracy and similarity are examined. Given that the use of analogical encoding leads to the development of more accurate TMMs (Hypothesis 11a) and the use of collaborative learning has no effect on this development (Hypothesis 12a), this leads to the expectation that the two training techniques will have no interactive effect on TMM accuracy. This is reflected in the following hypothesis:

Hypothesis 13a: *When generating hypotheses, MDTs that train with the analogical encoding technique, either with or without the collaborative learning technique, are more likely to have more accurate TMMs for hypothesis generation than MDTs trained without the analogical encoding technique.*

The expected results are depicted in Figure 2.8.

Figure 2.8. Expected Results for the Effect of Training Techniques on TMM Accuracy in Hypothesis Generation



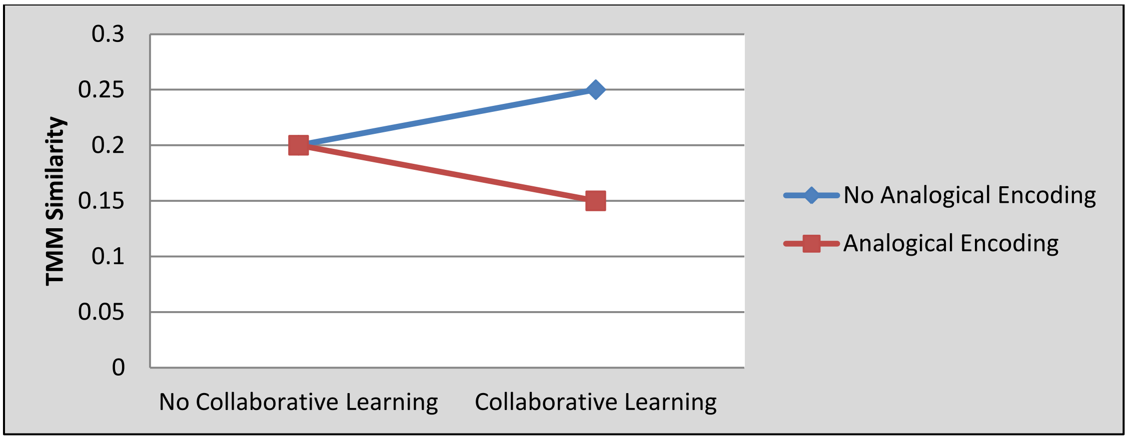
Source: Developed by the author based on arguments in Sections 2.4.2.1.1, 2.4.2.1.3, and 2.4.2.2.

Although the use of collaborative learning has no effect on the development of similar TMMs as predicted by Hypothesis 12b, an interaction effect is expected such that the use of collaborative learning with analogical encoding may enhance TMM similarity, whereas the use of collaborative learning without analogical encoding may not enhance TMM similarity. A combination of the two training techniques may lead to less similar TMMs because it exposes two incompatibility problems: (1) the incompatibility between individual pre-existing mental models and the training structure that is highlighted when learning with analogical encoding; and (2) the incompatibility between the mental models of the different members of the team, which disrupts the development of TMMs when collaborating with other individuals. By contrast, when collaborating with other individuals without the analogical encoding technique, the individuals face only the second incompatibility problem. They may overcome this problem by gaining the benefits from the interaction in dialogues between MDT members that produce a shared understanding or representation of the information (Jeong and Chi 2007). These arguments lead to the interaction as presented in the following research hypothesis:

Hypothesis 13b: *MDTs that train with (without) the analogical encoding technique have less (more) similar hypothesis generation TMMs than MDTs that train using the collaborative learning technique.*

These expectations are illustrated in Figure 2.9.

Figure 2.9. Expected Results for the Effect of Training Techniques on TMM Similarity in Hypothesis Generation



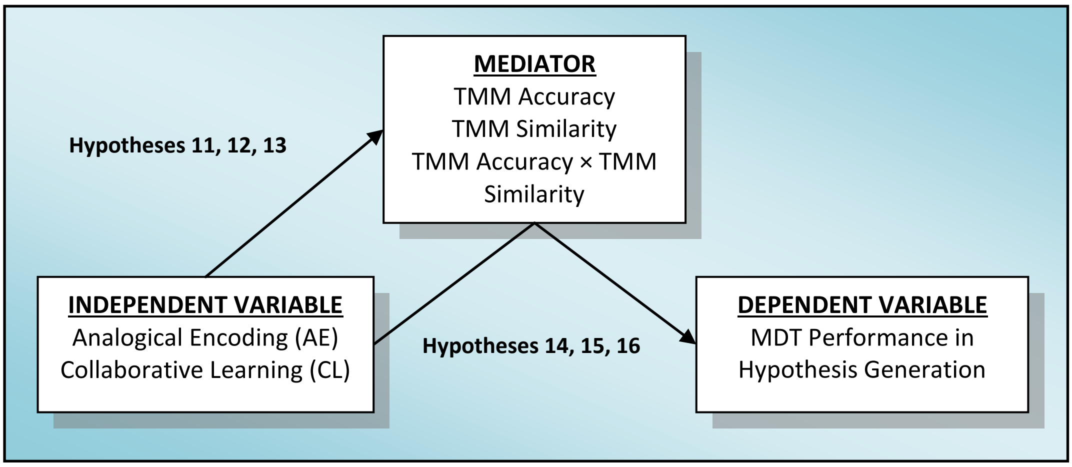
Source: Developed by the author based on arguments in Sections 2.4.2.1.2, 2.4.2.1.3, and 2.4.2.2.

2.4.2.3. Team Mental Model as Mediator between Training Interventions and MDT Performance in Hypothesis Generation

As outlined in Section 2.3.1, according to the input-process-outcome (IPO) framework that has been used in the team literature for studying team effectiveness, training interventions can be viewed as one of the inputs. Previous research also recognises that a TMM is a mediating variable between inputs such as training interventions and team performance

(Mathieu et al. 2008; DeChurch and Mesmer-Magnus 2010). Training interventions affect TMMs as predicted by Hypotheses 11, 12 and 13 and, as the mediator, TMMs in turn affect MDT performance. The hypothesised mediation relationship is depicted in Figure 2.10.

Figure 2.10. Expected Mediating Relationship of Team Mental Models in Hypothesis Generation



Source: Developed by the author based on arguments in Sections 2.4.2.1, 2.4.2.2, and 2.4.2.3.

As outlined in Section 2.4.1.4, an accurate mental model possessed by at least one member enables MDT members to be effective in making the right decision. The possession of accurate mental models by MDT members allows appropriate information and perspectives to be combined or integrated into the MDT's decision when MDTs conduct elaboration. In generating hypotheses, highly accurate TMMs enable MDT members to generate hypotheses effectively and efficiently. Consistent with the TMM literature, it is predicted the TMM accuracy will mediate the relationship between training interventions and MDT performance in generating hypotheses. As such, the following research hypotheses are proposed:

Hypothesis 14a: *TMM accuracy mediates the link between the analogical encoding technique and MDT performance in generating hypotheses.*

Hypothesis 14b: *TMM accuracy mediates the link between the collaborative learning technique and MDT performance in generating hypotheses.*

Hypothesis 14c: *TMM accuracy mediates the link between a combination of analogical encoding and collaborative learning techniques and MDT performance in generating hypotheses.*

The importance of TMM similarity is outlined in Section 2.4.1.2. In short, the existence of TMMs is crucial to enable MDT members to anticipate needs and actions and to initiate the exchange of information. These improvements lead to improved coordination and MDT effectiveness (Cannon-Bowers et al. 1993). Highly similar TMMs enable MDT members to retrieve the hypotheses similarly and efficiently using MDT resources to conduct hypothesis plausibility tests and to generate a high-quality hypothesis set. Consistent with the TMM literature, it is predicted that TMM similarity will mediate the relationship between training interventions and MDT performance in generating hypotheses. This leads to the following hypotheses:

Hypothesis 15a: *TMM similarity mediates the link between the analogical encoding technique and MDT performance in generating hypotheses.*

Hypothesis 15b: *TMM similarity mediates the link between the collaborative learning technique and MDT performance in generating hypotheses.*

Hypothesis 15c: *TMM similarity mediates the link between a combination of analogical encoding and collaborative learning techniques and MDT performance in generating hypotheses.*

It is also predicted that the TMM properties (TMM accuracy and similarity) will interact to enable MDTs to achieve higher performance. Specifically, the interaction of these properties mediates the link between the training interventions and MDT performance, as proposed in the following research hypothesis:

Hypothesis 16: *The interaction of TMM properties (accuracy and similarity) is positively related to MDT performance in generating hypotheses.*

2.4.2.4. The Effect of Analogical Encoding on Team Mental Model Accuracy and Similarity in Hypothesis Evaluation

When evaluating hypotheses, as discussed in Section 2.3.2.4, alternative perspectives or judgments should be encouraged, exchanged, discussed and integrated (Koehler 1991). Alternative perspectives and judgments are important to mitigate bias during hypothesis evaluation. Biased evaluation occurs because individuals seem to be relatively insensitive to other ways in which the problem might have been framed or interpreted, particularly once they have inherited an hypothesis (Koehler 1991; Koonce 1992). By encouraging elaboration of task-relevant information, the alternative hypotheses are made more prominent so that team members become less biased in favour of an inherited explanation (Koehler 1991; Brodbeck et al. 2007). The implication of this notion is that a variety of perspectives or judgments, according to the different mental models of team members, may be an advantage for teams.

However, the same advantage from less similar TMMs can be realised (or the negative effect can be avoided) when the MDTs are able to reach a consensus that is consistent with an accurate TMM. Research in social psychology suggests that consensus is reached either due to shared representations prior to discussion or by the generation of shared representations (or mental models) during discussion (Tindale 1993; Tindale et al. 1996; Tindale et al. 2012). Research also suggests that individual decision biases that are inaccurate can act as shared task representations or mental models (Tindale 1989, 1993). This individual decision bias when evaluating hypotheses can act as a mental model prior to discussion or can be shared with team members during discussions. This may exacerbate bias at the team level (Tindale 1993; Kerr and Tindale 2004). These results highlight the importance of accurate mental model development at the individual level prior to discussion and sharing at the team level.

Use of the analogical encoding technique, as noted in Section 2.3.2, encourages members to be less biased in favour of an inherited explanation. This is because the analogical encoding technique facilitates counterexplanation (Koonce 1992) and sufficiency checks (Anderson and Koonce 1998); these mitigate the evaluation bias. Analogical encoding provides a problem comparison (Gentner et al. 2003; Rittle-Johnson and Star 2011) in which a comparison is made between two different problems that can be solved with the same method. This type of comparison is simpler with a small number of elements to be mapped (Rittle-Johnson and Star 2011). Therefore, it is expected that MDT members will develop accurate mental models of hypothesis evaluation by comparing two problems with their respective possible causes and the correct cause. In addition, the explanation of these causes encourages members to make alternative hypotheses more prominent and to infer a general solution method that contains a balanced evaluation of hypotheses.

As outlined previously, hypothesis generation TMMs that have a taxonomic or network structure (Markman 1999; Anderson 2010) are acquired from prior knowledge or education. In the hypothesis generation stage where task-focused mental models include MDT members’ knowledge about causal hypotheses of the observed fluctuation, TMMs are accurate when the structures are compatible or have higher similarity with the ’correct‘ or referent model. TMMs are less accurate when they have little similarity with the referent model (i.e., models according to the training material) (Frederick et al. 1994).

On the other hand, in hypothesis evaluation, accurate TMMs are structured as *schema*. A schema is defined as a representation of categorical knowledge that contains particular types of objects, the parts of those objects and their typical attributes (Anderson 2010). A schema has a similar level of abstraction to a basic level category in a network representation and includes reference to higher level categories. However, it does not refer to specific lower level elements that are members of the category. Instead, according to Anderson (2010), schemas record regularities about a category by incorporating slots that contain typical values for that category. Having these slots completed with typical values allows individuals to make inferences about an item just by knowing the category to which it belongs (Bonner 2008). However, schemas are also flexible in that they allow typical values to be overwritten (Bonner 2008). Prior research in analogical encoding studies has found a positive effect for this technique in the induction or development of schema (Gick and Holyoak 1983; Gentner et al. 2003). As demonstrated by these studies, once a generalised schema has been induced from analogues (i.e., worked examples), new problems that can be categorised as instances of the schema can be solved without necessarily directly accessing representations of the initial examples. Without schema induction through analogical encoding, individuals fail to organise knowledge into a meaningful structure in a mental model during learning.

In hypothesis evaluation, a TMM is not accurate when knowledge about a general solution method that contains a balanced evaluation of hypotheses is not organised in the form of a schema. Given that there is no particular schema in their mental models, MDT members may take a default position where the decision bias when evaluating hypotheses can act as a mental model. For example, the mental model that contains the current formulation or understanding of the problem situation is updated once the auditor has obtained and evaluated information pertaining to the inherited hypothesis. MDT members may establish the inherited hypothesis as a focal hypothesis and adopt a conditional reference frame in which the focal hypothesis is temporarily accepted as true (Koehler 1991). In addition, this process means that MDT members may become more biased in favour of an inherited explanation when evaluating hypotheses. The use of analogical encoding is useful in overcoming this tendency because, by using this technique, a mental model can be developed that contains a schema of a balanced evaluation of hypotheses.

The effects of analogical encoding on TMM properties in hypothesis evaluation stage are different from the expected effects of this technique on TMM properties in hypothesis generation stage as expected by Hypothesis 11a and 11b. The complete description why these expectations are different is summarised in Table 2.3.

This discussion leads to the following hypothesis, stated in the alternative form:

Hypothesis 17a: *MDTs that train using the analogical encoding technique have more accurate hypothesis evaluation TMMs than MDTs that train without the analogical encoding technique.*

Given that the schema in hypothesis evaluation does not refer to specific lower level instances that are members of the higher level categories, a schema is simpler than a taxonomic or network structure (Bonner 2008; Anderson 2010). This makes the negative effect of the problem of compatibility of mental models less likely to occur when TMM members learn via training materials. As noted above, schemas are flexible in that they allow typical values to be overwritten (Bonner 2008), which means that inaccurate mental models can be altered when conducting schema induction with analogical encoding. As a result, all individual MDT members can develop similar, accurate mental models. Consequently, the following research hypothesis is proposed:

Hypothesis 17b: *MDTs that train using the analogical encoding technique have more similar hypothesis evaluation TMMs than MDTs that train without the analogical encoding technique.*

Table 2.3. Comparison of the Logic for the Directional Effects of Analogical Encoding on TMM Properties

	Analytical Procedures Stage			
	Hypothesis Generation		**Hypothesis Evaluation**	
Nature of this stage	A construction process (i.e., the individuals must construct explanations for the observed unexpected fluctuations).		A reduction process (i.e., individuals must choose among possibilities of explanations for the observed unexpected fluctuations).	
Nature of TMM	The knowledge of causal hypotheses for the observed unexpected fluctuations in a taxonomic structure.		The shared task representation in terms of the extent to which MDT members share the same view of evaluation for each specific hypothesis and are structured as a schema.	
Properties of TMM	**TMM Accuracy**	**TMM Similarity**	**TMM Accuracy**	**TMM Similarity**
	The degree to which the mental models closely relate to the correct mental model according to the training material.	The degree to which the mental models of individual team members are consistent or converge with one another.	A TMM is accurate when knowledge about a general solution method that contains a balanced evaluation of hypotheses is organised in the form of a schema.	A TMM is similar when team member's share a similar task representation in favour of the inherited hypothesis or the alternative hypothesis.
Type of analogical encoding technique proposed for this stage	Problem-category comparison		Problem comparison	
The benefits and limitations of analogical encoding	This technique helps individuals learn to better distinguish features of each category of causal hypotheses and to structure them in the form of a taxonomic structure.	In MDTs, team members may develop different mental models after receiving particular structures through the training via analogical encoding.	This technique is useful in overcoming the biased evaluation tendency because a mental model that contains a schema of a balanced evaluation of hypotheses can be developed.	Because a schema is simpler, the negative effect of the problem of compatibility of mental models is less likely to occur when MDT members learn using this technique.
The effects of analogical encoding on TMM properties	**Hypothesis 11a**	**Hypothesis 11b**	**Hypothesis 17a**	**Hypothesis 17b**
	Positive effect on TMM accuracy	No effect on TMM similarity	Positive effect on TMM accuracy	Positive effect on TMM similarity

2.4.2.5. The Effect of Collaborative Learning on Team Mental Model Accuracy and Similarity in Team Hypothesis Evaluation

As most MDT members have no particular schema regarding hypothesis evaluation in their pre-existing mental model, they do not face the problem of incompatible mental models when learning via training materials. Therefore, collaborative learning is expected to have a positive effect when learning to evaluate hypotheses. It is expected that the interaction in dialogues between MDT members will lead to a shared understanding or representation of the information (Jeong and Chi 2007). As outlined in Section 2.2.3, this shared understanding can be achieved by each partner changing their joint understanding in a dynamic way that may result in a more similar mental model (Jeong and Chi 2007; Chi 2009). However, the use of collaborative learning is not sufficient to make mental models more accurate. MDT members need schema induction (i.e., through the analogical encoding technique) in order to develop accurate mental models. Therefore, it is expected that the use of the collaborative learning technique alone will have no effect on the development of accurate TMMs.

The effects of collaborative learning on TMM properties in the hypothesis evaluation stage are different from the expected effects of this technique on TMM properties in the hypothesis generation stage as predicted by Hypothesis 12a and 12b. The complete description as to why these expectations are different is summarised in Table 2.4.

This expectation leads to the following research hypotheses:

Hypothesis 18a: *MDTs that train using the collaborative learning technique have more accurate hypothesis evaluation TMMs than MDTs that train without the collaborative learning technique.*

Hypothesis 18b: *MDTs that train using the collaborative learning technique do not have more similar hypothesis evaluation TMMs than MDTs that train without the collaborative learning technique.*

Table 2.4. Comparison of the Logics for the Directional Effects of Collaborative Learning on TMM Properties

	Analytical Procedures Stage			
	Hypothesis Generation		**Hypothesis Evaluation**	
Nature of this stage	A construction process (i.e., the individuals must construct explanations for the observed unexpected fluctuations).		A reduction process (i.e., individuals must choose among possibilities of explanations for the observed unexpected fluctuations).	
Nature of TMM	The knowledge of causal hypotheses for the observed unexpected fluctuations in a taxonomic structure.		The shared task representation in terms of the extent to which MDT members share the same view of evaluation for each specific hypothesis and are structured as a schema.	
Properties of TMM	**TMM Accuracy**	**TMM Similarity**	**TMM Accuracy**	**TMM Similarity**
	The degree to which the mental models closely relate to the correct mental model according to the training material.	The degree to which the mental models of individual team members are consistent or converge with one another.	A TMM is accurate when knowledge about a general solution method that contains a balanced evaluation of hypotheses is organised in the form of a schema.	A TMMs is similar when team member's share a similar task representation in favour of the inherited hypothesis or the alternative hypothesis.
The benefits and limitations of collaborative learning	This technique is beneficial when individuals have no pre-existing mental models but not for team members who have pre-existing mental models. Thus, the effects are cancelled out by each team member's different mental model.	Because of the conflict of structure or mental models, this technique may disrupt the learning process and thus may not facilitate the development of a similar mental model.	This technique does not facilitate schema induction in order to develop accurate mental models that contain a balanced evaluation of hypotheses.	Because team members do not face the problem of mental model incompatibility in their schemas, this technique allows interaction in dialogues between team members and it will lead to a shared understanding or representation of the information.
The effects of collaborative learning on TMM properties	**Hypothesis 12a**	**Hypothesis 12b**	**Hypothesis 18a**	**Hypothesis 18b**
	No effect on TMM accuracy	No effect on TMM similarity	No effect on TMM accuracy	Positive effect on TMM similarity

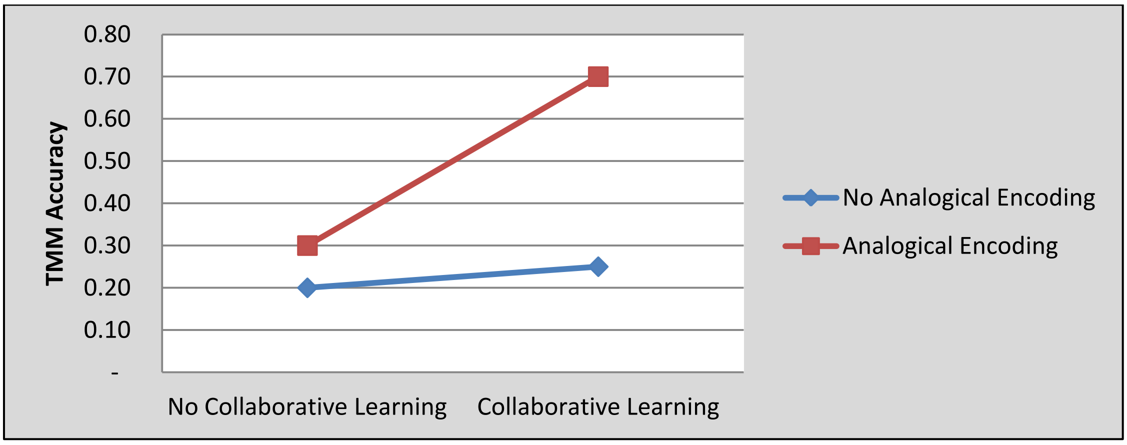
2.4.2.6. The Interactive Effect of Analogical Encoding and the Collaborative Learning on Team Mental Model Accuracy and Similarity in Team Hypothesis Evaluation

This section looks at the interaction effects of the two training techniques on TMM accuracy and similarity in hypothesis evaluation. As the use of analogical encoding leads to the development of more accurate TMMs (Hypotheses 17a) and as the use of the collaborative learning does not lead to the development of more accurate TMMs (Hypothesis 18a), the following interactive effect of these two training techniques is proposed, stated in alternative form:

Hypothesis 19a: *TMM accuracy in hypothesis evaluation is higher in the combined collaborative learning/analogical encoding techniques condition and is lower in the no analogical encoding/collaborative learning techniques condition and in the two no collaborative learning technique conditions.*

The expected results are summarised in Figure 2.11.

Figure 2.11. Expected Results for the Effect of Training Techniques on TMM Accuracy in Hypothesis Evaluation

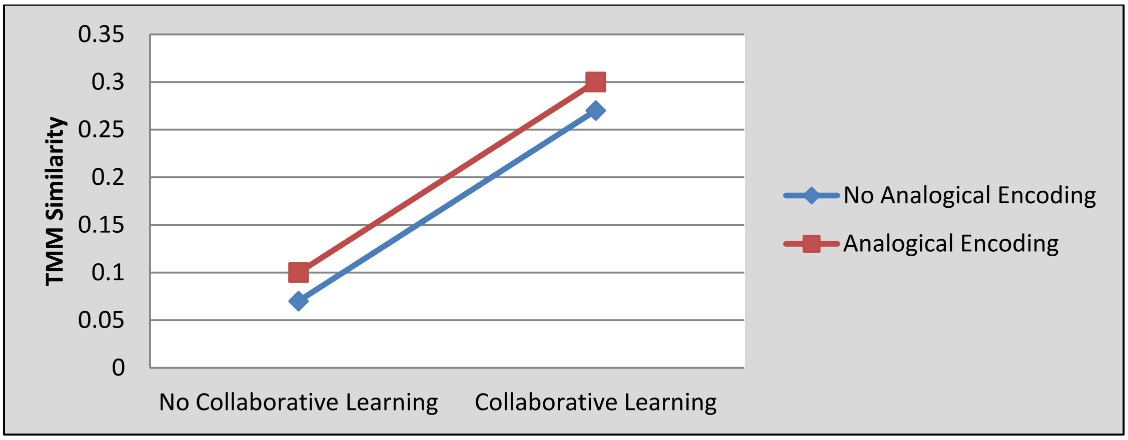


Source: Developed by the author based on arguments in Sections 2.4.2.4, 2.4.2.5, and 2.4.2.6.

With respect to TMM similarity, as predicted by Hypotheses 17b and 18b, both the use of analogical encoding and collaborative learning lead to the development of more similar TMMs. Thus, it is predicted that these two training techniques have no interaction effect on TMM similarity as in the following hypothesis and summarised in Figure 2.12.

Hypothesis 19b: *TMMs in hypothesis evaluation for MDTs that train with and without the analogical encoding technique are more similar when MDTs train using the collaborative learning technique.*

Figure 2.12. Expected Results for the Effect of Training Techniques on TMM Similarity in Hypothesis Evaluation

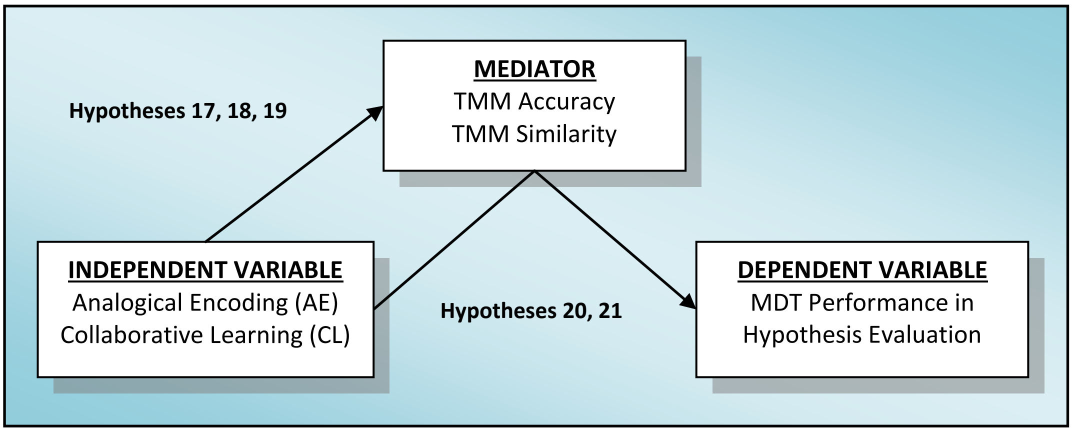


Source: Developed by the author based on arguments in Sections 2.4.2.4, 2.4.2.5, and 2.4.2.6.

2.4.2.7. Team Mental Models as Mediators between Training Interventions and MDT Performance in Hypothesis Evaluation

The role of TMMs as mediators of the link between training interventions and MDT performance is also predicted in the hypothesis evaluation stage. Training interventions affect TMMs as predicted by Hypotheses 15, 16, and 17 and as the mediator, TMMs affect MDT performance. The hypothesised mediation relationship is depicted in Figure 2.13.

Figure 2.13. Expected Mediating Relationship of Team Mental Models in Hypothesis Evaluation



Source: Developed by the author based on arguments in Sections 2.4.2.4, 2.4.2.5, 2.4.2.6 and 2.4.2.7.

As outlined in Section 2.4.1.4, an accurate mental model possessed by at least one member enables MDT members to be effective in making the right decision. In evaluating hypotheses, the existence of highly accurate TMMs allows appropriate information and perspectives to be combined or integrated into the MDT's decision when MDTs conduct elaboration. This leads to an effective hypothesis evaluation. Consistent with prior TMM research, it is predicted that TMM accuracy and similarity mediate the relationship between training interventions and MDT performance in evaluating hypotheses. Accordingly, the following research hypotheses are proposed:

Hypothesis 20a: *TMM accuracy mediates the link between the analogical encoding technique and MDT performance in evaluating hypotheses.*

Hypothesis 20b: *TMM accuracy mediates the link between the collaborative learning technique and MDT performance in evaluating hypotheses.*

Hypothesis 20c: *TMM accuracy mediates the link between a combination of analogical encoding and collaborative learning techniques and MDT performance in evaluating hypotheses.*

In evaluating hypotheses, highly similar TMMs enable MDT members to conduct efficient elaboration when evaluating hypotheses. MDT members may have a similar understanding of the evidence to support the hypotheses. In turn, MDT performance will be improved. This leads to the following hypothesis:

Hypothesis 21a: *TMM similarity mediates the link between the analogical encoding technique and MDT performance in evaluating hypotheses.*

Hypothesis 21b: *TMM similarity mediates the link between the collaborative learning technique and MDT performance in evaluating hypotheses.*

Hypothesis 21c: *TMM similarity mediates the link between a combination of the analogical encoding and collaborative learning techniques and MDT performance in evaluating hypotheses.*

2.4.3. Transactive Memory Systems (TMSs)

Transactive memory systems (TMSs) are a form of cognitive structure that encompasses both the knowledge uniquely held by particular group members as well as a collective awareness of who knows what (Kozlowski and Ilgen 2006). This concept developed around the same time as the research on team mental models began, but TMSs have been studied in another line of research. The TMS concept refers to knowledge about member specialisation and strategies to access the knowledge (Kozlowski and Ilgen 2006). TMSs have been examined in both laboratory and field settings and have been linked to both team performance and satisfaction (e.g., Liang et al. 1995; Hollingshead 1998a, 1998b; Austin 2003; Lewis 2003, 2004; Lewis et al. 2005; Ellis 2006; Pearsall and Ellis 2006; Jackson and Moreland 2009; Michinov and Michinov 2009). These studies suggest that teams with better TMSs will be more effective because a well-developed TMS enables each team member to keep track of the other member's expertise and to direct new information that matches that member's expertise to the appropriate member, as well as using that tracking to access needed information (Wegner 1986, 1995; Mohammed and Dumville 2001; Kozlowski and Ilgen 2006). In this way, team members use each other as external memory aids, thereby creating a compatible and distributed memory system (i.e., possessed by each team member).

TMSs have two components: structure, which is an organised store of knowledge; and processes, which comprise a set of knowledge-relevant transactive processes that occur among members. These include encoding, storage and retrieval processes (Wegner et al. 1985; Lewis and Herndon 2011). While the TMS structure is a knowledge representation of members' unique and shared knowledge (including members' shared understanding of who knows what), TMSs processes are the mechanisms by which the group coordinates the learning of individual members and the retrieval of knowledge so that the knowledge can be applied to group tasks (Lewis and Herndon 2011).

Prior studies on TMSs suggest that they begin to develop when members learn something about one another's expertise (Moreland et al. 1996; Moreland 1999; Brandon and Hollingshead 2004; Peltokorpi 2008; Lewis and Herndon 2011). When members interact during task processing as they train together, more information about the depth and validity of their knowledge can be obtained. This helps the team's understanding about who knows what to become refined, more accurate, and more similar across members (Liang et al. 1995; Moreland et al. 1996; Hollingshead 1998a; Moreland 1999; Austin 2003; Lewis 2004).

Notably, these studies were conducted in the context of group training with learning-by-doing (e.g., learning to assemble a radio using materials from a radio kit) (Liang et al. 1995; Moreland et al. 1996; Moreland and Myaskovsky 2000; Rulke and Rau 2000). These studies found that group learning can increase the efficiency of transactive processes by providing members with diagnostic feedback about the functioning of retrieval and communication activities and by helping to establish routines for interacting in the future (Lewis and Herndon 2011).

However, it is recognized in the TMSs literature that TMSs do not always have a strong relationship with performance for all types of tasks. Lewis and Herndon (2011) argued that TMS are most relevant for execute tasks (i.e. tasks that involve the actual performance or execution of operations (McGrath 1984) and divisible tasks (i.e., the tasks with a subtask structure, where different subtasks can be performed by different individuals with different skills and abilities (Steiner 1972; Larson 2010). As reviewed by Lewis and Herndon (2011), studies have found that TMSs are relevant for improving the performance of these types of tasks.

2.4.4. Training Interventions in Enhancing the Development of the Transactive Memory Systems of MDTs in Performing an Analytical Procedures Task

This section explores whether the two training interventions have an impact on TMS development. As analogical encoding does not focus on the knowledge relevant for TMS development, the use of this technique does not provide the knowledge necessary to develop TMSs. In addition, as outlined previously, the use of this technique at the team level leads to decreased team performance because of the increasing levels of difficulty (i.e., perceptions of the mental effort necessary for task execution) (Funke and Galster 2009). Learning to perform a complex task using this technique is mentally difficult, uses resources, and leaves individuals (and teams) with a reduction in available resources (e.g., information-processing capacity) for additional team task demands such as learning the knowledge relevant for TMS development (Funke and Galster 2009; Funke et al. 2012; Bedwell et al. 2014). Consequently, the use of the analogical encoding technique (i.e., problem-category comparison) may not be effective as a team-training intervention for improving TMSs. Based on these predictions, the following hypothesis is proposed, stated in the null form:

Hypothesis 22: *TMSs of MDTs that train using the analogical encoding technique are not more developed than TMSs of MDTs that train without the analogical encoding technique.*

As noted above, the notion of TMSs provides a cognitive explanation for the observation that teams that train together outperform teams that train as individuals (Liang et al. 1995; Moreland et al. 1996; Moreland 1999; Moreland and Myaskovsky 2000). These prior studies suggest that collaborative learning gives team members an opportunity to obtain direct knowledge and feedback on their performance when conducting real tasks (Brandon and Hollingshead 2004; Lewis et al. 2005; Lewis and Herndon 2011). The group training employed in these studies is similar to the collaborative learning technique (Jackson and Moreland 2009; Michinov and Michinov 2009). The improvement of the group's performance when trained using collaborative learning may occur via the development of TMSs. A similar result is expected in this study although the collaborative learning technique is used with the learning-by-examples method rather than learning-by-doing. Accordingly, the following hypothesis is offered:

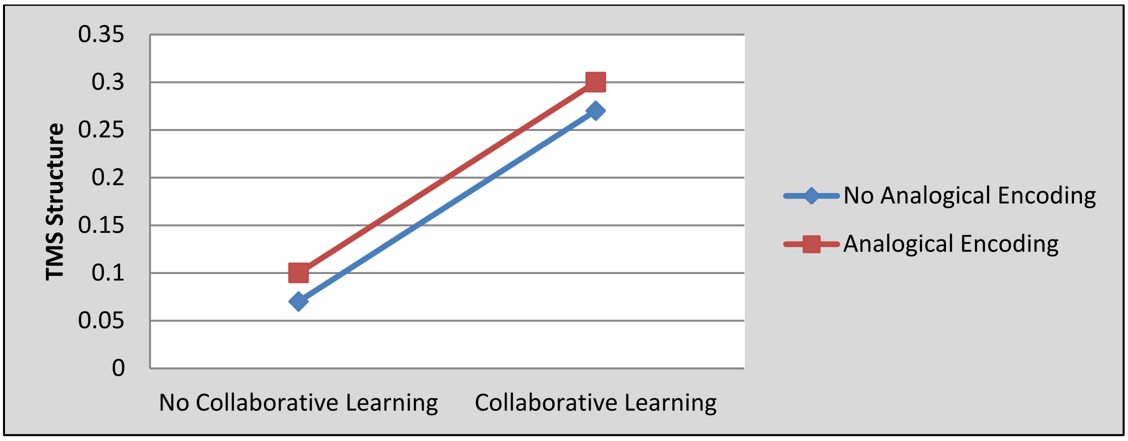
Hypothesis 23: *TMSs of MDTs that train using collaborative learning are more developed than TMSs of MDTs that train without the collaborative learning technique.*

Given that there are no effects on TMSs from the use of the analogical encoding technique, it is also predicted that these two training techniques will have no interaction effect. This leads to the following hypothesis:

Hypothesis 24: *TMSs of MDTs that train with and without the analogical encoding technique are more developed than MDTs that train using the collaborative learning technique.*

The expected results are summarised in Figure 2.14.

Figure 2.14. Expected Results for the Effect of Training Techniques on TMS Development



Source: Developed by the author based on arguments in Section 2.4.4.

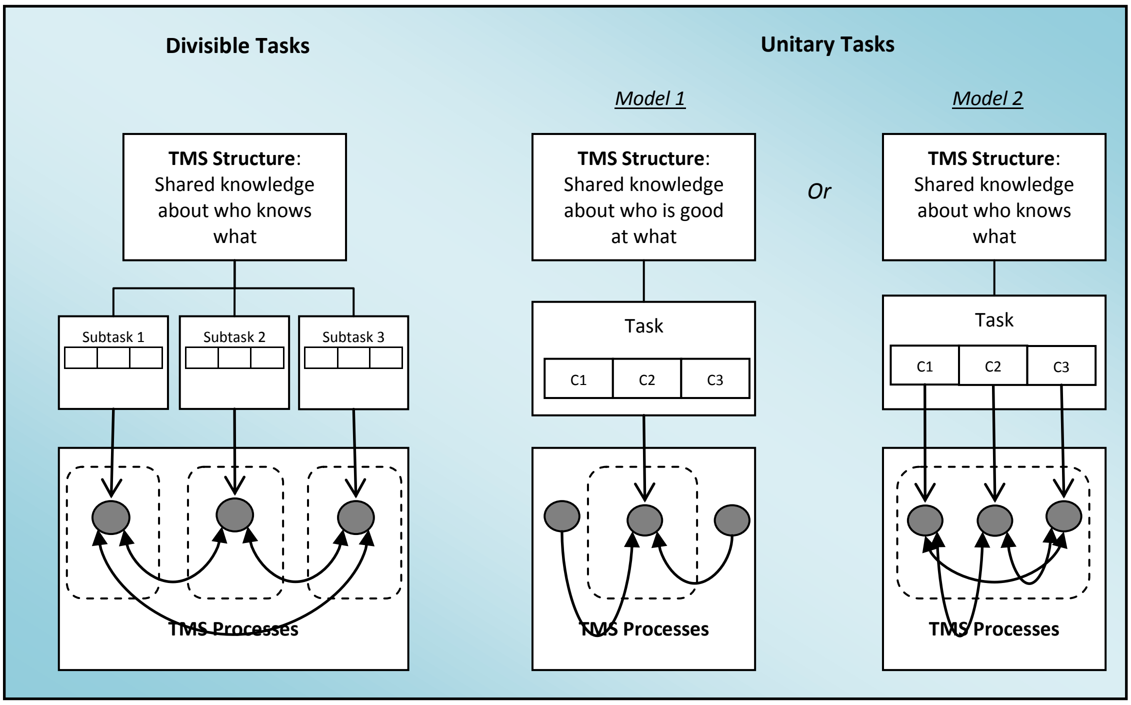
2.4.5. Transactive Memory Systems as a Mediator between Training Interventions and MDT Performance in an Analytical Procedures Task

This section explores the role of TMSs as a mediating variable between training and MDT performance. As outlined previously, prior research recognises that TMSs do not always have a strong relationship with performance for all types of tasks. TMSs are most relevant for execute and divisible tasks (Lewis and Herndon 2011). On the other hand, this thesis focuses on the analytical procedures task which is not categorised as an execute or divisible task. According to McGrath's (1984) task typology, an analytical procedures task can be categorised as a produce task (i.e., a task that involves generating ideas as in the hypothesis generation stage), and a choose task (i.e., a task that requires the group to give an answer or solution to a problem or challenge as in the final judgment stage). Alternatively, using another typology by Steiner (1972), Bedard et al. (1998) suggest that the analytical procedures task can be classified as unitary (i.e., a task that cannot be meaningfully divided into subtasks), optimising (i.e., a task whose goal is the production of some specific, desirable product) and disjunctive (i.e., a task where member inputs are combined into a single solution). In this way, the analytical procedures task is very different to the types of tasks previously used to examine the effect of TMSs on team performance. Due to the differences in the types of tasks examined in prior studies, it is possible that TMSs may not be relevant for MDTs performing an analytical procedures task.

As argued by Lewis and Herndon (Lewis and Herndon 2011), TMSs are relevant for task activities that involve produce and choose tasks but less relevant for unitary tasks. Produce tasks are likely to benefit especially from access to knowledge that is diverse, because that diversity can lead to a greater quantity of ideas (Larson 2010). In these tasks, recognising expertise helps members elicit information from the person most likely to contribute useful ideas. Produce tasks also benefit from integrations created by transactive processes, because combining the ideas of the different team members may lead to new and better ideas. It has also been argued that choose tasks are apt to benefit from a division of cognitive labour. Dividing the cognitive labour for the task will help members cope with cognitive demands of choose tasks, which require cycles of reviewing evidence, creating new hypotheses, and probing for new evidence (Larson 2010). Knowing who knows what will help members identify the person most likely to possess the correct solution or to come up with a superior alternative for the group to consider. Transactive processes that help members recall and discuss all available information and that help pool the expertise that is distributed across the group increase the chance that the group will find a solution or make a good decision on a choose task (Stasser and Stewart 1992). In addition, the individual and collective learning produced by transactive processes improves the performance of choose tasks because it increases the possibility of new solutions and ideas emerging out of task processing. Therefore, it can be argued that TMSs are also relevant for an analytical procedures task which is categorised as a produce and choose task.

Although Lewis and Herndon (2011) argue that TMSs are less relevant for unitary tasks, they are still relevant for a unitary task such as an analytical procedures task. Lewis and Herndon (2011) argue that this is because performance of these tasks does not depend on the application of diverse and specialised knowledge, nor on combining and integrating that knowledge. Their argument is based on the assumption that group members who perform unitary tasks usually have the same skills and abilities. However, in this study, members of the MDTs who perform the analytical procedures have diverse and specialised knowledge. Although the demand of unitary tasks does not allow an individual member to be assigned to perform specific subtasks on the basis of their specialised knowledge, this context still requires TMS structures to access diverse knowledge and TMS processes to help the team members pool expertise distributed across the group. The explanation of this argument is as follows. If a group performs a unitary task, group members can determine the way they perform the task by choosing one of two ways (Steiner 1972): (1) one member performs all phases of the task with the others assisting only if needed; or (2) they can work together on the one task (see Model 1 and 2 in Figure 2.15).

Figure 2.15. Transactive Memory Systems in Divisible and Unitary Tasks



Source: Developed by the author based on Steiner (1972) and Lewis and Herndon (2011).

In Model 1, the important knowledge in the TMS structure is who the most capable member is. On the basis of this knowledge, group members will have him or her complete the task. Neither pooling of expertise nor complex transactive processes are needed to perform the task. Thus, TMSs are less relevant for groups that use Model 1. In contrast, the required knowledge in the TMS structure in Model 2 relates not only to who is good at what but also includes the shared understanding of who knows what. Members need to pool their expertise to perform the task. Therefore, TMSs are more relevant for groups that use Model 2. In the MDT context, because no one can perform all the phases due to the complexity and diverse nature of the task, teams are less likely to use Model 1 and more likely to use Model 2. Based on this, it is argued that to some extent TMSs are relevant for MDTs performing an analytical procedures task.

It is therefore predicted that TMSs mediate the link between training interventions and MDT performance. The following hypotheses are proposed:

Hypothesis 25a: *TMSs mediate the link between the analogical encoding technique and MDT performance.*

Hypothesis 25b: *TMSs mediate the link between the collaborative learning technique and MDT performance.*

Hypothesis 25c: *TMSs mediate the link between a combination of the analogical encoding and collaborative learning techniques and MDT performance.*

2.5. Summary of Research Hypotheses

Table 2.5 summarises the research hypotheses proposed in this chapter. The table contains a hypothesis for every combination of the independent variables (in the columns) and the dependent variables (in the rows) for each stage of the analytical procedures task. The directional effects of the independent variables are also provided.

Table 2.5. Summary of Research Hypotheses

<table>
<tr><td rowspan="4">**Independent Variables**</td><td colspan="6">**Dependent Variables**</td></tr>
<tr><td>Performance at Individual Level</td><td colspan="5">Performance at Team Level</td></tr>
<tr><td colspan="6">Stage of Analytical Procedures Task</td></tr>
<tr><td colspan="3">Hypothesis Generation</td><td colspan="2">Hypothesis Evaluation</td><td>Final Judgment</td></tr>
<tr><td>*AE*</td><td>**H1** (0)</td><td colspan="2">**H4** (0)</td><td colspan="2">**H7** (+)</td><td rowspan="2"></td></tr>
<tr><td>*CL*</td><td>**H2** (+)</td><td colspan="2">**H5** (+)</td><td colspan="2">**H8** (+)</td></tr>
<tr><td>*AE* × *CL*</td><td>**H3** (+)</td><td colspan="2">**H6** (+)</td><td colspan="2">**H9** (+)</td><td>**H10** (+)</td></tr>
<tr><td></td><td rowspan="17"></td><td>TMM accuracy</td><td>TMM similarity</td><td>TMM accuracy</td><td>TMM similarity</td><td rowspan="17"></td></tr>
<tr><td>*AE*</td><td>**H11a** (+)</td><td>**H11b** (0)</td><td>**H17a** (+)</td><td>**H17b** (+)</td></tr>
<tr><td>*CL*</td><td>**H12a** (0)</td><td>**H12b** (0)</td><td>**H18a** (-)</td><td>**H18b** (+)</td></tr>
<tr><td>*AE* × *CL*</td><td>**H13a** (0)</td><td>**H13b** (+/-)</td><td>**H19a** (+)</td><td>**H19b** (0)</td></tr>
<tr><td></td><td>TMM accuracy as a mediator</td><td>TMM similarity as a mediator</td><td>TMM accuracy as a mediator</td><td>TMM similarity as a mediator</td></tr>
<tr><td>*AE*</td><td>**H14a** (+)</td><td>**H15a** (+)</td><td>**H20a** (+)</td><td>**H21a** (+)</td></tr>
<tr><td>*CL*</td><td>**H14b** (+)</td><td>**H15b** (+)</td><td>**H20b** (+)</td><td>**H21b** (+)</td></tr>
<tr><td>*AE* × *CL*</td><td>**H14c** (+)</td><td>**H15c** (+)</td><td>**H20c** (+)</td><td>**H21c** (+)</td></tr>
<tr><td>TMM accuracy and TMM similarity</td><td colspan="2">**H16** (+)</td><td colspan="2" rowspan="9"></td></tr>
<tr><td></td><td colspan="2">TMSs</td></tr>
<tr><td>*AE*</td><td colspan="2">**H22** (0)</td></tr>
<tr><td>*CL*</td><td colspan="2">**H23** (+)</td></tr>
<tr><td>*AE* × *CL*</td><td colspan="2">**H24** (0)</td></tr>
<tr><td></td><td colspan="2">TMSs as a mediator</td></tr>
<tr><td>*AE*</td><td colspan="2">**H25a** (+)</td></tr>
<tr><td>*CL*</td><td colspan="2">**H25b** (+)</td></tr>
<tr><td>*AE* × *CL*</td><td colspan="2">**H25c** (+)</td></tr>
</table>

AE represents the analogical encoding technique; *CL* the collaborative learning technique; and *AE* × *CL* is an interaction between the analogical encoding and collaborative learning techniques.

(0), (+), (+/-) represents the directional effects of independent variables. **(0)** represents the no directional effects, **(+)** represents the positive directional effects or ordinal interaction effects, whereas **(+/-)** represents the disordinal interaction effects.

CHAPTER 3

RESEARCH METHOD

3.1. Introduction

This chapter describes the research method used to collect data to test the hypotheses developed in Chapter 2. The experimental design and the independent variables examined in this thesis are outlined in Section 3.2. The participants involved in the study are described in Section 3.3. Section 3.4 describes the experimental procedure used to test the hypotheses. Section 3.5 provides a detailed description of the manipulation of the independent variables. Finally, Section 3.6 describes the dependent variable measures used in this thesis.

3.2. Experimental Design and Independent Variables

The experiment uses a 2 x 2 between-subjects factorial design with a control group. The control group is used to establish a base-line knowledge and performance level (i.e., with no specific analytical procedures training) for participants from the two disciplines. This enables the study to measure the learning effect from the analytical procedures training techniques. The two independent variables of interest in this thesis relate to the form of training received by participants, i.e., whether or not participants learned collaboratively with their fellow team member and whether or not they received analogical encoding training. In the no collaborative learning conditions, the participants learned individually without interacting with their fellow team member, whereas in the collaborative learning conditions participants learned together by interacting with the other team member. In the no analogical encoding conditions, the participants learned from two worked examples of an analytical procedures task, which they received sequentially and separately (i.e., they learned from the case 1 worked example and solution first and then from the case 2 worked example and solution). After completing each case, participants answered the same questions relating to the case. In contrast, while the participants in the analogical encoding condition received the same training material, they also received two diagrams which compared the problems and solutions for the two cases side-by-side (rather than separately after each case). They were then asked to compare and contrast the worked examples by answering the same specific questions concurrently for the two cases. This design resulted in four training conditions (see

Table 3.1): individual learning without analogical encoding (Condition 1), individual learning with analogical encoding (Condition 2), collaborative learning without analogical encoding (Condition 3) and collaborative learning with analogical encoding (Condition 4).

Table 3.1. Experimental Design

	Without Analogical Encoding	**With Analogical Encoding**
Without Collaborative Learning	*Condition 1*	*Condition 2*
With Collaborative Learning	*Condition 3*	*Condition 4*

3.3. Participants

Participants consisted of 152 postgraduate students at a large Australian university. This thesis examines the training and performance of MDTs in a GHG assurance setting. In order to form the multidisciplinary teams, the participants were recruited from two different educational backgrounds. Half the participants were recruited from a postgraduate accounting program, including the Master of Professional Accounting, Master of Commerce, and Master of Financial Analysis.[27] The other half were recruited from a postgraduate program that included one or more courses in environmental science or engineering, including the Master of Environmental Management and Master of Engineering.

The majority of the participants (*n* = 129, 85%) were recruited from the experimental laboratory subject pool set up by the university's School of Business. Participants were also recruited directly through invitation flyers distributed by attending relevant business and science postgraduate student courses and handing out 'invitation to participate' flyers (*n* = 23 15%) (**see** Appendix 1). These flyers requested interested students to sign up to the School of Business experimental laboratory subject pool in order to participate in the partly-computerised task in the School of Business's experimental laboratory.[28]

---

[27] Due to varied levels of accounting background in these accounting programs, to ensure the appropriateness of the participants, an important requirement was set for the accounting participants to ensure they had studied auditing (or were in at least their sixth week of semester studying auditing).

[28] The experimental laboratory subject pool set up by the university's School of Business consists of potential participants from all schools and programs in the university. Half of the participants were recruited from accounting programs and other half from environmental science and engineering programs registered in this subject pool.

In this thesis, students enrolled in an advanced level postgraduate program and who had limited or no work experience were recruited as research participants. This type of student is considered to be an appropriate participant pool for this study for several reasons. First, since the experiment in this thesis involves knowledge acquisition, it is important that participants do not already possess the knowledge that is the focus of the knowledge acquisition task. This participant choice is consistent with previous research examining learning environments in accounting (Bonner and Walker 1994; Bonner et al. 1997; Borthick et al. 2006; Brewster 2011). In addition, as this thesis aims to use a number of different training techniques in the development of specific knowledge structures, using student participants with no experience in GHG assurance engagements allows the study to effectively control and manipulate mental model development through training. The use of experienced practitioner participants with pre-developed knowledge structures would not facilitate the knowledge structure manipulation used in this thesis (Bonner and Walker 1994; Bonner et al. 1997; Borthick et al. 2006; Brewster 2011).

Second, such participants have attained basic knowledge and skills in their respective domain, which is indicated by their postgraduate status. This knowledge and skill set reflects that of actual practitioners who may be involved in the preparation and assurance of GHG statements.

Third, it can be argued that since analytical procedures is a task involving moderate to high levels of complexity and because such a task requires specialized knowledge that is normally acquired through professional experience (Bonner and Pennington 1991; Koonce 1993; Hirst and Koonce 1996), students or novices may not be appropriate for this task (Trotman 1996; Elliott et al. 2007; Liyanarachchi 2007; Mortensen et al. 2012). However, the use of novices in this study is consistent with the recent tendency in audit firms to assign analytical procedures tasks to less experienced staff (Trompeter and Wright 2010). As this study is motivated to provide empirical evidence relating to how to accelerate the acquisition of the specialized knowledge through training for less experienced staff, the use of students can be justified. As argued by Moreno et al. (2007), students are the most appropriate group for analytical procedures training because they possess necessary domain knowledge but lack enough training or experience in performing analytical procedures to have developed significant expertise (Bonner et al. 1997).

Participants were first placed into two groups depending on whether they were an accounting student or an environmental science/engineering student. Participants from each group were then randomly allocated to either a treatment group (n = 126) or a control group (n = 26). The 126 treatment group participants were further randomly allocated to one of the four treatment groups. The participants completed a two-hour experimental session after being randomly allocated to one of the specific training techniques examined in this thesis, hereafter referred to as the training conditions. Regardless of the training technique received by each participant, for the final task (an analytical procedures task) the participants worked in a two-person multidisciplinary team comprising one accounting and one engineering student. Completion of all stages of the task took two hours. As a token of appreciation for their participation, each of these participants received a payment of $45[29] in the form of a retail gift card. The gift cards were redeemable at major supermarkets and department stores. Additionally, in order to motivate participant performance, three further team payments were made.[30] A payment of $50 (i.e., one $25 retail gift card for each team member) was awarded to the team with the best performance result (as defined in the discussion of dependent variables in Section 3.6). Similarly, a payment of $40 (i.e., one $20 retail gift card for each MDT member) was awarded to the MDT with the second best performance, and a payment of $30 (i.e., one $15 retail gift card for each MDT member) was awarded to the MDT with the third best performance.

The 26 participants allocated to the control group completed a 25-minute experimental session including only the first few stages of the full task, i.e., the basic GHG training and the first stage only of the multi-stage experimental task. These participants did not receive training via any specific training technique and are hereafter referred to as the no training or control condition. Participants in the control condition completed the experimental tasks individually. Inclusion of this control group facilitated the determination of a base-line knowledge and performance level for participants from the two disciplines and thus made it possible to measure the learning effect from the training techniques. Each of these

---

[29] The rate of payment was determined using the rates recommended by the Business School Experimental Laboratory which ranged from $15 to $20 per hour. However, because of the cognitively demanding nature of the task used in this study and also to encourage participation from postgraduate students, the rate of payment was determined at $22.50 per hour.

[30] The purpose of the additional incentives is to motivate participants to perform as best as they could regardless of their experimental conditions. This is consistent with prior studies in accounting (e.g., Bonner and Walker 1994).

participants received a $10 retail gift card as their compensation for completing the task. No further compensation was received by the control condition participants.

All participants voluntarily participated in the experimental sessions. All were asked to read the participant information statement, which provided basic information regarding the experiment and to sign the informed consent form before commencing the experiment. These stages were required to fulfil ethics requirements for behavioural studies. See Appendix 2 for the participant information statement and the informed consent form used in this thesis.[31]

The final participant treatment pool consisted of 126 individual participants forming 63 two-person teams or dyads. There were 26 control condition participants. Participants in the training conditions (*n* = 126) were randomly assigned into 63 dyads to complete the experimental tasks. Each MDT consisted of one accounting student and one science/engineering student.

Demographic data presented in Table 3.2 reveals that most participants were aged between 20 and 25 (*n* = 108; 71%). The group included 49% males (*n* = 77) and 51% females (*n* = 75). The mean work experience of these participants was 1.0 years. [32] None of the participants had work experience in the preparation or assurance of GHG statements. The participants in the training conditions were not familiar with the other member of their team prior to the experimental session (mean familiarity = 1.78 on seven-point scale). The majority of participants were international students (*n* = 140, 92%). The statistical analysis indicates that there were no significant differences in age (χ^2 = 10.796, *p*-value = 0.546), gender (χ^2 = 1.158, *p*-value = 0.885), work experience (*F* = 1.210, *p*-value = 0.309), familiarity (*F* = 0.142, *p*-value = 0.935), student residency (χ^2 = 8.462, *p*-value = 0.076) and cognitive ability (*F* = 1.041, *p*-value = 0.389) across experimental conditions.

---

[31] The experiment was approved by the Ethics Committee of the University.

[32] Examples of work experience were work as a consultant in an engineering consulting firm (for engineers) and as an auditor in an accounting firm (for accountants).

Table 3.2. Descriptive Statistics for Demographic Variables

Demographic Variables	**Condition 0** **(*n* = 26)**	**Condition 1** **(*n* = 32)**	**Condition 2** **(*n* = 34)**	**Condition 3** **(*n* = 30)**	**Condition 4** **(*n* = 30)**	**Overall** **(*n* = 152)**
Age						
< 20 years old	0 (0%)	0 (0%)	0 (0%)	1 (3%)	0 (0%)	1 (1%)
20 – 25 years old	21 (81%)	26 (81%)	24 (71%)	18 (60%)	19 (63%)	108 (71%)
26 – 30 years old	5 (19%)	6 (19%)	8 (24%)	7 (23%)	11 (37%)	37 (24%)
> 30 years old	0 (0%)	0 (0%)	2 (6%)	4 (13%)	0 (0%)	6 (4%)
Gender						
Female	13 (50%)	16 (50%)	18 (53%)	17 (57%)	13 (43%)	77 (51%)
Male	13 (50%)	16 (50%)	16 (47%)	13 (43%)	17 (57%)	75 (49%)
Work Experience	0.79 (0.85)	0.80 (1.08)	0.89 (1.96)	1.63 (2.60)	1.00 (1.54)	1.02 (1.75)
Familiarity	n/a	1.88 (1.79)	1.65 (1.37)	1.77 (1.52)	1.83 (1.34)	1.78 (1.50)
Residency [33]						
International [34]	20 (77%)	29 (91%)	33 (97%)	28 (93%)	30 (100%)	140 (92%)
Domestic	6 (23%)	3 (9%)	1 (3%)	2 (7%)	0 (0%)	12 (8%)
Cognitive Ability	71.77 (6.39)	72.68 (6.28)	73.82 (7.14)	75.60 (8.58)	74.60 (8.14)	73.80 (7.44)

Condition 0: control group (participants received no training in analytical procedures task); **Condition 1:** participants received no collaborative learning and no analogical encoding training; **Condition 2:** participants received no collaborative learning and received analogical encoding training; **Condition 3:** participants received collaborative learning and no analogical encoding training; **Condition 4:** participants received collaborative learning and analogical encoding training. ***Work Experience***: measured by years of work experience. ***Familiarity***: measured by indicating participants' familiarity with their team members prior to the experiment (using a seven-point scale with end points 1 indicating not familiar and 7 indicating very familiar). ***Cognitive Ability***: measured by participants' self-reported academic performance (i.e., weighted average mark (WAM) using a 100-point scale).

3.4. Experimental Procedure

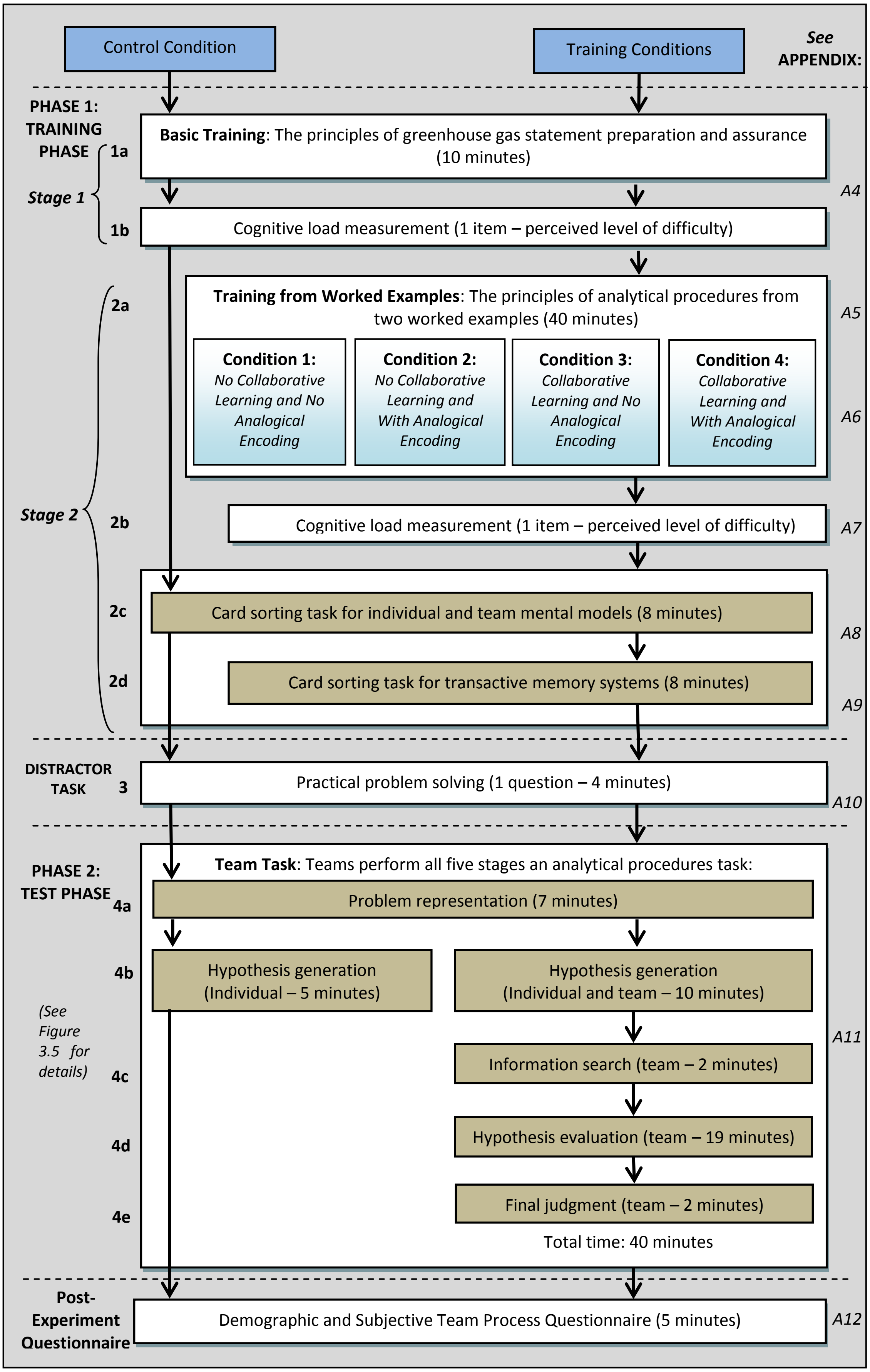
Figure 3.1 provides a diagrammatic representation of the experiment. The experiment was conducted in a controlled setting in the experimental laboratory and included a training phase and a test phase, with each phase involving several stages. All phases of the experiment were completed in a single two-hour sitting for the four training conditions. The no training control condition, where only the first phase and the initial stages of phase 2 were included in the task, was completed in a single 25-minute sitting.

---

[33] Given the relatively large proportion of participants who are international students, the results (i.e., individual performance) were reanalysed using participant residency status as a covariate. The results are inferentially the same when participant residency status is included as a covariate, indicating that it is not a significant covariate ($F = 0.388$, p-value = 0.534).

[34] The majority of participants (85%) are international students from Asian countries. Prior studies indicate that Asian cultures are categorized as collectivist cultures (e.g., Hofstede 1980; Triandis 1995). The extent to which their cultural background may affect the way that participants work as team members and in turn MDT performance is discussed in the limitation section in Section 5.4 of Chapter 5.

Figure 3.1. Experimental Procedure



The time allocated to each distinct phase and stage of the experiment was strictly monitored to ensure that any differences noted in outcomes were not due solely to extra time spent on a specific part of the task or on the overall task. The verbal instructions given during the experiment are provided in Appendix 3.

The materials for the training and test phases of the experiment were created with the assistance of a Big Four audit firm with expertise in GHG assurance. The Stage 1 training phase materials were created by the researcher and reviewed by an expert from the firm. The materials were also tested in workshops by academic staff in the accounting area. The materials for the Stage 2 training phase and the test phase were developed in conjunction with the firm. In this way the firm’s experience with GHG assurance practice enhances the external validity of the experimental materials. The firm provided input relating to all stages of the case development, including an expert opinion on the solution to the main test case. The cases were developed from actual GHG assurance engagements conducted by the firm, thus the expert confirmed that the task is routinely done by MDTs. The cases were also simplified to enable these materials to be used for educational purposes. The expert was aware that the task would need to be able to be completed by students with no GHG background and no audit experience and in the case of the science students, no audit training (i.e., have not studied auditing at university). The materials were reviewed by GHG assurers within the firm with both accounting and science backgrounds to ensure that both perspectives were adequately addressed. All materials were pilot tested using six postgraduate students (three accounting students and three engineering students) prior to the experimental sessions to ensure they were clear and could be completed within the strict time allocated to each stage. The experimental materials consisted of a training phase and a test phase. The training phase was completed from hardcopy material, whereas the test phase was completed using a computerised program. Each phase consisted of several stages as outlined below.

3.4.1. Training Phase

The training phase consists of two stages. Each stage is described in the following sections.

3.4.1.1. Stage 1 of Training Phase

In the first stage of the training phase, all participants (both in the training and control groups) received the same training on the principles of GHG emissions measurement and assurance (stage 1a). At the completion of this stage, participants provided a self-rated assessment of the level of difficulty for the materials. This was used to measure cognitive load during this stage (stage 1b).

The first stage of the training phase included a brief introduction to basic knowledge relating to reporting and assuring GHG emissions. The development of the training materials required the researcher to undertake significant research into the current GHG reporting and assurance requirements. This was necessary because the emerging state of the GHG assurance market and the unique characteristics of the subject matter involved meant that no relevant training materials or cases were available for use in the study. The training materials were created by the researcher through a process of reviewing current GHG reporting and assurance standards including government regulations and the GHG Protocol (del Pino and Bhatia 2002; WBCSD and WRI 2004, 2005; del Pino et al. 2006; StandardsAustralia 2006a, 2006b; Fransen et al. 2007; DEFRA 2009; DCCEE 2010c, 2010d, 2010b, 2010a). This material was then validated by the GHG assurance expert at the Big Four firm.

The stage 1a training material consisted of two pages (see Appendix 4). The material included information on climate change and its link to GHG emissions, the GHG emissions statement and GHG assurance. To provide an understanding of how to prepare a GHG emissions statement, the training materials describe five steps in processing emissions information. These steps include determining from which parts of the organisation the data needs to be collected; identifying which activities in the organisation release GHG emissions and the source of emissions from these activities; collecting activity data for the identified emission-releasing activities; converting activity data into GHG emissions by multiplying activity data by emissions factors; and gathering and summarising emissions from multiple locations, possibly in different countries and business divisions. In order to familiarise participants with the concepts, they were presented with an example of how to process emissions information in a company according to the five steps. Participants were given 10 minutes to read and learn this material. All participants (including the control group) received this training. On completion of the stage 1a training, participants rated the difficulty of the training materials on a seven-point Likert scale (stage 1b). They were allocated one minute to complete the rating. The answer to this question provided a measure of perceived cognitive load during learning. Analysis reveals that the participants rated this stage as moderately easy to understand (mean = 2.78 using a seven-point Likert-scale). There were no significant differences in cognitive load for this stage across experimental conditions (*F* = 0.203, *p*-value = 0.936).

3.4.1.2. Stage 2 of Training Phase

In the second stage of the training phase, the teams in the different training conditions were randomly allocated into one of the four experimental conditions: individual training without analogical encoding (Condition 1); individual training with analogical encoding (Condition 2); collaborative training without analogical encoding (Condition 3); and collaborative training with analogical encoding (Condition 4). Participants in the control group did not receive the second stage of training. A detailed description of training manipulation is provided in Section 3.5.

The stage 2 training material, which consisted of two separate training cases involving analytical procedures tasks in a GHG assurance setting, was given to all participants in the training conditions. The manner in which the participants were grouped while reviewing these cases differentiated the training condition. That is, in the no collaborative training conditions, participants were asked to complete this stage of learning individually, whereas in the collaborative training condition participants were assigned into a dyad (or team), consisting of one accounting student and one science/engineering student in order to facilitate collaborative learning between the dyad members. The manner in which the participants were instructed to use the two cases then differentiated the analogical encoding/no analogical encoding treatments. At the completion of the second stage, participants once again provided a self-rated assessment of the level of difficulty of the material as a measure of cognitive load during this stage. Analysis reveals that on average the participants rated this stage as moderately difficult (mean = 4.75 using a seven-point Likert-scale).

3.4.1.2.1. Training Material

The second stage of the training phase consisted of several distinct subtasks. All training condition participants received training material providing a detailed description of the role of analytical procedures in GHG assurance engagements (see Appendix 5).

The definition and steps involved in an analytical procedures task were described in a one-page introduction. Following this introduction, two training cases were provided as worked examples. The first example case related to a facility management business for commercial office buildings. The second case related to a supplier of food to supermarkets. Each case contained a seeded error to facilitate the use of analytical procedures to determine the error as well as the processes involved in error detection. The problem seeded into the first case indicated that the client had understated both GHG emissions and energy consumption by 10% compared to expected GHG emissions and energy consumption. In contrast, in the second case, the client overstated GHG emissions by 30% but there was no difference in energy consumption compared to expected amounts. Both cases included a list of potential explanations or causes for the differences noted. It was indicated that these explanations were generated by the assurance team engaged on the assurance. The two cases also included information on assurance tests and test results related to these potential causes.

Following the description of each of case, two identical questions were asked of all participants. The first question related to the hypothesis generation stage and asked the participants to explain how the assurance team in the cases would perform the comparison of key indicators and then generate the appropriate potential causes that may have led to the observed fluctuations (i.e., discrepancy between expected and reported amounts). The second question related to the hypothesis evaluation and final judgment stages. This question asked participants to explain how the MDT would evaluate the potential causes based on the given items of information related to the assurance tests and the result of tests and how they would then select the most likely cause. The purpose of these two training cases or worked examples was to train participants in the analytical procedures process. In particular, through using worked examples, the materials illustrated how to generate potential causes for the noted differences between expected and actual performance and how to evaluate those causes based on the results of evidence derived from the assurance tests performed. The cases provided step-by-step demonstrations on how to answer these two questions for each of the cases.

Solutions for the cases were provided to all training condition participants on the page following the training cases and included a brief explanation as to why the correct solution was, in fact, the correct solution (refer Appendix A5.3 and A5.5). The solution provided for the first question relating to the hypothesis generation process was accompanied with a presentation of the important indicators that should be considered. In addition, participants were given the reasoning that led to the identification of the specific category of cause (i.e., understatement of energy consumption in the first case and overstatement of emission quantifications in the second case). The answer also included the specific causal explanations or hypotheses that should be generated. In the first case, because the problem category was understatement of energy consumption, five potential causal explanations with specific types of errors/non-errors were provided to illustrate the causal explanations that should be generated in this problem category (see Appendix A5.3). In the second case, the problem category was overstatement of emission quantification; therefore, five potential causal explanations were provided to illustrate the causal explanations that should be generated in this problem category (see Appendix A5.5).

In each case, the answer provided for the second question (i.e., how potential causes are evaluated) was included in a table presenting the full analytical procedures process: i.e., a list identifying each potential casual hypothesis, the corresponding assurance test that should be selected to address each hypothesis, the test results and the evaluation of the results. This table demonstrated how to evaluate hypotheses. It also included a detailed example of the type of information that should be evaluated to identify the correct cause and to rule out the other hypotheses. The solutions also provide an example on how to conduct a sufficiency check when evaluating a hypothesis. In the first case, the generated non-error cause was sufficient to account for the identified fluctuation; therefore, it was selected as the most likely cause. However, in the second case, the generated non-error cause was insufficient to explain the noted fluctuation (i.e., the cause only explained 0.5% of the total 30% difference). Instead of the non-error hypothesis, in the second case, the generated error cause was selected as the most likely cause of misstatement because it substantially explained the observed difference between reported and actual GHG emissions (i.e., the cause explained 100% of the difference).

The solutions on how to select the most likely cause were shown in the last column of the tables and were explained in the space following the tables. The last column in the table for the first case indicated that the most likely cause was a non-error cause (i.e., the client consumed energy efficiently during the year through an energy efficiency program leading to a reduction in both energy and emissions), whereas the correct cause in the second case was indicated to be an emissions calculation error due to incorrect use of higher emissions factors. These two types of causes (i.e., error and non-error causes) were chosen for the training cases to ensure that participants understood that the fluctuation may come from both of these types of causes.

3.4.1.2.2. Knowledge Structure and Team Cognitive Structure Measurement: Stage 2c and 2d

After completing the training material stage, all participants were asked to individually complete two card-sorting tasks (stage 2c and 2d). The first card-sorting task (stage 2c) was conducted to measure the individual knowledge structures and TMMs. Each participant was provided with an identical set of 12 cards relating to hypotheses for the cause of the fluctuation of GHG emissions, each with a distinct potential explanation typed on it. Participants were asked to group these cards into categories. The contents of these cards are included in Table 3.2 and the specific written instruction is shown in Appendix 8. The results of the individual card-sorting task were also used to measure TMMs and were used in data analysis relating to Hypotheses 11 to 21. A detailed discussion of the purpose and operationalisation of this stage of the experiment is provided in Section 3.6.5.1.

The second card-sorting task was conducted to measure transactive memory systems (TMSs). This was used in data analysis relating to Hypotheses 22 to 25. Each participant was provided with an identical set of 12 cards, each with a distinct subtask typed on it relating to roles that would be performed by an audit team during the completion of a GHG analytical procedures task. These roles could be performed by each individual member or by both team members working together as a team. Participants were provided with four category header cards. These represented subtasks the participants believed that ***both*** accounting experts and environmental scientists/engineers would do together; subtasks they believed that both accounting experts and environmental scientists/engineers would do individually and separately; subtasks they believed that ***only*** accounting experts would do (environmental scientists/engineers would not do this task); and subtasks they believed that ***only*** environmental science/engineers would do (accounting experts would not do this task). Participants were asked to group the 12 cards into the four categories provided. The contents of these cards are included in Table 3.3 and the specific instruction to conduct this task is shown in Appendix 9. A further discussion of the purpose and operationalisation of this stage is provided in Section 3.6.6.1.

3.4.2. Distractor Task

After completing the final card-sorting task for the stage 2 training (i.e., stage 2d), participants were asked to individually complete a task that acted as a distractor task (i.e., stage 3). The inclusion of a distractor task is consistent with prior research (e.g., Bonner et al.

1996) and is included in order to clear participants' minds before performing the final task. The task used as a distractor was an unrelated task sourced from the financial problem-solving scenarios used in Devolder (1993). The problem-solving scenario describes a situation where the individual is unhappy with repairs to his/her television that cost him/her $125 because the television still has the same problem as before it was repaired. The participants were asked to write an essay about what they would do about this situation (see Appendix 10).

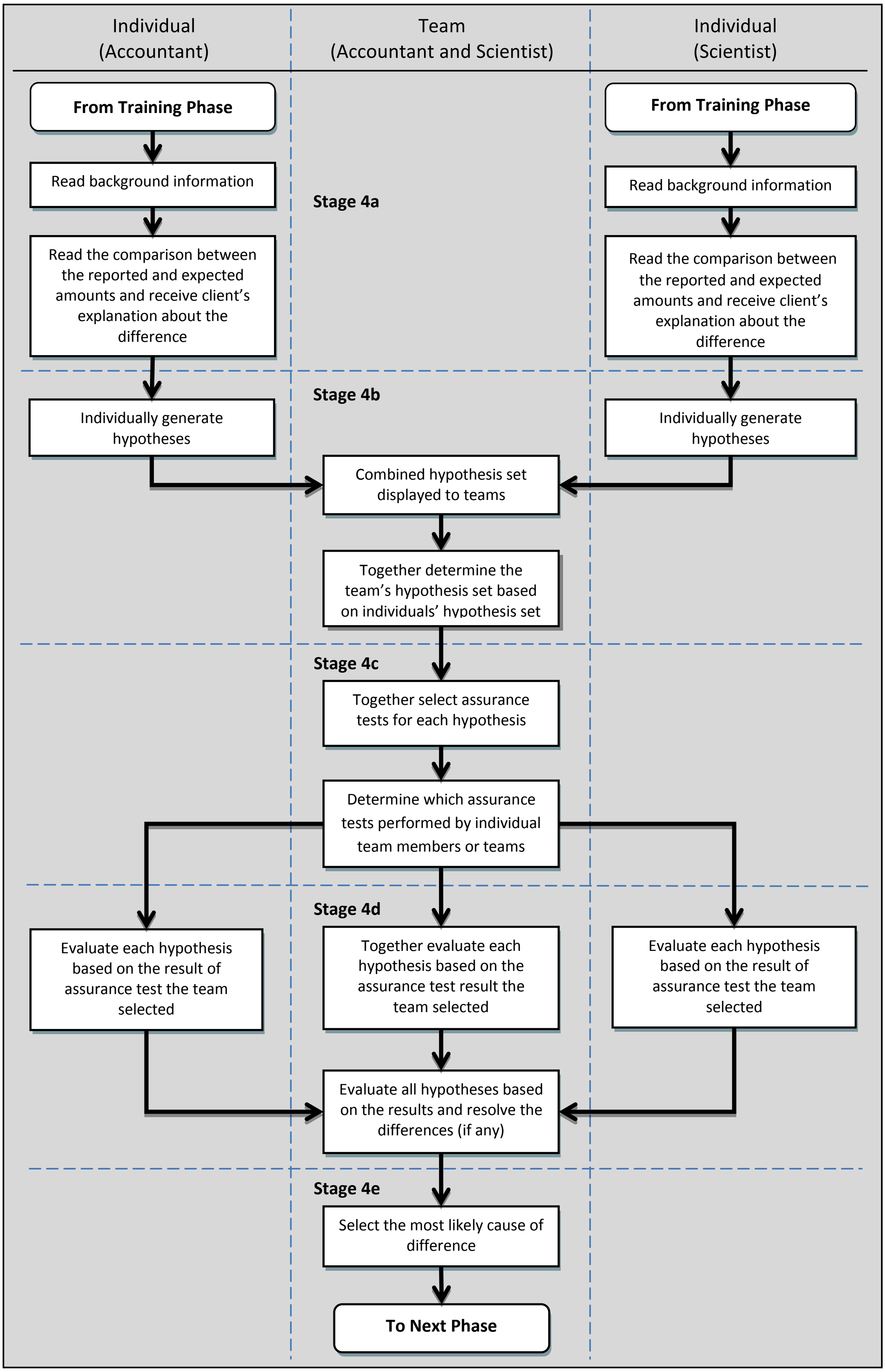
In addition to functioning as a distraction between the training and test phases of the experiment, the problem-solving scenario was intended to be used as a measure of cognitive ability or 'practical' problem-solving ability (PPSA) in a manner consistent with Devolder (1993). The Devolder (1993) PPSA scoring scheme uses a structured approach to analysing an individual's ability to solve complex problems. This scoring scheme includes whether the individual realises the problem(s), suggests a solution(s), makes effective use of available resources, avoids future negative consequences, references relevant information, formulates how to carry out the action required, and provides a solution that is specific and complete. Bierstaker and Wright (2001) provided evidence that this measure was useful in predicting the performance of both accounting students and experienced auditors on both analytical procedures and internal-control evaluation tasks.

3.4.3. Test Phase: Team Task

The next phase (i.e., stage 4) to be completed by the training condition participants was the test phase consisting of a multi-stage team task. Figure 3.2 illustrates the steps in this phase. The control group only completed stages 4a and 4b of this phase (individual hypothesis generation only). In this phase, participants were assigned to a dyad (team), consisting of one accounting student and one science/engineering student, to complete the multi-stage team task.

Participants who trained together in the collaborative training conditions were assigned the same partner to complete this phase as an intact team. This assignment is consistent with the use of intact teams in previous studies relating to group training studies (e.g., Liang et al. 1995; Moreland et al. 1996; Moreland 1999; Moreland and Myaskovsky 2000). The remaining participants were randomly assigned to a dyad consisting of one accounting student and one science/engineering student.

Figure 3.2. Test Case Procedure



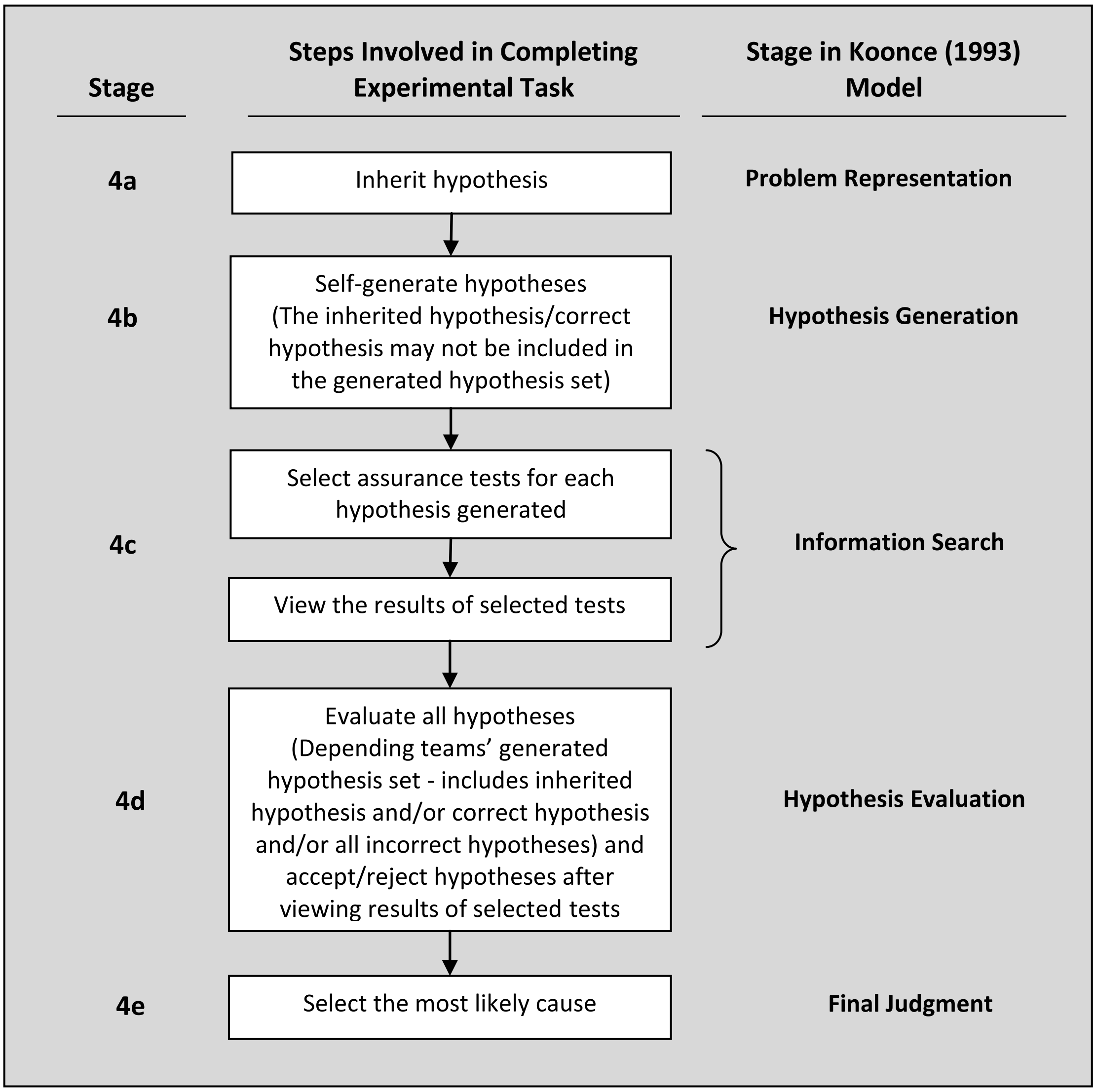
The team task required all participants to work in a team to perform an analytical procedures task in order to uncover the cause of a misstatement seeded into a set of GHG assurance working papers. Simulating auditing practice (Koonce 1993; Asare and Wright 2003; Green and Trotman 2003), training condition participants performed all stages of the multi-stage analytical procedures task (i.e., stages 4a – 4e) (including hypothesis generation, information search and hypothesis evaluation) prior to making a final judgment by nominating the most likely cause of the noted fluctuations.

In order to assess the effectiveness of the training techniques used in this thesis, a set of test materials covering the key GHG assurance concepts from the training material was developed in consultation with assurers from a Big Four accounting firm experienced in GHG assurance. Similar to the two training cases, the test case also contained a seeded cause; however the cause was different from those seeded into the training cases. The test case was computerised and was completed interactively in the experimental laboratory using a personal computer connected to a website that was specifically developed for the current study (see Appendix 11 for each of the computer screen shots that appeared during the experiment).

The relationships between the stages of the analytical procedures process and design of the experiment are shown in Figure 3.3. Because the four stages of the process were examined concurrently, the hypothesis set the participants generated during the hypothesis generation stage would be an input for the hypothesis evaluation stage and the final judgment. In this design, the participants self-generated the hypotheses and the hypotheses the participants evaluated and selected as the most likely were not provided by the experimenter.

A detailed description of the experimental procedures for the completion of the test case (Figure 3.2) is given in the following sections.

Figure 3.3. Analytical Procedures Process



3.4.3.1. Background Information and Problem Representation: Stage 4a

In the test phase of the experiment, regardless of the training technique previously received, the training participants worked in a team, or dyad, comprised of one accounting student and one science/engineering student to complete the test material. Participants were asked to read the GHG test case background material individually. The background information comprised three pages and described the client's products, production process, sources of emissions and energy use and its organisational boundary. In addition, comparative GHG statements were provided for two years, along with key ratios (i.e., energy consumption intensity) and the percentage change in the ratios.

Participants were then directed to the significant variance between the actual and projected results. They were told that the projections were developed by a highly reliable software package used by their firm and were computed from projections of the client's current activity data and relevant emission factors, last year's data, and industry trends. The background material indicated that the client had understated the emissions by 20.4% but had reported energy consumption as expected. Participants were also told that, based on discussions among assurance team members, their assurance team has determined that the difference is considered to be unexpected and material because the materiality threshold was 4%.

3.4.3.2. Hypothesis Generation: Stage 4b

In generating hypotheses, there were two steps that the participants undertook. First, they generated potential hypotheses individually. All these hypotheses were then compiled by the computer program and automatically presented as a single set of hypotheses to the two participants on one team member's computer screen to facilitate their work as a team. At this point, the two participants moved to a single computer screen and worked together. The second step required MDT members to discuss together the combined set of generated hypotheses and to select from the combined list of hypotheses which of the hypotheses should be included in the team's hypothesis set for further audit work.

This design was chosen for several reasons. First, this design allows the measurement of the dependent variables. By generating hypotheses individually, the individual team member's ability can be measured for testing Hypotheses 1, 2 and 3. The MDT performance in hypothesis generation for testing Hypotheses 4, 5 and 6 could then be measured after the team selected the team list from the lists generated by the individual team members.

Second, this design eliminates the effects of a number of process gains and losses that frequently arise when teams perform their tasks. Specifically, by generating the hypotheses individually, the participants can avoid suffering from *production blocking*, a type of process loss.[35] Production blocking occurs when individuals forget ideas they are thinking about while waiting their turn to speak in the group. It also occurs when listening to the ideas of other

---

[35] This type of process loss has been investigated in research on brainstorming, a method of idea generation in group problem solving that is designed to free the individual members from the inhibiting effects of self-criticism and criticism by others during problem-solving sessions (Osborn 1957). To examine the effectiveness of this method, prior studies generally compare the productivity of interactive groups of individuals with the same number of individuals working alone (nominal groups). The consistent finding is that interactive groups are not able to produce as many ideas as the nominal groups (e.g., Diehl and Stroebe 1987, 1991).

group members as this may distract and interfere with their thinking (Diehl and Stroebe 1987) and ultimately affect groups' retrieval performance (Weldon and Bellinger 1997; Rajaram and Pereira-Pasarin 2010; Rajaram 2011). In hypothesis generation, it is possible that when retrieving hypotheses from memory, team members, who are unable to speak while the other members are speaking may forget or suppress their hypothesis as it seems less relevant or less original at a later time (Bedard et al. 1998).

This design also eliminates *cognitive interstimulation*, a type of process gain that occurs when team members generate hypotheses together. This process gain occurs when team members support each other in the memory retrieval process by pooling their knowledge. Here, the responses of other group members may serve as synergistic retrieval cues or prompts and cause others to retrieve additional hypotheses (Hill 1982; Casey et al. 1984; Larson 2010).

By eliminating these two sources of process gains and losses, this study is able to focus on three other sources of process gains and losses (i.e., information/knowledge pooling, failure to recognise another team member's expertise and conformance pressure). The first source of process gain is *informational factor* (information/knowledge pooling) both in memory retrieval and in the plausibility assessment processes. This occurs due to the higher amount of information possessed by team members and provides the team with diverse inputs, perspectives and points of views. This leads to the creation of more hypotheses of a higher quality (Hill 1982; Casey et al. 1984; Bedard et al. 1998).

Second, this study is able to focus on process losses that occur when there is a *failure to recognise a team member's expertise.* This occurs when team members do not know who is good at what or what other members know. As a result, they are less likely to elicit information from the team member who is most likely to contribute useful hypotheses and they fail to integrate their ideas with the other team member's ideas. Such integration might have led to new and better hypotheses (Libby et al. 1987; Littlepage and Silbiger 1992; Larson 2010; Lewis and Herndon 2011).

The third source of potential process loss is *conformance pressure*, which occurs when: (1) team members suppress alternative hypotheses during memory retrieval and also suppress perspectives that are needed to check hypothesis consistency and plausibility; (2) team members are reluctant to correct another member's errors or criticise them due to politeness or to avoid embarrassing other members when conducting the plausibility assessment; and

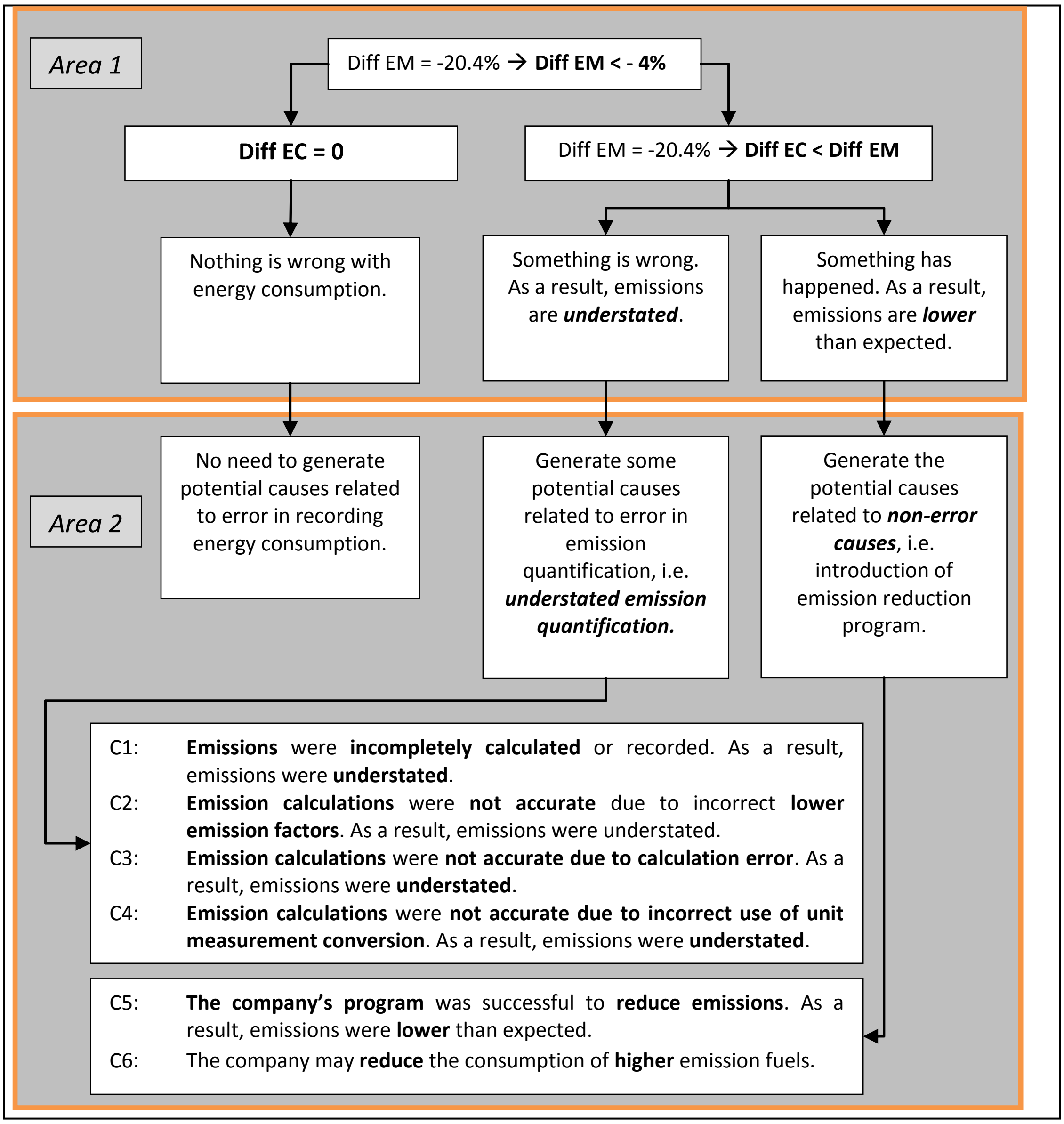
(3) team members combine or aggregate hypotheses without thorough consistency-checking and hypotheses estimation processes (Deutsch and Gerard 1955; Ismail and Trotman 1995; Gruenfeld et al. 1996; Brodbeck et al. 2007).

This design also allows the study to focus only on the consistency-checking stage and eliminates the hypotheses estimation stage in hypothesis generation. As suggested by prior studies (Gettys and Fisher 1979; Gettys et al. 1980; Fisher et al. 1983; Gettys et al. 1986), people internally generate hypotheses after conducting a two-stage process: (1) a memory retrieval process and (2) a separate plausibility assessment process. In the plausibility assessment, the hypotheses can be subjected to one or more stages (Fisher 1987): (1) checking a hypothesis for consistency against problem information; (2) estimating the likelihood of a hypothesis being the actual cause; and (3) estimating the likelihood that a set of hypotheses contains the actual cause. As the experimental design did not allow the participants to generate additional hypotheses after the team hypothesis set was selected from the list generated by the individuals, the second and third processes were eliminated. The results of the current study must be assessed by considering this design.

In the experiment, participants were asked to self-generate the hypotheses; therefore although they received the inherited hypothesis in the preceding stage, they may not include the inherited hypothesis in their hypothesis set. Similarly they may not generate a correct hypothesis in their hypothesis set.

Figure 3.4 illustrates how the hypothesis generation is correctly conducted for this case. As shown in Figure 3.4, after identifying that the emissions were lower than expected and that there was no fluctuation in energy consumption, the teams should: (1) generate hypotheses related to an error in emission quantification, i.e., understated emissions quantification; (2) generate hypotheses related to non-error causes, i.e., introduction of an emissions reduction program; and (3) not generate potential causes related to errors in recording energy consumption. As shown in Figure 3.4, there are six hypotheses that could be generated to fit these categories.

Figure 3.4. The Correct Hypothesis Generation and the List of Plausible Hypotheses



C1: **Emissions** were **incompletely calculated** or recorded. As a result, emissions were **understated**.

C2: **Emission calculations** were **not accurate** due to incorrect **lower emission factors**. As a result, emissions were understated.

C3: **Emission calculations** were **not accurate due to calculation error**. As a result, emissions were **understated**.

C4: **Emission calculations** were **not accurate due to incorrect use of unit measurement conversion**. As a result, emissions were **understated**.

C5: **The company's program** was successful to **reduce emissions**. As a result, emissions were **lower** than expected.

C6: The company may **reduce** the consumption of **higher** emission fuels.

3.4.3.3. Hypothesis Testing: Stage 4c

After reaching consensus on the team hypothesis set, participants were then provided with eight possible assurance tests they could elect to perform. A list of the assurance tests provided to participants is presented in Table 3.3. They were then asked to select the appropriate assurance test for each hypothesis included in their set of agreed hypotheses. Team members were also asked to decide how they would allocate the hypothesis testing between the two team members. They were able to choose between performing the assurance tests together as a team or, alternatively, they could choose to have some or all of the assurance tests performed individually for some or all potential causes.

Table 3.3. List of Assurance Tests Provided to Participants

No.	Assurance Tests
1.	By type of energy and facility, compare the energy consumption as input to emission calculations to reported energy consumption.
2.	Review and test the appropriateness of the use of emission factors in emission calculations.
3.	Review and test the organisation's method for determining facilities and emission sources under operational control.
4.	Review and test the input data and unit measurement to emission calculations.
5.	Review and test the organisation's method for measuring and calculating energy consumption.
6.	Review the organisations' energy efficiency program.
7.	Compare reported energy consumption and back to summary in financial reports and agree to source documents.
8.	Review and test the processing steps in calculating and aggregating emissions.

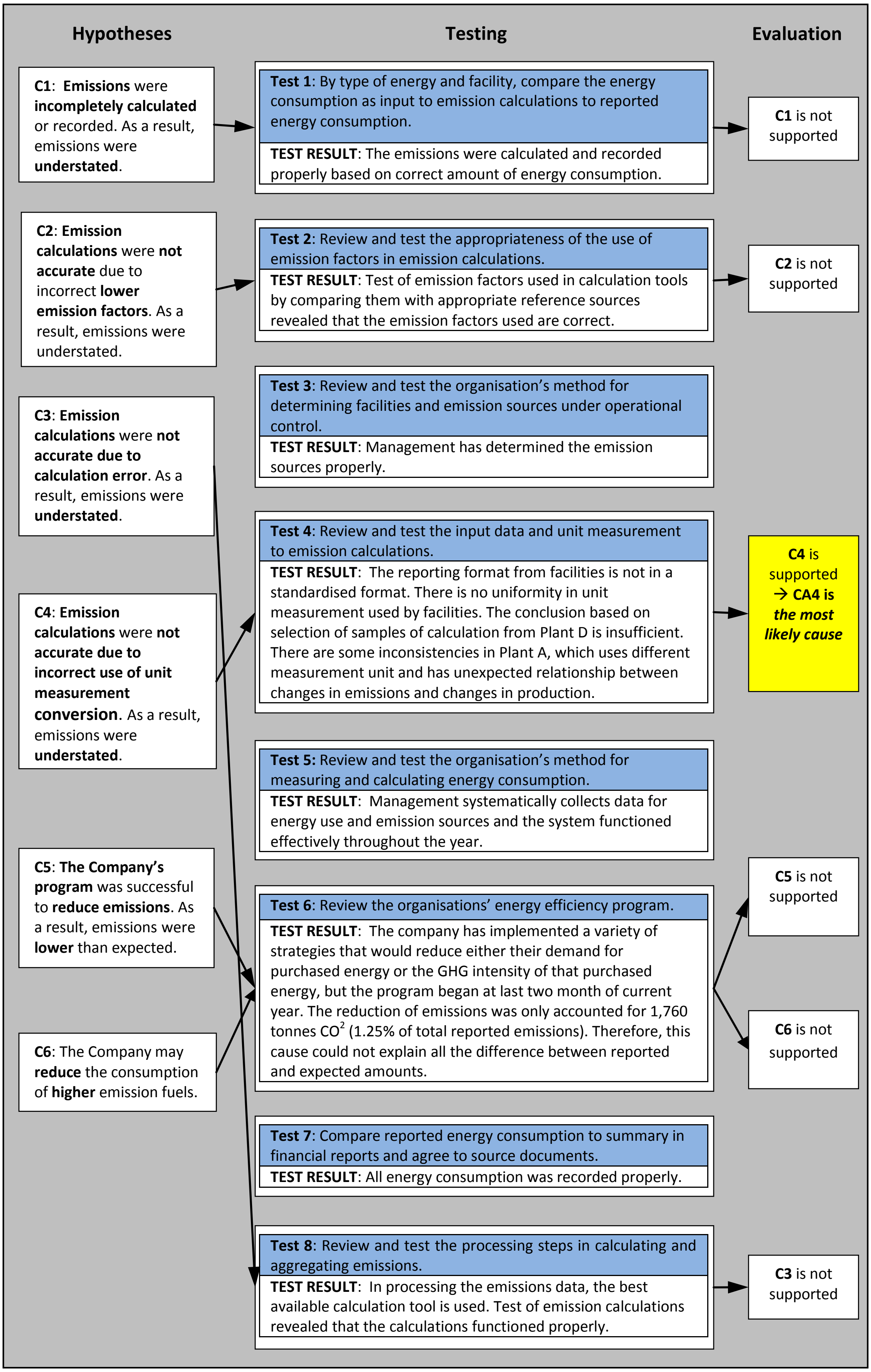
If the tests were allocated to individual team members, after the individual completed the test and provided their decision on the outcome of the test, the team discussed this and determined the team decision regarding the test outcomes later. Figure 3.5 presents the appropriate assurance test for each plausible hypothesis. As shown in Figure 3.5, from six plausible hypotheses, the team can select and allocate five appropriate assurance tests.

3.4.3.4. Hypothesis Evaluation: Stage 4d

The next step was hypothesis evaluation. Although evaluation of individual hypotheses could be performed individually by one team member or by both team members together, depending on the allocation of tests in the previous stage, the final evaluation is based on team discussion. After viewing the results of the test, participants were asked to evaluate each hypothesis by answering 'yes' or 'no' to whether each hypothesis was the likely cause. They answered 'no' if they thought that, based on the results provided, the cause was not the likely cause or 'yes' if they thought that the cause explained the difference.

Participants were also asked to provide an explanation for their evaluation (see Appendix 11 for computer screens displaying these steps). If an individual team member performed this evaluation, his/her response was then discussed at the team level. The team was required to reach a consensus and resolve any differences between team members in order to determine the team's decision. To facilitate this, the other team member was able to check the assurance test performed by the first team member in order to review and confirm the other team member's response.

Figure 3.5. The Correct Hypothesis Testing and Evaluation



Hypotheses

C1: **Emissions** were **incompletely calculated** or recorded. As a result, emissions were **understated**.

C2: **Emission calculations** were **not accurate** due to incorrect **lower emission factors**. As a result, emissions were understated.

C3: **Emission calculations** were **not accurate due to calculation error**. As a result, emissions were **understated**.

C4: **Emission calculations** were **not accurate due to incorrect use of unit measurement conversion**. As a result, emissions were **understated**.

C5: **The Company's program** was successful to **reduce emissions**. As a result, emissions were **lower** than expected.

C6: The Company may **reduce** the consumption of **higher** emission fuels.

Testing

Test 1: By type of energy and facility, compare the energy consumption as input to emission calculations to reported energy consumption.

TEST RESULT: The emissions were calculated and recorded properly based on correct amount of energy consumption.

Test 2: Review and test the appropriateness of the use of emission factors in emission calculations.

TEST RESULT: Test of emission factors used in calculation tools by comparing them with appropriate reference sources revealed that the emission factors used are correct.

Test 3: Review and test the organisation's method for determining facilities and emission sources under operational control.

TEST RESULT: Management has determined the emission sources properly.

Test 4: Review and test the input data and unit measurement to emission calculations.

TEST RESULT: The reporting format from facilities is not in a standardised format. There is no uniformity in unit measurement used by facilities. The conclusion based on selection of samples of calculation from Plant D is insufficient. There are some inconsistencies in Plant A, which uses different measurement unit and has unexpected relationship between changes in emissions and changes in production.

Test 5: Review and test the organisation's method for measuring and calculating energy consumption.

TEST RESULT: Management systematically collects data for energy use and emission sources and the system functioned effectively throughout the year.

Test 6: Review the organisations' energy efficiency program.

TEST RESULT: The company has implemented a variety of strategies that would reduce either their demand for purchased energy or the GHG intensity of that purchased energy, but the program began at last two month of current year. The reduction of emissions was only accounted for 1,760 tonnes CO^2 (1.25% of total reported emissions). Therefore, this cause could not explain all the difference between reported and expected amounts.

Test 7: Compare reported energy consumption to summary in financial reports and agree to source documents.

TEST RESULT: All energy consumption was recorded properly.

Test 8: Review and test the processing steps in calculating and aggregating emissions.

TEST RESULT: In processing the emissions data, the best available calculation tool is used. Test of emission calculations revealed that the calculations functioned properly.

Evaluation

C1 is not supported

C2 is not supported

C4 is supported → **CA4 is *the most likely cause***

C5 is not supported

C6 is not supported

C3 is not supported

As shown in Figure 3.5, from the five appropriate assurance test results available, the teams should be able to evaluate that only one test result confirms that is supported. The inherited hypothesis (i.e., the company's program was successful in reducing emissions) was not supported by Test No. 6 (i.e., review the organisation's energy efficiency program). As indicated by the test results, the reduction of emissions only accounted for 1,760 tonnes CO^2 (1.25% of total reported emissions). Therefore, this hypothesis could not explain all of the difference between the reported and expected amounts and thereby did not satisfy the sufficiency check. Based on these test results, the teams should not accept the evidence to support the inherited hypothesis. On the other hand, the results of Test No. 4, (i.e., review and test the input data and unit of measurement for the emission calculations) indicate that the reporting format from the facilities is not in a standardised format and there is no uniformity in unit measurements used by the facilities.

Furthermore, the sample of calculations from Plant D is insufficient. In addition, there are some inconsistencies in Plant A, which uses a different unit of measurement and also has an unexpected relationship between changes in emissions and changes in production. The teams should evaluate the results of Test No. 4 as supporting the hypothesis that emission calculations were understated due to incorrect use of unit of measurement conversion.

In this stage, participants evaluated the hypotheses they generated during the previous stage. Because the hypotheses were self-generated (not provided by the experimenter), not all teams included the inherited hypothesis and correct hypothesis in their hypothesis set.

3.4.3.5. Final Judgment as the Most Likely Cause: Stage 4e

The final stage required the teams to nominate the most likely cause for the noted fluctuation. This final judgment was made based on the team's evaluation of hypotheses in the previous step. They were also asked to provide an explanation of their final judgment in order to document their judgment. This documentation is important in order to ensure that the final judgment was a considered opinion not just a guess. This stage was included because although the analytical procedures task is characterised as an iterative process, since the auditor may reperform components if necessary (Koonce 1993), the design of the experimental procedures in this thesis did not allow the participants to reperform the hypothesis generation stage to generate a new hypothesis, nor to reperform hypothesis testing and evaluation. Instead, the participants were allowed to generate a new hypothesis in their explanation if they thought that the generated hypotheses were not supported by the results of assurance tests. As shown in Figure 3.5, of six plausible hypotheses only one hypothesis (i.e., emission calculations were understated due to incorrect unit of measurement conversion) was supported and this should be nominated as the most likely cause of the observed fluctuation.

3.4.4. Post-Experiment Questionnaire

Finally, all participants were asked to complete demographic questions relating to age, gender, work experience, familiarity and residence status. The specific items in the questionnaire are shown in Appendix 12.

3.4.5. Control Group Participants

In addition to the primary analysis using the four training condition treatments, an additional analysis was also conducted to compare these conditions with the control group. The control group was included in order to allow the determination of the base line, or inherent knowledge structure differences between participants with an accounting and a science/engineering background. This group of control participants were required to complete only stage 1 of the test phase in addition to the stage 1 basic training phase and the knowledge structure measurement card-sorting task in stage 2c of the training phase.

The participants in the control group condition received the same Stage 1 training phase training on GHG emissions measurement principles and assurance as the four training condition treatments, but did not complete all of Stage 2 of the training phase. After the 10-minute basic principles learning stage (i.e., stages 1a and 1b), the control group proceeded directly to perform the first 8-minute card-sorting task (i.e., stage 2c) to measure their individual knowledge structure. Participants then completed the 7-minute individual hypothesis generation stage (i.e., stage 4a) of the test phase (i.e., they individually generated potential hypotheses based on the observed fluctuation. All time constraints were consistent with those applied to the training condition groups. The participants’ responses from this group were compared with those of participants in the training conditions and analysed as part of the additional analyses.

3.5. Manipulation of Independent Variables

Table 3.4 provides to describe training manipulation. The detailed discussion of the operationalisation of the manipulation of the independent variables is provided in the following four sections.

Table 3.4. Training Manipulation

Training Procedures	Training without the Analogical Encoding and the Collaborative Learning Technique	Training with the Analogical Encoding Technique and without the Collaborative Learning Technique	Training without the Analogical Encoding and with the Collaborative Learning Technique	Training with the Analogical Encoding and the Collaborative Learning Technique
Receive two different worked examples along with solutions for the two cases, which included explanatory diagrams.	✓	✓	✓	✓
Read and answer four prompt questions relating to the first case and then read and answer the same four prompt questions for the second case.	✓	✗	✓	✗
Read the cases and receive the two solution diagrams side-by-side and compare and contrast the problems and solutions in the two cases and answer the four prompt questions.	✗	✓	✗	✓
Work collaboratively with their fellow team member to answer the four prompt questions.	✗	✗	✓	✓

3.5.1. Training without the Analogical Encoding Technique

In this condition, all participants received and reviewed the training material sequentially for one case, followed by the second case. Each participant was provided with the same two different cases along with solutions for the two cases, which included explanatory diagrams, i.e., worked examples. After reading the problems, solutions and accompanying explanatory diagrams for the first case, each participant was asked to answer four questions (outlined below) relating to that case prior to reviewing the second case and answering the same four questions (see Appendix 6 for complete training manipulation). The first question asked participants to 'Describe how the assurance teams in the cases made comparisons between expected and reported amounts and then think about the possible reasons that may have caused the fluctuations.’ The second question is: ‘Describe how the team in Case A (B) generates the potential causes that led to the observed fluctuations.’ The next question is: ‘Describe why the team in Case A (B) generates these five potential causes.’ Finally, the last question is: ‘Describe how the team in Case A (B) evaluates the potential causes based on the results of the assurance test and selects the most likely cause.’

The first three questions relate to the mental representation and hypothesis evaluation stages of the analytical procedures task. The purpose of the first question is to help participants recognise patterns in the key indicators provided in the cases and to develop their understanding of the problem situation. This assists development of mental representations (Koonce 1993). The cases provide the participants with training to help them identify the key indicators that are needed in order to make judgments about the problem situation. For example, in the first case their attention can be drawn – by learning the diagram provided – to the fact that the client had understated GHG emissions and energy consumption by 10% compared to the expected GHG emissions and energy consumption and that the difference was material (more than the 3% materiality threshold). This information should help participants recognise that GHG emissions and energy consumption indicators are important in understanding the problem situation. Participants’ attention is also drawn to the possible reasons that may cause the fluctuations through learning whether the fluctuation in the GHG emissions is the same or a different magnitude to the fluctuation in energy consumption. After noting that the fluctuation in energy consumption is materially lower (i.e., not the same magnitude as compared to the fluctuation of GHG emissions) through the first diagram, participants’ attention is drawn towards realising that something is wrong with the energy consumption amount, i.e., either energy consumption is understated or something has happened to cause energy consumption to be lower than expected. Through the diagram provided, participants’ attention is also drawn to the fact that they can rule out the possibility of an error in the quantification of emissions.

The purpose of the second question was to help participants diagnose the possible causes of the fluctuation on the basis of pattern recognition of identified key indicators. For example, in the first case, the first possibility was that energy consumption had been erroneously understated. The team should therefore generate potential causes related to an error in recording energy consumption. The second possibility was related to non-error causes, (i.e., more or less energy and/or emissions due to introducing an energy efficiency program or external factors such as weather). The team in the training cases had to generate hypotheses from this category. The diagram provided presented this hypothesis generation process.

The purpose of the third question was to encourage participants to think about the membership of hypotheses in the identified categories to enable them to generate the complete set of hypotheses. The participants were also able to provide an explanation as to why a particular hypothesis was included in the hypothesis set. By answering this question, the participants were expected to be able to explain why different types of hypothesis can be generated in a particular identified category.

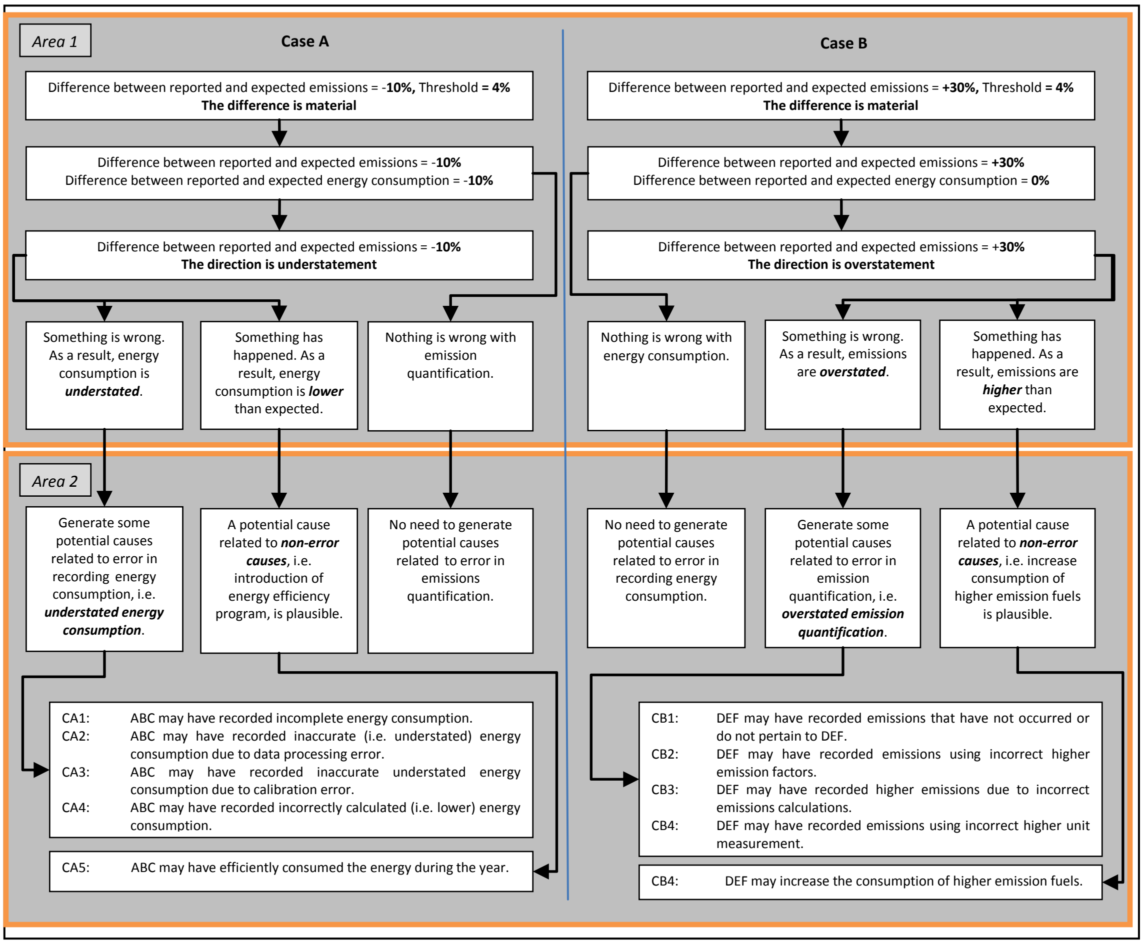
The final question relates to the hypothesis evaluation stage of the analytical procedures task. This question asked participants to describe how the assurance teams in the training case examples evaluated the potential causes based on the results of assurance tests, and how the teams selected the most likely cause. The purpose of this question was to help participants think about the correct way to evaluate hypotheses by explaining why a particular hypothesis was supported by the results of assurance tests and why other hypotheses were not supported. The diagrams provided with the training material facilitate the learning activity by presenting the appropriate assurance test and the correct evaluation of the test result for each potential cause.

This no analogical encoding condition is consistent with the separate cases condition used in previous analogical encoding studies (Gick and Holyoak 1983; Catrambone and Holyoak 1989; Loewenstein et al. 1999; Thompson et al. 2000; Kurtz et al. 2001; Gentner et al. 2003; Loewenstein et al. 2003) where the participants were instructed to analyse each case individually (i.e., read and answer the first case and then to read and answer the second case). As discussed in Chapter 2 Section 2.2.4, this condition actually promotes deep learning and processing about each case (i.e., it requires participants to dive deep into each case and answer the prompts within each case), however as outlined in Section 2.2.2.2, training with this condition, individuals may focus mainly on the features of the presented material and thus they tend to encode them in a more concrete, context-specific manner. It may lead individuals to organise knowledge in a superficial structure by not appreciating structural features in the presented material that would be highly useful when resolving a new problem with similar structural features (Gentner and Markman 1997).

3.5.2. Training with the Analogical Encoding Technique

In this condition, each participant was asked to perform an analogical encoding training exercise. Analogical encoding is operationalised via the detailed comparison of two worked examples (Gentner et al. 2003). In particular, after receiving the two different cases involving analytical procedures in a GHG assurance engagement setting (the two cases are presented in Appendix 5**)**, the participants in this condition next received the two solution diagrams side-by-side. This design was used in order to allow comparison of the problems and solutions in both cases (see Figure 3.6). The participants were asked to compare and contrast the problems and solutions in the two cases and to answer the four questions (see Appendix 6 for the provided answer template).

Figure 3.6. Comparison of Worked Examples for Hypothesis Generation in the Analogical Encoding Conditions



Prior studies in analogical encoding (Catrambone and Holyoak 1989; Gentner et al. 2003) suggest that designing a comparison instruction or prompt is important to increase learning outcomes. Explicit instructions that included specific comparison prompts are found to lead to better learning outcomes than simply presenting the examples side by side or giving generic prompts to compare the two examples (Catrambone and Holyoak 1989; Loewenstein et al. 1999; Thompson et al. 2000; Loewenstein et al. 2003). As a result, the four questions or prompts included at the end of the case material were carefully designed to facilitate the constructive learning activity in two important cognitive processes in an analytical procedures task: hypothesis generation and hypothesis evaluation.

The first three prompt questions relate to the mental representation and hypothesis evaluation stage of the analytical procedures task. As argued in Chapter 2, the use of problem-category comparison (Cummins 1992; VanderStoep and Seifert 1994; Day et al. 2010; Rittle-Johnson and Star 2011) is beneficial in facilitating the development of knowledge structures for causal hypotheses. By using this technique, the knowledge of causal hypotheses can be structured in the form of a hierarchical network that is called a taxonomic structure (Markman 1999; Anderson 2010). Learners can achieve this goal by organising their knowledge in a breadth-first, hierarchical manner; they identify indicators at the highest level of the domain and then recursively decompose information to the next more detailed level (Eylon and Reif 1984; Zeitz and Spoehr 1989).

The first prompt question asked participants to describe as many (maximum of five) similarities and differences as possible in the way the assurance teams made their comparisons between expected and reported amounts and to think about the possible reasons that caused the noted fluctuations.[36] The purpose of this question was to help participants understand the problem situation in order to assist the development of mental representations for different problem situations and, at the same time, to identify indicators of these problems as the components at the upper levels of the network. In this way, the two cases, involving two different problem categories, provided patterns that can be inferred (See Area 1 in Figure 3.6).

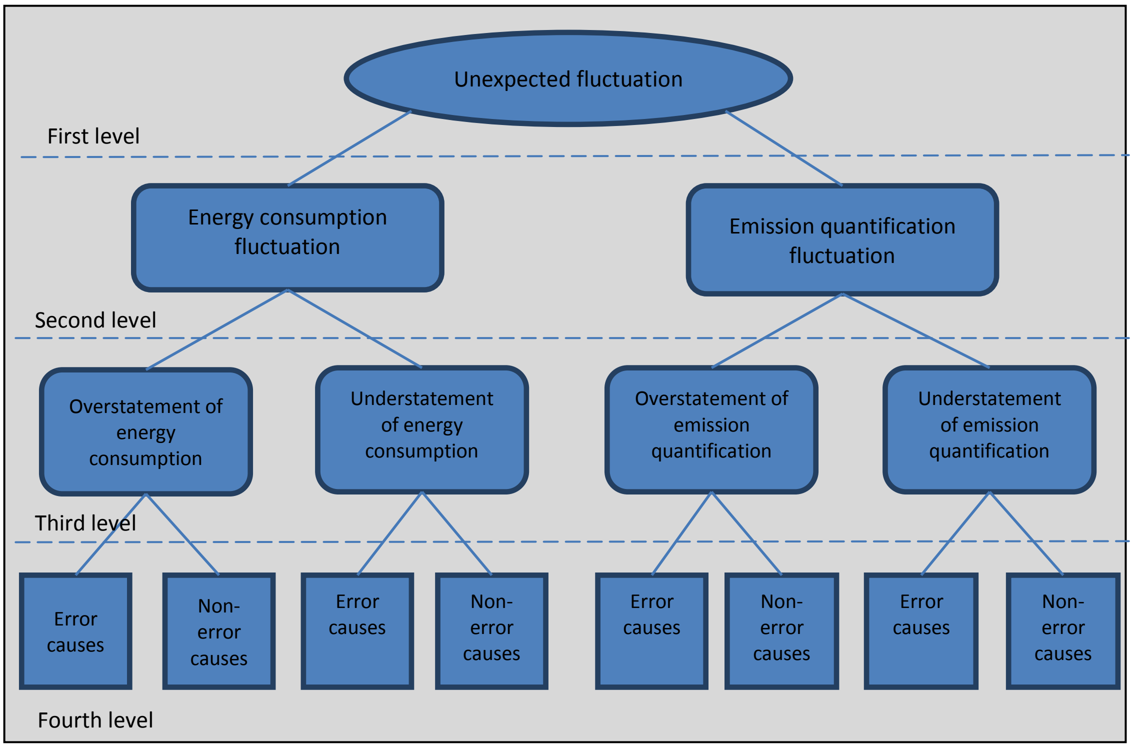
The comparison of the cases using analogical encoding aims to assist the development of a taxonomic knowledge structure such as that shown in Figure 3.7. First, although the cases have a similar problem, they are different in their key indicators. In both cases, the

---

[36] The participants were expected to describe as many similarities and differences as they could. However, to optimise the cognitive demand, the number of items was limited to five items because people are probably only able to deal with four or five items of information simultaneously when required to process rather than merely hold information (Cowan 2001, 2010).

materiality threshold was exceeded, but in the first case, the GHG emissions were understated by 10% while in the second case the GHG emissions were overstated by 30%. By comparing these features of the two cases, the key indicators that are needed in order to make a judgment about the problem situation can be identified (i.e., sources and direction of likely causes).Using the similarity between the two cases, the unexpected fluctuation can be inferred as the category at the highest level of the network.

Figure 3.7. Taxonomic Knowledge Structure Induced by the Analogical Encoding Manipulation



The second feature of the two cases is that these cases differ in the direction of the fluctuation in the GHG emissions and energy consumption. While in the first case the direction of fluctuation in GHG emissions and the fluctuation in energy consumption is the same (i.e., understatement), in the second case the fluctuation leading to an overstatement in GHG emissions is not in the same direction as for the energy consumption (i.e., zero). Comparing this feature allows participants to conduct diagnostic reasoning for the causes of the fluctuation from the identified key indicators. For the first case, because the direction of the fluctuation in GHG emissions is the same as that in the fluctuation of energy consumption, participants are led to think that one possibility for this is that something is wrong with energy consumption. In other words, either energy consumption is erroneously understated or something has happened (i.e., non-error causes) that resulted in lower energy consumption. However, because the direction and magnitude of the two indicators are the same, participants can rule out the possibility of an error in quantification of emissions. Comparing these features with those of the second case, participants can distinguish important features. In contrast to the first case, the direction of the fluctuation of GHG emissions in the second case is different to the direction of the fluctuation in energy consumption. Because the fluctuation in energy consumption is nil (i.e., no discrepancy between expected and reported amounts), participants are led to the assessment that nothing is wrong with energy consumption and are therefore led to focus on other possibilities. Since the direction of the fluctuation in the GHG emissions is an overstatement, the participants are able to consider two other possibilities: either something is wrong that has resulted in emissions being overstated (error causes) or something has happened that resulted in emissions being higher than expected (non-error causes). Comparing these different examples and paying attention to the distinguishing features of each category (Rittle-Johnson and Star 2011) should enable the participants to identify the nature of the potential causes (i.e., energy consumption or emission quantifications) as the category at the second level that can be used to distinguish the hypothesised causes of the unexpected fluctuation (at the first or highest level). Participants can also identify the direction of the causes (i.e., understatement or overstatement) as the category at the third level and the types of causes (i.e., error causes and non-error causes) at the fourth level.

The second prompt question asked participants to describe as many (maximum of five) similarities and differences as possible in the way the assurance teams generated the potential causes that may have led to the observed fluctuations in both cases. The purpose of this question was to encourage the participants to think about the correct way of retrieving the categories of hypotheses based on previously identified types of causes. As shown in Area 2 of Figure 3.6, the team in the first training case generated four hypotheses in the category of understatement of energy consumption and one hypothesis in the category of non-error causes of lower energy consumption. On the other hand, the team in the second training case generated particular hypotheses based on the category of overstatement of emissions quantification and another hypothesis from the category of non-error causes for the higher emissions. The aim of this comparison of hypothesis generation in the two cases is to enable the participants to further refine the knowledge structure that they initially developed by analysing and answering the first question.

The third prompt question asked participants to state why the assurance team in the first training case generated different types of potential causes from the team in the second training case. The purpose of this question is to help participants to think about the membership of further categories beneath the levels that have been identified. These categories can be recognised based on similarity and differences along some dimensions. Comparison of a list of potential causes from two different upper level categories enables participants to think about the further categories. Potential causes for each group can be classified based on error and non-error causes. Error causes can be decomposed into type of error (e.g., based on assertions such as occurrence, completeness, accuracy and cut-off). By conducting the learning activities through the instructions provided by the first three questions, participants are more likely to organise their knowledge of the causal hypotheses in a meaningful structure in their mental representation as illustrated in Figure 3.7.

The final prompt question relates to the hypothesis evaluation stage of the analytical procedures task. This question asked participants to describe as many (maximum of five) similarities and differences as possible in the way the assurance teams evaluated the potential causes based on the results of the assurance tests in both cases. The purpose of this question was to enable participants to understand the correct way to evaluate hypotheses. As argued in Chapter 2, to overcome the decision bias in evaluating hypotheses (i.e., the tendency to be biased in favour of an incorrect inherited hypothesis), the alternative hypotheses must be made more prominent by two strategies: counterexplanation (Koonce 1992) and a sufficiency check (Anderson and Koonce 1998). The former involves consideration of why a specific hypothesis may not be correct, whereas the latter involves consideration of the completeness of each hypothesis in terms of how much of the unexpected fluctuation's variance it can explain. To achieve this hypothesis evaluation training goal, a specific type of analogical encoding is employed, namely, problem comparison. In this technique, a comparison between two different problems can be solved with the same method (Rittle-Johnson and Star 2011). Comparing two worked examples with different problems and containing different correct causes should allow the participants to conduct counterexplanation for the causes. In the first case, a non-error cause (a type of cause that is often inherited from a client) is supported by the results of the assurance test, but in the second case the non-error cause is insufficient to explain the noted fluctuation (i.e., the cause only explained 0.5% of the total 30% difference). The comparison between the cases also allows the error hypotheses to be made prominent to the participants when evaluating them. Since the sufficiency check suggests additional potential causes, this mechanism may lead to counterexplanation of the inherited non-error cause. This comparison also enables participants to understand the principle of the sufficiency check and to emphasise how important it is to consider the completeness of each hypothesis in terms of how much of the unexpected fluctuation's variance it can explain. In this way, the comparison also enables participants to select the correct hypothesis as the most likely cause.

It can be argued that this condition may actually get individuals to think across cases (i.e., see differences and similarities) but at the expense of deeper processing for each case/context because the individuals have to move back and forth each case. While similarities/differences can be determined, it may not allow them to understand each case in its completeness. However, as argued above, focusing on shared (or divergent) aspects between examples promotes the abstraction of a common relational structure that can be stored as a particular structure in long-term memory. Rather than reducing the deeper processing, this technique actually allows the structural features of examples to be made more salient. In turn, these features can be encoded into a particular structure that is more easily retrieved when the learner encounters a new case with the same structure (Gentner et al. 2003).

3.5.3. Training with the Collaborative Learning Technique

In this condition, participants worked collaboratively with their fellow team member to complete the training materials. After receiving and reviewing the training material, participants in this condition worked together as a team with another participant from a different educational background. To ensure that participants collaborated in providing answers to the four questions (as outlined previously), they were instructed to discuss the cases with the other team member before answering the questions. They were also instructed verbally to improve their understanding and their perspective about the problems and solutions in the cases through this discussion and exchange. See Appendix 6 for the instructions for this condition. During the experimental session, participants in this condition were observed by the author to engage in a high level of discussion.

3.5.4. Training without the Collaborative Learning Technique

In this condition, all participants worked individually without interacting with their team member. After receiving and reviewing the training material, participants provided answers to the four questions on an individual basis.

3.6. Dependent Variables

This section presents the measurement of the dependent variables that were investigated in this thesis. Section 3.6.1 provides the description of the measurement of *individual* team member ability in generating hypotheses. This measure was used to test Hypotheses 1, 2 and 3. The next sections, Sections 3.6.2, 3.6.3, and 3.6.4 provide a description of the measurement of *team* performance in hypothesis generation, hypothesis evaluation and final judgment, respectively. These measures were used to test Hypotheses 4 to 10. The final two sections present the measurement of two cognitive structures: team mental models (TMMs) in Section 3.6.5 and transactive memory systems (TMSs) in Section 3.6.6. These measures were used to test Hypotheses 11 to 25.

3.6.1. Individual Team Member Ability in Hypothesis Generation

Individual participant ability to generate hypotheses was measured by their individual performance in generating high quality hypotheses. This measure was chosen because the objective of training at the individual level is to improve the individual team member's ability to perform hypothesis generation efficiently and effectively by generating a full hypothesis set in the correct category.[37]

The quality of the hypothesis set was measured using a scale determined by the Big Four GHG expert based on the error seeded within the case. A set of six hypotheses as shown in Figure 3.5 was determined to represent the 'correct' hypothesis set (i.e., plausible causes when the

---

[37] The quantity of hypotheses generated was not used as a measure for either individual or team performance for several reasons. First, the analytical procedures literature (e.g., Bhattacharjee et al. 1999; Bonner 2008) suggests that effective and efficient analytical procedures are related to the generation of a moderate number of hypotheses. Therefore, a higher (lower) quantity of hypotheses generated is not necessarily an indication of better (worse) performance. The second reason is that in this thesis the participants were trained in developing the correct hypotheses via worked examples where the optimal correct number of plausible hypothesis based on the conditions in the cases was between five and six hypotheses. As a result, it was expected that on average they would not generate more than the number of hypotheses used in the examples.

emissions are lower than expected). To be categorised as correct, a cause was required to have the correct nature, type and direction. That is, this set consists of six plausible potential causes and includes the specific nature of the potential causes (i.e., emission quantifications), as well as the type of errors/non-errors (e.g., incomplete emission sources, incorrect use of emission factors, incorrect use of units of measurement) and the direction of the cause (i.e., understatement). Each hypothesis generated by the participants was coded as follows:

- assigned 0 if it did not identify any of the following: nature, type and direction of the cause;
- assigned 1 point for each relevant nature of cause identified (i.e., emission quantifications);
- assigned 1 point for correctly identifying the type of cause (i.e., error); and
- assigned 1 point for correctly identifying the direction of each hypothesis (i.e., understatement).

Thus, the quality score for each hypothesis was measured on a scale of zero to three and the total quality score for the six correct hypotheses ranges from zero (no hypothesis is correct) to 18 (six hypotheses with complete and specific nature, type and direction of error information provided). An example of the scoring rubric is shown in Figure 3.8.

In order to determine the quality ratings for the hypotheses generated by participants, two coders – the author and an experienced auditor who was blind as to the research hypotheses and the participants' experimental training treatment – independently coded the quality of the 126 hypothesis sets generated by all of the training treatment participants.

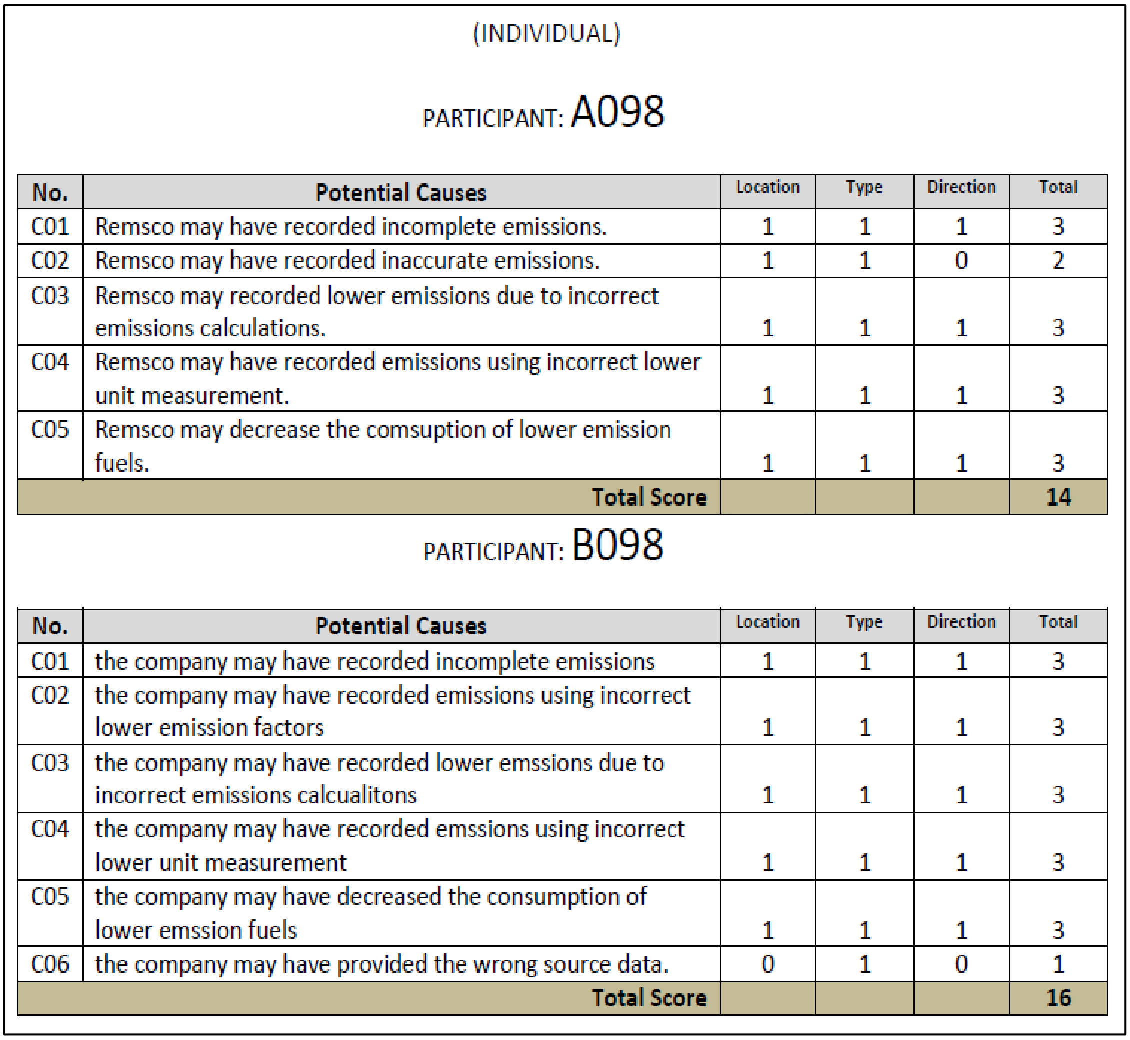
The two coders who never disagreed by more than two out of the 18 rating points discussed their individual judgments.[38] An inter-rater reliability analysis using the Kappa statistic was

---

[38] The author has six years of experience as an auditor in a Big Four auditing firm as well as experience as an auditing lecturer. The second coder has 15 years of experience as an auditor in a Big Four auditing firm (attaining the position of manager) as well as experience as an auditing lecturer for a postgraduate auditing course at a large university in Australia. Before the coding began, the second coder received a booklet containing a description of the study, the training material and the final case used in the test phase as well as its solution. The second coder also received a listing of the participants' hypothesis sets and the participants' written explanations for each step in the hypothesis evaluation and final judgments in the final case. However, the second coder was not provided information identifying which training condition each participant belonged to. The two coders also discussed and agreed the quality ratings scale (as determined by Big Four GHG expert) that was used in the coding process.

performed to determine consistency among the coders. The inter-rater reliability for the coders indicates the agreement was almost perfect (Kappa = 0.820, *p*-value < 0.001). All disagreements were reconciled between the coders.

Figure 3.8. Scoring Rubric for Individual Hypothesis Generation



(INDIVIDUAL)

PARTICIPANT: A098

No.	Potential Causes	Location	Type	Direction	Total
C01	Remsco may have recorded incomplete emissions.	1	1	1	3
C02	Remsco may have recorded inaccurate emissions.	1	1	0	2
C03	Remsco may recorded lower emissions due to incorrect emissions calculations.	1	1	1	3
C04	Remsco may have recorded emissions using incorrect lower unit measurement.	1	1	1	3
C05	Remsco may decrease the comsuption of lower emission fuels.	1	1	1	3
	Total Score				**14**

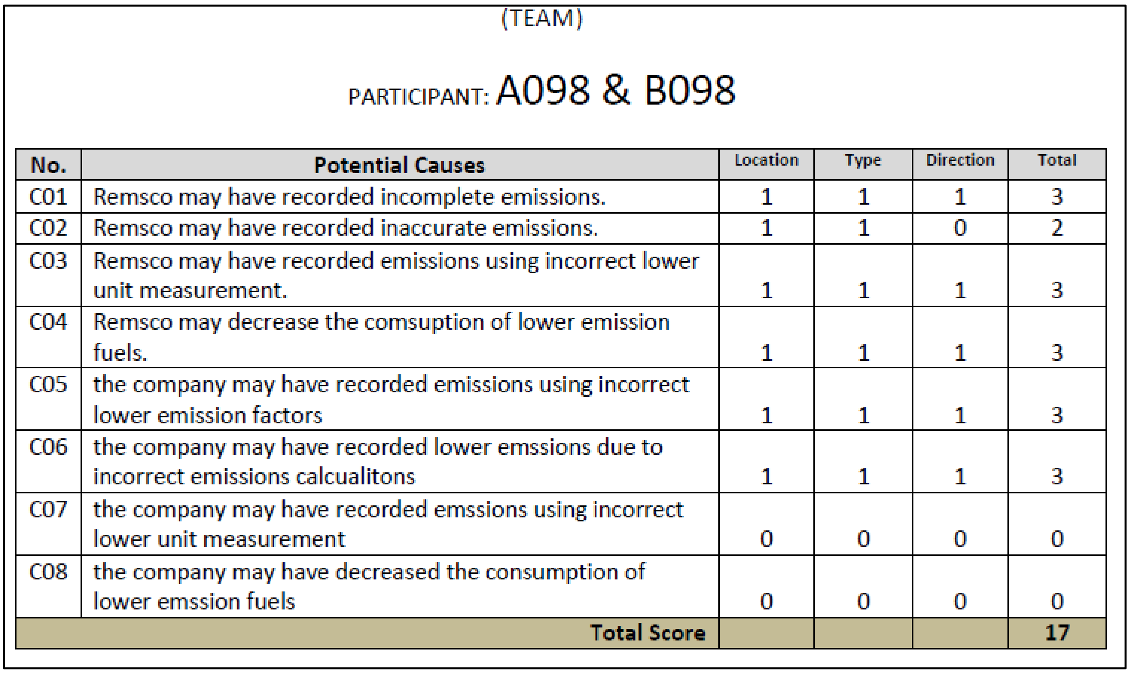
PARTICIPANT: B098

No.	Potential Causes	Location	Type	Direction	Total
C01	the company may have recorded incomplete emissions	1	1	1	3
C02	the company may have recorded emissions using incorrect lower emission factors	1	1	1	3
C03	the company may have recorded lower emssions due to incorrect emissions calcualitons	1	1	1	3
C04	the company may have recorded emssions using incorrect lower unit measurement	1	1	1	3
C05	the company may have decreased the consumption of lower emssion fuels	1	1	1	3
C06	the company may have provided the wrong source data.	0	1	0	1
	Total Score				**16**

3.6.2. MDT Performance in Hypothesis Generation

The first dependent variable used to measure *team* performance relates to the quality of the hypotheses generated during the hypothesis generation stage of the task. The measurement was conducted in a manner similar to that outlined for the individual hypothesis generation as explained in Section 3.6.1 above. Two coders – the author and an experienced auditor who was blind as to the research hypothesis and the participants' training treatment membership – independently coded the quality of the hypothesis sets generated by the 63 teams using the quality ratings scale discussed in Section 3.6.1. An example of a scoring rubric of the quality ratings is as shown in Figure 3.9. The two coders, who never disagreed initially by more than two out of the 18 rating points discussed their individual judgments and reached consensus. An inter-rater reliability analysis using the Kappa statistic was performed to determine consistency among coders. The inter-rater reliability for the coders indicates the agreement was almost perfect (Kappa = 0.879, *p*-value < 0.001). All disagreements were reconciled between the coders.

Figure 3.9. Scoring Rubric for Team Hypothesis Generation



(TEAM)

PARTICIPANT: A098 & B098

No.	Potential Causes	Location	Type	Direction	Total
C01	Remsco may have recorded incomplete emissions.	1	1	1	3
C02	Remsco may have recorded inaccurate emissions.	1	1	0	2
C03	Remsco may have recorded emissions using incorrect lower unit measurement.	1	1	1	3
C04	Remsco may decrease the comsuption of lower emission fuels.	1	1	1	3
C05	the company may have recorded emissions using incorrect lower emission factors	1	1	1	3
C06	the company may have recorded lower emssions due to incorrect emissions calcualitons	1	1	1	3
C07	the company may have recorded emssions using incorrect lower unit measurement	0	0	0	0
C08	the company may have decreased the consumption of lower emssion fuels	0	0	0	0
	Total Score				**17**

3.6.3. MDT Performance in Hypothesis Evaluation

The second dependent variable used to measure MDT performance relates to hypothesis evaluation. Consistent with prior research in analytical procedures (Asare and Wright 2003; Green and Trotman 2003), MDT performance was not only measured at the hypothesis generation stage, but also for other stages of the analytical procedures task, in this case, hypothesis evaluation. MDT performance in the hypothesis evaluation stage was measured by determining whether the MDT correctly evaluated their hypotheses based on the information gathered during the information search stage (i.e., accuracy of hypothesis evaluation). In particular, a team's hypothesis evaluation was coded as '1' when the team correctly evaluated the inherited hypothesis (i.e., by not accepting that the inherited hypothesis explained the fluctuation after evaluating evidence refuting that hypothesis). A team's evaluation was coded as '0' when the team incorrectly evaluated the inherited hypothesis (i.e., accepting the inherited hypothesis after viewing evidence suggesting it was not the correct cause).

Similarly, an accuracy coding was made when teams evaluated the correct hypothesis. A team's hypothesis evaluation was coded as '1' when the team identified the correct hypothesis (i.e., accepting and not dismissing the correct hypothesis after viewing evidence suggesting it was correct). The hypothesis evaluation was coded as '0' when the team failed to evaluate the correct hypothesis accurately (i.e., not accepting or dismissing the correct hypothesis after viewing evidence suggesting it was correct). Two coders (described in Section 3.6.1) independently coded the hypothesis evaluation of the 63 MDTs. The agreement level between the two coders was 100 per cent.

This thesis uses the *choice approach* to examine hypothesis evaluation.[39] In this approach, participants are given a menu of likely hypotheses and asked to select their choice (i.e., to accept or to reject the evidence) after being provided with varying amounts of audit evidence. The reason for the use of this approach is that Asare and Wright (1995, 1997a, 1997b) found that auditors revise assessments only for the hypothesis directly implicated by the evidence obtained rather than the entire hypothesis set. That is, auditors may use simpler cognitive strategies such as focusing on one hypothesis at a time. This finding suggests that a choice approach wherein auditors identify the most likely hypothesis has more external validity than a likelihood approach wherein all hypotheses are evaluated (Asare and Wright 2001).

In this thesis, the measure of performance in hypothesis evaluation consists of evaluation of both the inherited and the correct hypothesis. This is because the hypotheses the participants evaluated were self-generated (not provided by the experimenter), therefore not all teams included the inherited hypothesis and correct hypothesis in their hypothesis set. Thus, it is necessary to measure their performance in both inherited hypothesis and correct hypothesis to capture a complete performance.

An example of data used for the analysis of MDT performance in hypothesis evaluation and final judgment is shown in Figure 3.10.

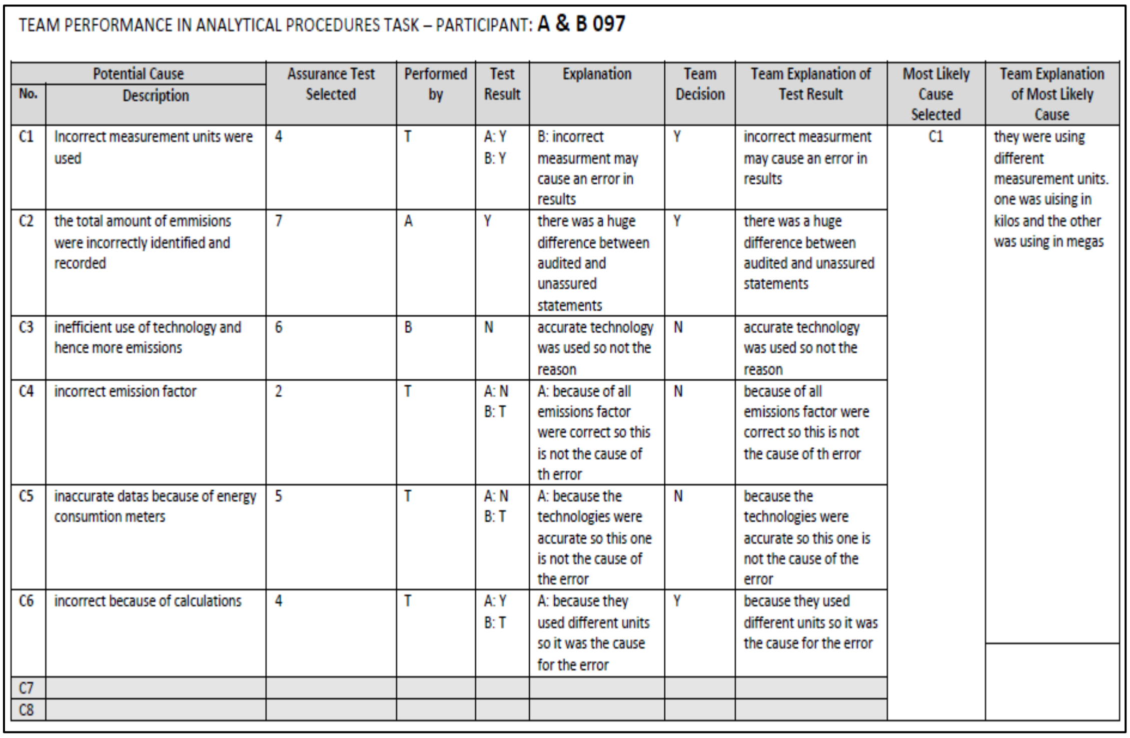
---

[39] Prior studies have employed several approaches in examining hypothesis evaluation in auditing. These include likelihood rating (e.g., Asare and Wright 1997a), choice (e.g., Asare and Wright 2003) and process tracing or verbal protocol (e.g., Mock et al. 2008).

3.6.4. MDT Performance in Final Judgment

The third dependent variable used to determine MDT performance is the team's accuracy in the selection of the most likely cause of the fluctuation (i.e., their final judgment). Consistent with prior research (e.g., Bhattacharjee et al. 1999; Asare and Wright 2003; Green and Trotman 2003), each participant's performance in the final judgment was assessed in terms of overall accuracy in identifying the actual cause. The MDT's final judgment was assessed as accurate (coded as '1') if they nominated the correct hypothesis (i.e., lower emissions were recorded due to the use of an incorrect unit of measurement when calculating emissions) or inaccurate (coded as '0'). Two coders (described in Section 3.6.1) independently coded the final judgment of the 63 MDTs. The agreement level between the two coders was 100 percent. An example of the data for this analysis is shown in Figure 3.10.

Figure 3.10. An Example of Data for Hypothesis Evaluation and Final Judgment Performed by MDTs



TEAM PERFORMANCE IN ANALYTICAL PROCEDURES TASK – PARTICIPANT: **A & B 097**

Potential Cause		Assurance Test Selected	Performed by	Test Result	Explanation	Team Decision	Team Explanation of Test Result	Most Likely Cause Selected	Team Explanation of Most Likely Cause
No.	Description								
C1	Incorrect measurement units were used	4	T	A: Y B: Y	B: incorrect measurment may cause an error in results	Y	incorrect measurment may cause an error in results	C1	they were using different measurement units. one was uising in kilos and the other was using in megas
C2	the total amount of emmisions were incorrectly identified and recorded	7	A	Y	there was a huge difference between audited and unassured statements	Y	there was a huge difference between audited and unassured statements		
C3	inefficient use of technology and hence more emissions	6	B	N	accurate technology was used so not the reason	N	accurate technology was used so not the reason		
C4	incorrect emission factor	2	T	A: N B: T	A: because of all emissions factor were correct so this is not the cause of th error	N	because of all emissions factor were correct so this is not the cause of th error		
C5	inaccurate datas because of energy consumtion meters	5	T	A: N B: T	A: because the technologies were accurate so this one is not the cause of the error	N	because the technologies were accurate so this one is not the cause of the error		
C6	incorrect because of calculations	4	T	A: Y B: T	A: because they used different units so it was the cause for the error	Y	because they used different units so it was the cause for the error		
C7									
C8									

3.6.5. Team Mental Models

TMMs have been measured using several approaches in prior studies. Two different approaches are used in this thesis. TMMs have been measured using an aggregate approach in which individual mental models are compared with each other to assess similarity as well as to a referent model to assess accuracy as a team-level construct (e.g., Mathieu et al. 2000;

Marks et al. 2002; Lim and Klein 2006). TMMs have also been measured using the qualitative method in which MDT members' knowledge content and structure are elicited and extracted by observing and coding from documents and/or videotaped team interactions (Langan-Fox et al. 2000; Mohammed et al. 2010).

Prior literature on TMMs assumes that team members hold multiple mental models simultaneously (e.g., Rouse et al. 1992; Cannon-Bowers et al. 1993) that can be conceptualised to represent various types of knowledge (Mohammed et al. 2010). Consistent with this view, it is assumed in this thesis that team members hold multiple models when performing the analytical procedures task. Hence, two types of TMMs are measured in this thesis: one for the hypothesis generation stage and one for the hypothesis evaluation stage. These are described below.

3.6.5.1. Team Mental Models in Hypothesis Generation

Team mental models during the hypothesis generation stage are measured using an aggregate of the individual team member mental models. As outlined in Chapter 2, task-focused TMMs are especially relevant because decision-making is an information-intensive activity (Jackson et al. 1995; DeChurch and Mesmer-Magnus 2010). In this thesis, task-focused mental models are the relevant type of team mental model to investigate because task-focused mental models are examined in the context of performing the hypothesis generation stage of an analytical procedures task, which requires knowledge about causal hypotheses of the observed fluctuation.

The participants were presented with 12 cards. Each card contained a hypothesis relating to the cause of the fluctuation of GHG emissions (see Table 3.5). The hypotheses on the 12 cards were developed using the 12 most plausible potential causes as determined by the Big Four GHG expert used in establishing the case. As shown in Table 3.5, plausible potential causes include both error and non-error causes and represent the referent model for the GHG analytical procedures task. The participants were introduced to most of these potential causes during the previous training phase of the experiment.

Table 3.5. Knowledge Structure According to Training Phase Referent Model Including Contents of the 12 Cards Used for the Card Sort Task after the Phase 1 Stage 2 Training

Direction of potential causes	**Nature of potential causes**	
	Energy Consumption	Emissions Quantification
Overstatement	- Fictitious energy consumptions were recorded. ***[ERROR]***	- More emissions were recorded due to incorrect unit measurement when calculating emissions. ***[ERROR]***
	- Incorrect higher energy content factor was used when calculating energy consumption. ***[ERROR]***	- More emissions were recorded due to incorrect use of a higher emission factor. ***[ERROR]***
	- More energy was consumed because of long winter in the current year. ***[NON-ERROR]***	- More emissions were recorded because of the shift of energy consumption to higher emissions energy source. ***[NON-ERROR]***
Understatement	- Less energy was recorded due to incomplete recording of energy consumption. ***[ERROR]***	- Fewer emissions were recorded due to incorrect unit measurement when calculating emissions. ***[ERROR]***
	- Energy meters were inaccurately lower because of infrequent calibration. ***[ERROR]***	- Fewer emissions were recorded due to incomplete recording of energy emissions. ***[ERROR]***
	- Less energy was consumed due to introducing an energy efficiency program. ***[NON-ERROR]***	- Fewer emissions were recorded because an emission reduction program was introduced to use renewable energy (zero emission energy). ***[NON-ERROR]***

In order to capture the task-focused mental models, participants were asked to sort sets of cards by putting them into piles representing categories that made sense to them. When the cards were sorted, participants created category header cards according to their own wishes by writing a name on top of each pile to represent the name for that category. They were instructed to make as many or as few categories as they liked (see Appendix 8 for the card-sorting instruction).

The referent model, which is the correct way to categorise the cards, was used in assessing the nature of the memory structure demonstrated by participants. Table 3.5 depicts how the cards should be sorted according to the training phase referent model used in this thesis. For example, the three cards relating to overstatement of energy consumption can be grouped together and labelled as ‘overstatement of energy consumption’ as shown in the top left hand side of the table. According to this model, three cards can be organised into each of the four categories of causal hypothesis (i.e., overstatement of energy consumption, understatement of energy consumption, overstatement of emissions quantifications and understatement of emission quantifications).

The structure developed by each of the participants was then compared to the structure according to the referent model. As noted in Chapter 2, pre-existing knowledge structures influence the development of required knowledge structures supplied through training. This is especially so if there is incompatibility between pre-existing knowledge structures and the referent model as this will affect the development of the training-based knowledge structure (Borthick et al. 2006). Given that accountant participants will have specific pre-existing knowledge structures for causal hypotheses based on audit assertions (Frederick et al. 1994), and given that GHG assurance may necessitate the development of different knowledge structures, the referent model for this thesis has a different structure to the audit assertion structure. Specifically, in this thesis, the causal hypotheses were organised according to two elements, i.e., the direction of misstatement (i.e., overstatement or understatement) and the nature of the potential causes (i.e., energy consumption or emission quantifications) as shown by the taxonomic structure in Figure 3.7. By using a different knowledge structure, this thesis is able to consider how pre-existing auditing knowledge may affect auditors' GHG knowledge structures. In this way this thesis is able to examine whether MDT members' prior knowledge affects their cognitive processes during learning and learning outcomes. Prior knowledge is measured by a categorical measure in terms of participant knowledge of auditing, i.e., '0' for a MDT member who has no prior knowledge in auditing (scientists/engineers) and '1' for a MDT member who has prior knowledge in auditing (accountants).[40]

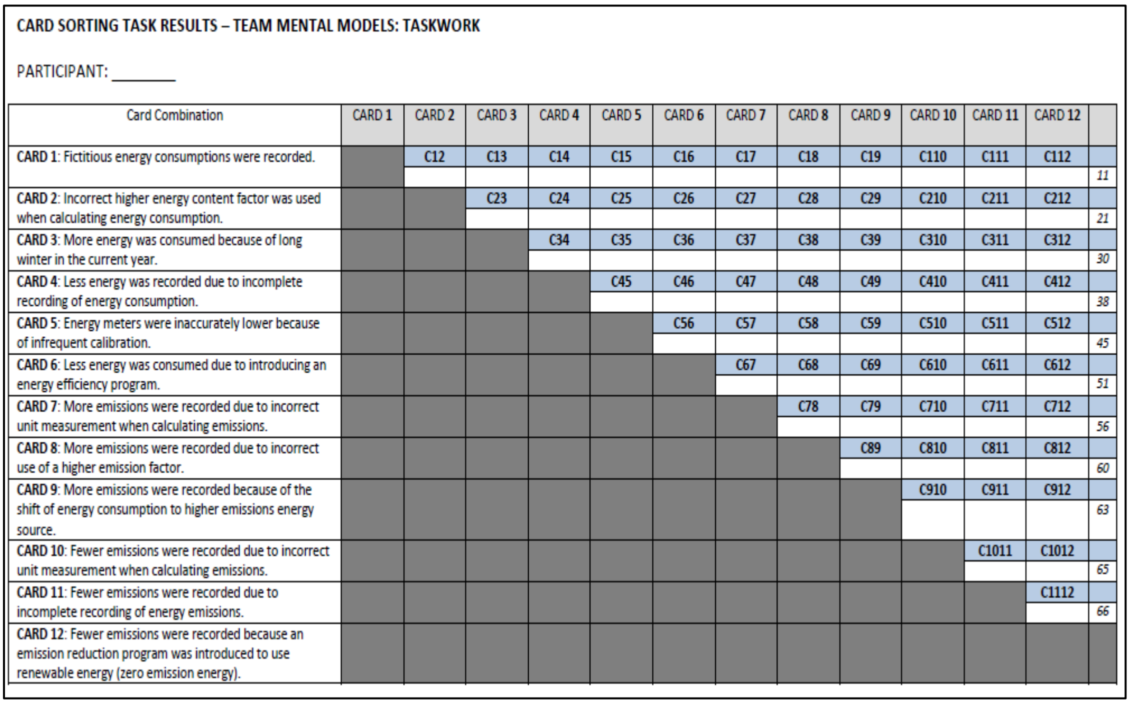
In analysing the card-sorting outcomes, consistent with prior research (e.g., Bonner et al. 1996; Borthick et al. 2006), each pairing of cards was scored a '1' for causes grouped together or '0' if not. This score was converted into a 12 x 12 similarity matrix. See Figure 3.11 for the similarity matrix used in this thesis. To determine a participant's similarity to the referent/expert or correct model, i.e. their *accuracy*, the correlation was computed between the string of 0s and 1s in each member's similarity matrix and the predetermined string of 0s and 1s consistent with the sorting of the cards according to the referent model. This measure of the correspondence between two similarity matrices is commonly called a '*cophenetic correlation*' (Sneath and Sokal 1973).

---

[40] Prior knowledge in auditing is the criteria used in determining the prior knowledge because it is an important factor in performing an analytical procedures task. Accountants generally understand the basic principle of this task and usually perform this task in practice and therefore will have some prior knowledge structure relating to this task.

In this thesis, the similarity and accuracy of TMMs is measured by using individual knowledge structures or mental models. Specifically, each member’s string of 0s and 1s was correlated with the other team member’s to create a TMM similarity score. Each member’s string of 0s and 1s was correlated to the referent model and then averaged to create a TMM accuracy score. These measures have also been used in prior organisational psychology studies (e.g., Smith-Jentsch et al. 2001).

Figure 3.11. Similarity Matrix for Individual Knowledge Structure and Team Mental Models



CARD SORTING TASK RESULTS – TEAM MENTAL MODELS: TASKWORK

PARTICIPANT: _______

Card Combination	CARD 1	CARD 2	CARD 3	CARD 4	CARD 5	CARD 6	CARD 7	CARD 8	CARD 9	CARD 10	CARD 11	CARD 12	
CARD 1: Fictitious energy consumptions were recorded.		C12	C13	C14	C15	C16	C17	C18	C19	C110	C111	C112	
													11
CARD 2: Incorrect higher energy content factor was used when calculating energy consumption.			C23	C24	C25	C26	C27	C28	C29	C210	C211	C212	
													21
CARD 3: More energy was consumed because of long winter in the current year.				C34	C35	C36	C37	C38	C39	C310	C311	C312	
													30
CARD 4: Less energy was recorded due to incomplete recording of energy consumption.					C45	C46	C47	C48	C49	C410	C411	C412	
													38
CARD 5: Energy meters were inaccurately lower because of infrequent calibration.						C56	C57	C58	C59	C510	C511	C512	
													45
CARD 6: Less energy was consumed due to introducing an energy efficiency program.							C67	C68	C69	C610	C611	C612	
													51
CARD 7: More emissions were recorded due to incorrect unit measurement when calculating emissions.								C78	C79	C710	C711	C712	
													56
CARD 8: More emissions were recorded due to incorrect use of a higher emission factor.									C89	C810	C811	C812	
													60
CARD 9: More emissions were recorded because of the shift of energy consumption to higher emissions energy source.										C910	C911	C912	
													63
CARD 10: Fewer emissions were recorded due to incorrect unit measurement when calculating emissions.											C1011	C1012	
													65
CARD 11: Fewer emissions were recorded due to incomplete recording of energy emissions.												C1112	
													66
CARD 12: Fewer emissions were recorded because an emission reduction program was introduced to use renewable energy (zero emission energy).													

3.6.5.2. Team Mental Models in Hypothesis Evaluation

The TMM measurement technique used in the hypothesis evaluation stage differs to that used in the hypothesis generation stage as it uses the qualitative method. This method assumes that team documents and audio or videotaped team communication reveal the team’s mental models as a collective (Carley 1997; Waller et al. 2004; Mohammed et al. 2010). Observations of teams from such sources have the potential to provide vast amounts of information in the context of task performance while interfering minimally with the tasks and thus provide a continuous source of data that reflect TMMs (Cooke et al. 2000).

In this thesis, the data sources for which observation and coding are possible are the written documentation relating to hypothesis evaluation, including the participants’ explanation for each evaluation they performed. As explained in Section 3.6.3, after viewing the results of the audit tests, participants, either as an individual or together as a MDT, were asked to evaluate each hypothesis by answering ‘yes’ or ‘no’ to the question as to whether it was the correct hypothesis and also to provide an explanation for their evaluation. The MDT was required to reach a consensus and to resolve any differences between team members in order to determine the team’s decision, which they documented in the computerised program. The written hypothesis evaluation documentation therefore provides data on team members’ shared task representations. As outlined in Chapter 2, the components of mental models that are shared among group members are conceptualised as shared task representations.

As argued in Chapter 2, the tendency to be biased in favour of an inherited hypothesis acts as shared task representation when MDTs are evaluating hypotheses. This ‘inaccurate’ task representation, which favours the inherited hypothesis and which is shared by team members, explains the tendency to be biased in favour of the inherited hypothesis when evaluating hypotheses continues to persist at the group level.

The measure used in this thesis for shared task representation is determined by reviewing the extent to which team members share the same view or evaluation for each specific hypothesis. This was determined by reviewing written documentation for individual and team decisions during the hypothesis evaluation stage in order to determine whether the team members shared the task representation in favour of the inherited hypothesis (or other explanations that are characterised as a non-error hypothesis) or whether they shared task representation in favour of an alternative (i.e., error) hypothesis. The coding process was conducted by reviewing individual/team evaluations for each hypothesis as well as the team explanations and the team decisions on each hypothesis. Finally, the team’s explanation for their overall evaluation was also examined.

The TMM accuracy score was derived as follows. The outcome of the coding noted above was that teams were coded as ‘0’ when the teams shared the task representation in favour of the inherited hypothesis and the teams were coded as ‘1’ when the teams shared a task representation in favour of an alternative (i.e., error) hypothesis. An example of the data for this analysis is shown in Figure 3.9 presented earlier.

The TMM similarity was measured by coding the similarity of MDT member’s hypothesis evaluation task representation. TMM similarity was coded as ‘1’ when both members generated either an inherited or an alternative error hypothesis in their hypothesis set. TMM similarity was coded as ‘0’ when the MDT members generated dissimilar hypotheses (i.e., one member generates an inherited hypothesis but the other member does not). This assumes that a MDT member who generates an inherited hypothesis has a task representation in favour of the inherited hypothesis. Similarly, a MDT member who does not generate an inherited hypothesis has a task representation in favour of the alternative hypothesis.

Two coders (described in Section 3.6.1) independently coded the written documentation of each of the 63 MDTs. The inter-rater reliability for the coders indicates the agreement was almost perfect (Kappa = 0.933, *p*-value < 0.001). All disagreements were reconciled between the coders.

3.6.6. Transactive Memory Systems (TMSs) Structure

According to TMS theory, groups develop an implicit structure for dividing responsibility for information, based on members’ shared understanding of one another’s expertise (Brandon and Hollingshead 2004; Lewis and Herndon 2011). In this way they develop a TMS structure. In this thesis, TMS structure is measured by employing a card-sorting technique. The card-sorting task involved the allocation between MDT members of subtasks involved in an analytical procedures task. To operationalise this measure, each participant received 12 cards containing separate tasks involved in the assurance of GHG emissions.

The subtasks are derived by conducting an analysis on relevant steps in performing an analytical procedures task. The primary source document for the analysis is an international GHG emissions assurance standard by the International Auditing and Assurance Standards Board (IAASB), ISAE 3410 *Assurance Engagement on Greenhouse Gas Statements* (IAASB 2012). This assurance standard provides international guidance for assurance practitioners in conducting GHG emissions assurance engagements. In addition, the relevant current GHG guidelines and publications (StandardsAustralia 2006b; DCCEE 2010b) were also reviewed in order to identify the subtasks. This list was then validated by the GHG assurance contact at the Big Four firm. The list of subtasks is provided in Table 3.6.

Table 3.6. The List of Subtasks in an Analytical Procedures Task as a Measure of Transactive Memory Systems Structure: Contents of the 12 Cards Used for the Card Sort Task during Training Stage 2d.

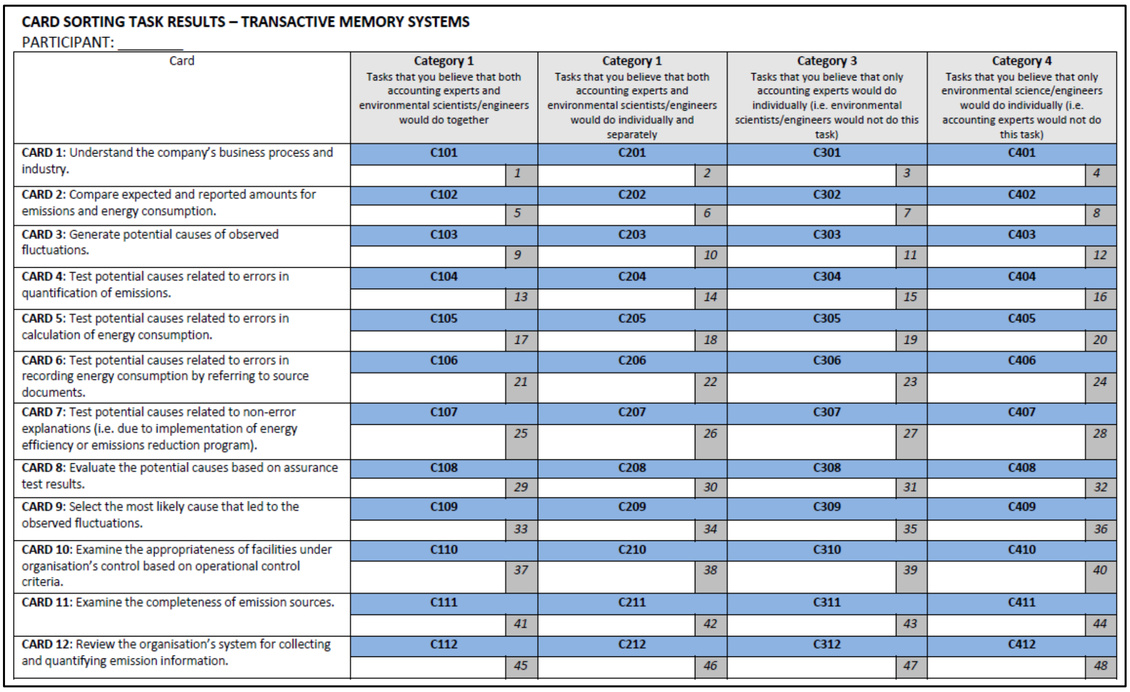
No.	The Tasks Relating to Working as a Team in Performing an Analytical Procedures Task
1.	Understand the company's business process and industry.
2.	Compare expected and reported amounts for emissions and energy consumption.
3.	Generate potential causes of observed fluctuations.
4.	Test potential causes related to errors in quantification of emissions.
5.	Test potential causes related to errors in calculation of energy consumption.
6.	Test potential causes related to errors in recording energy consumption by referring to source documents.
7.	Test potential causes related to non-error explanations (i.e. due to implementation of energy efficiency or emissions reduction program).
8.	Examine the appropriateness of facilities under organisation's control based on operational control criteria.
9.	Examine the completeness of emission sources.
10.	Review the organisation's system for collecting and quantifying emission information.
11.	Select the most likely cause that led to the observed fluctuations.
12.	Evaluate the potential causes based on assurance test results.

The card-sorting task for this measure was conducted as follows. Participants were asked to sort the cards into piles representing one of four categories: (1) tasks they believed that **both** accounting experts and environmental scientists/engineers would do together; (2) tasks they believed that both accounting experts and environmental scientists/engineers would do individually and separately; (3) tasks they believed that **only** accounting experts would do (i.e. environmental scientists/engineers would not do this task); and (4) tasks they believed that **only** environmental science/engineers would do (i.e. accounting experts would not do this task) (see Appendix 9 for the instruction to the participants).

In order to provide the concepts written on the sorting cards (i.e., the subtasks relating to working as a team in performing the analytical procedures task), 12 subtasks were elicited. As shown in Table 3.6, the concepts include specific subtasks that are involved in each stage of the analytical procedures task (i.e., mental representation, hypothesis generation, information search, hypothesis testing and evaluation, and final judgment).

The average team TMS score was derived as follows. Similar to the TMM measurement, the TMS structure was measured by using an aggregate approach (Cooke et al., 2000) in which participants' individual structures were compared with each other's to assess similarity in order to represent a team-level construct. Each pairing of cards was scored a '1' for subtasks grouped together or ‘0’ if not. This score was converted into a 4 x 12 similarity matrix. See Figure 3.12 for the similarity matrix used for this measure. To determine a TMS score, each team member’s string of 0s and 1s was correlated with every other member’s as a team score.

Figure 3.12. Similarity Matrix for Transactive Memory Systems Measurement



CARD SORTING TASK RESULTS – TRANSACTIVE MEMORY SYSTEMS

PARTICIPANT: ________

Card	**Category 1** Tasks that you believe that both accounting experts and environmental scientists/engineers would do together	**Category 1** Tasks that you believe that both accounting experts and environmental scientists/engineers would do individually and separately	**Category 3** Tasks that you believe that only accounting experts would do individually (i.e. environmental scientists/engineers would not do this task)	**Category 4** Tasks that you believe that only environmental science/engineers would do individually (i.e. accounting experts would not do this task)
CARD 1: Understand the company’s business process and industry.	**C101** 1	**C201** 2	**C301** 3	**C401** 4
CARD 2: Compare expected and reported amounts for emissions and energy consumption.	**C102** 5	**C202** 6	**C302** 7	**C402** 8
CARD 3: Generate potential causes of observed fluctuations.	**C103** 9	**C203** 10	**C303** 11	**C403** 12
CARD 4: Test potential causes related to errors in quantification of emissions.	**C104** 13	**C204** 14	**C304** 15	**C404** 16
CARD 5: Test potential causes related to errors in calculation of energy consumption.	**C105** 17	**C205** 18	**C305** 19	**C405** 20
CARD 6: Test potential causes related to errors in recording energy consumption by referring to source documents.	**C106** 21	**C206** 22	**C306** 23	**C406** 24
CARD 7: Test potential causes related to non-error explanations (i.e. due to implementation of energy efficiency or emissions reduction program).	**C107** 25	**C207** 26	**C307** 27	**C407** 28
CARD 8: Evaluate the potential causes based on assurance test results.	**C108** 29	**C208** 30	**C308** 31	**C408** 32
CARD 9: Select the most likely cause that led to the observed fluctuations.	**C109** 33	**C209** 34	**C309** 35	**C409** 36
CARD 10: Examine the appropriateness of facilities under organisation’s control based on operational control criteria.	**C110** 37	**C210** 38	**C310** 39	**C410** 40
CARD 11: Examine the completeness of emission sources.	**C111** 41	**C211** 42	**C311** 43	**C411** 44
CARD 12: Review the organisation’s system for collecting and quantifying emission information.	**C112** 45	**C212** 46	**C312** 47	**C412** 48

3.6.7. Measurement of Variables for Additional Analyses

In addition to the primary analyses to test the proposed research hypothesis, additional analyses were also conducted to provide deeper understanding about the factors underlying the results. As argued in Chapter 2, at the individual level, the use of a combination of the analogical encoding and collaborative learning techniques is expected to lead to an increased ability to generate hypotheses as a result of these techniques simultaneously reducing cognitive load, encouraging deep processing, and facilitating the development of knowledge structures. Consequently, it is important to examine these two variables (i.e., the cognitive load and knowledge structure).[41]

---

[41] In this thesis, there is no specific additional analysis on the effect of training techniques on deep learning processing. This is because, based on prior studies, each experimental condition was classified into a specific overt learning activity (i.e., active, constructive and interactive) based on the corresponding level of deep cognitive processing (see Chi 2009, for a review). In addition, a complete analysis of deep learning processing requires analysis of the actual processes a learner is undertaking.

The measurement of these two variables is discussed in Section 3.6.7.1 and 3.6.7.2.

As noted in Chapter 2, the use of a combination of the analogical encoding and collaborative learning techniques at team level is expected to lead to an improved MDT performance as a result of improved team processes. Therefore, an examination of process gains and losses and team process is needed to fully understand the results. Section 3.6.7.3 describes the measurement of team process gains and losses. Section 3.6.7.4 describes the measurement of an alternative, subjective team process measure. Finally, Section 3.6.7.5 provides a description of TMS processes, a process component of TMS as a supplement to the analysis of the role of TMS on MDT performance.

3.6.7.1. Cognitive Load

Cognitive load is measured by the participants providing their perceptions of task difficulty using a seven-point Likert-scale with end points labelled extremely easy and extremely difficult (Kalyuga et al. 1999; Mayer and Chandler 2001). Consistent with prior studies, the participants were asked to make a retrospective judgment after the training session concerning the difficulty of the training session. This measure was chosen because, as found by DeLeeuw and Mayer (2008), difficulty ratings assessed after learning were most sensitive to differences related to the germane processing load. As this thesis is particularly interested in whether the training techniques affect germane load during learning, the difficulty ratings were used as the cognitive load measure. In addition, although learner estimates of cognitive load are subjective, studies that have compared these ratings with other physiological or psychological measures of mental load show that they are effective and are also the most pragmatic way to assess mental effort (Paas et al. 2003). Specifically, the difficulty ratings were obtained through an instruction which asked the participants to respond to the question: ‘Please rate how difficult you found this training material’. The response choices ranged from 1 (*extremely easy*) to 7 (*extremely difficult*) (see Appendix 7). The cognitive load was measured at three points (i.e., after Stages 1 and 2 of the training phase and after the test-phase). The data used for the additional analyses was at the point after participants had completed the learning from worked examples training (i.e., Stage 2 of the training phase).

For example, in collaborative learning conditions, the analysis is conducted not only on the content of their responses to the prompts, but also on dialogues when team members interact (Chi 2009). In this thesis, this analysis was not conducted because the participants’ interactions were not video- or audiotaped.

Absolute cognitive load is calculated relative to the learning outcome. Prior studies in educational psychology have used performance efficiency metrics in assessing the instructional techniques. According to cognitive load theory, performance efficiency is defined in terms of two variables: learner performance and learner cognitive load (Paas et al. 2003; Clark et al. 2006). Instructional environments that result in higher learning outcomes with less cognitive load are more efficient than environments that lead to lower outcomes with greater cognitive load. In this thesis, performance efficiency was calculated for the transfer tests using the Paas and van Merriënboer (1993) computational approach, which standardises each participant's scores for individual learning performance, and cognitive load invested in the learning phase. For this purpose, consistent with Paas and van Merriënboer (1993), the grand mean was subtracted from each score and the result was divided by the overall standard deviation to yield z-scores for cognitive load (R) and performance (P). Finally, a performance efficiency score, E, was computed for each participant using the formula: $E = [(P - R)/2^{½}]$. A performance efficiency is obtained by subtracting cognitive load (CL) from performance outcomes (P), i.e., $E = P - CL$. When performance is greater than cognitive load, the efficiency value is positive. When performance is lower than cognitive load, the efficiency is negative. Performance was measured by the individual performance in generating hypotheses that was measured at the end of the training phase (i.e., test phase) (refer to Section 3.3.1). This measure has also been used in prior accounting studies (Brewster 2011).

3.6.7.2. Individual Knowledge Structure

A card-sorting task was used to measure and distinguish between the knowledge structures of individual participants. This measure allows a comparison of knowledge structures from different disciplines (accounting and science) as well as allowing an assessment of the impact of the different training techniques (analogical encoding and collaboration learning) on these knowledge structures. Using card sorting to measure knowledge structure has been used in a number of prior accounting studies (Frederick et al. 1994; Nelson et al. 1995; Bonner et al. 1996; Bonner et al. 1997; Kopp and O'Donnell 2005; Borthick et al. 2006). In their review of techniques for studying memory structure, Choo and Curtis (2000) note that the use of card-sorting is a well-known and straightforward technique.

The underlying reasons for using the card-sorting technique in this thesis are explained as follows. The current study attempts to investigate the effect of the use of two training techniques on some aspects of learning processes, including how the learners organise their knowledge during the organising, integrating and encoding processes. All of these processes occur in learners' working memories (Clark et al. 2006; Mayer 2008). The use of a card-sorting technique is suitable because card sorting can represent knowledge that is easily and often accessed from short-term memory, where concepts are compared on the basis of feature matching (Langan-Fox et al. 2000). Category structures are thought to be assembled in working memory (Anderson 2010). Therefore, the use of this technique as a way to represent cognitive categorisation is particularly suitable to measure the learning process in working memory.

However, the use of card sorting as a measure of knowledge structure has also been criticised on the basis that the resulting categories may or may not be representative of the structure or organisation of the knowledge in a participant's memory (Olson and Biolsi 1991; McNamara 1994; Kounios 1996; Coyne et al. 2010). In addition, the category structures can be context-dependent, with different situations leading a person to categorise the same object in different ways (Langan-Fox et al. 2000). Despite these criticisms, the use of this technique is appropriate in the context of this thesis because the category structures are developed from knowledge that the participants acquired during the training stage. It is therefore expected that the use of this technique will be useful to measure the effect of learning on knowledge structures because different instruction methods in the learning material are expected to have a different effect on the way the learners categorise the concepts (Borthick et al. 2006). The resulting categories are assumed to match representations of the stimuli in memory (van der Kloot and van Herk 1991) and from learning. Categories resulting from a card-sorting study must be based on knowledge present in participant's memory, because the experimental procedures restrict access to external sources of information. Thus, the card-sorting task is considered a fairly direct method of obtaining evidence of knowledge stored in memory (Olson and Biolsi 1991).

In this thesis, since the individual knowledge structure was measured immediately prior to the hypothesis generation stage, it provides a proxy for the knowledge structure that was used during the hypothesis generation stage.

3.6.7.3. Team Process Gains

Team process gains and losses have been used to measure how and to what degree group processes affect group performance. When group processes lead to performance that exceeds expectations, this is referred to as a process gain; when group processes lead to performance that falls below expectations, it is referred to as a process loss. Therefore, both gains and losses are relative and must be defined in terms of some baseline or expectation. The baseline may include the average of individual members; however, most prior social psychology studies on groups have used potential group performance as the baseline against which process gains and losses are measured (Kerr and Tindale 2004; Tindale and Starkel 2010). One such potential productivity baseline is the performance level of the group's most capable member (Kerr and Tindale 2004).

In this thesis, team process gains and losses are measured for the hypothesis generation stage of the task by comparing the performance level of the team's most capable member and the actual team performance. The performance level of the team's most capable member was determined by comparing the performance level of the two members of a team and selecting the member who had the higher score. The individual performance in hypothesis generation was based on the quality ratings as described previously in Section 3.3.1. Actual MDT performance was measured using the same quality ratings as explained in Section 3.3.2.

In this thesis, consistent with prior studies (e.g., Miner 1984), a measure of process gains and losses was calculated using the difference between the performance of the team's most capable member and the actual MDT performance. There are two possible categories that can be derived: *process gains* when the actual MDT performance is higher than the performance level of a team's most capable member, and *no process gains*, when the performance level of the team is either below the performance of the most capable member (i.e., process loss) or the same as the most capable member. To supplement this measure, a second analysis is also conducted by measuring the level of process gains and losses with a continuous measure in each experimental condition. Specifically, comparisons of the performance of the team's most capable member and the actual MDT performance are made for each experimental condition.

3.6.7.4. Alternative Subjective Team Process Measure

In the organisational psychology literature, team process can be measured objectively by independent coders through observation from videos or audiotapes of actual team processes or it can be measured subjectively by the research participants. In the current study, in addition to the process gains measure used as a proxy for team process, an alternative subjective team process measure was also employed. This measure used the nine items that were developed by Mathieu et al. (2006) which are based on the team process dimension by Marks et al. (2001).

Marks et al. (2001) developed a framework that includes a taxonomy of team processes that are thought to be most effective for teams performing action/psychomotor tasks (refer to McGrath's (1984) task typology in Chapter 2). The taxonomy included three superordinate categories: transition, action, and interpersonal. Marks et al. (2001) point out that teams act episodically. During the initial phase of their work (i.e., the transition phases), teams plan out what they will do in later stages, set their goals and plan their strategy. The group then transitions to the actual action stage, where it carries out its assigned tasks through coordinated activity. During this stage, members concentrate on task accomplishments, monitoring progress and systems, coordinating team members, as well as monitoring and backing up their fellow team members. Once this action phase is completed, the team re-enters the transition phase and begins preparing for subsequent tasks. Across all phases, the members are also managing the interpersonal aspects of the team in order to minimise conflict and maximise motivation, which includes conflict management, motivation and confidence building, and affect management (Marks et al. 2001).

In this thesis, team processes were indexed using three scales that correspond to Mark et al.'s (2001) superordinate categories above, each with three items: transition, action and interpersonal (Mathieu et al. 2006). To examine whether the use of this measure is suitable in the context other than team performing action/psychomotor tasks as in the current study, an additional analysis was undertaken. The nine items are presented in Table 3.7.

Table 3.7. Subjective Team Process Measure (Marks et al. 2001; Mathieu et al. 2006)

No.	
1.	Members of my team discussed our goal(s) in this task.
2.	Members of my team discussed what we can do to achieve our goals.
3.	Members of my team discussed our analysis of provided information in order to achieve our goals.
4.	Members of my team took the time we needed to share task-related information.
5.	Members of my team actively learnt from one another.
6.	Members of my team effectively communicated with each other throughout the task.
7.	Members of my team created an environment of openness and trust.
8.	Members of my team really trust each other.
9.	Members of my team think in terms of what is best for the team.

3.6.7.5. Elaboration of Task-Relevant Information

As outlined in Chapter 2, information elaboration is an important team process in order to improve MDT performance. Homan et al. (2008) developed a three item self-reported measure for information elaboration, which is based on the definition of information elaboration provided by van Knippenberg et al. (2004). The items are shown in Table 3.6. However, as shown in the right hand column of Table 3.8, the dimensions of information elaboration used by Homan et al. (2008) are included in two of the subjective team processes measures proposed by Mathieu et al. (2006), as outlined earlier. As such, these items are comparable with a measure of information elaboration as used by Homan et al. (2008). Thus, the two items of subjective team processes were used as a proxy for information elaboration.

Table 3.8. Information Elaboration Measure Items

Homan et al. (2008)	Mathieu et al. (2006)
1. The group members contributed a lot of information during the group task. 2. The group members contributed unique information during the group task. 3. During the task, we tried to use all available information.	1. Members of my team discussed our analysis of provided information in order to achieve our goals (Item No. 3). 2. Members of my team took the time we needed to share task-related information (Item No 4).

3.6.7.6. Transactive Memory Systems (TMSs) Processes

In addition to TMS structure, which is investigated in the primary analysis, TMS processes are also examined as part of the additional analyses. A process component of TMS consists of a set of transactive processes (encoding, storage, and retrieval processes) related to knowledge acquisition and use (Lewis et al. 2007; Lewis and Herndon 2011). In addition, these TMS processes are the mechanisms by which the group coordinates members' learning and retrieval of knowledge so that the knowledge can be applied to group tasks (Lewis and Herndon 2011).

In this thesis, transactive processes were analysed by examining two mechanisms in the analytical procedures task by which the group coordinates learning and retrieval of knowledge and applies it to group tasks. Specifically, these two mechanisms are: (1) how team members select hypotheses from the hypotheses generated by the individual members to be included as the team hypothesis set; and (2) how team members allocate the assurance procedures that need to be performed in the hypothesis evaluation stage to individual team members. The measure used for the first mechanism is the proportion of a member's hypotheses selected to be included as team hypotheses. The measure used in this thesis for the second mechanism is the proportion of assurance procedures to be tested by individual members and the team.

3.6.8. Summary of Dependent Variable Measures

The dependent variables measures that were used in this thesis are summarised in Table 3.9 below.

Table 3.9. The Measures of Dependent Variables

No.	Dependent Variables	Measures	Hypothesis
Measures for Primary Analyses			
1.	Individual performance in generating hypotheses	Individual hypothesis quality ratings scale (i.e., the total quality score for the six correct hypotheses ranges from zero (i.e., no hypothesis is correct) to 18 (i.e., six hypotheses with complete and specific nature, type and direction of error provided).	1, 2, and 3
2.	MDT performance in generating hypotheses	Team hypothesis quality ratings scale (i.e., the total quality score for the six correct hypotheses ranges from zero (i.e., no hypothesis is correct) to 18 (i.e., six hypotheses with complete and specific nature, type and direction of error provided).	4, 5, and 6
3.	MDT performance in evaluating hypothesis	Accuracy of hypothesis evaluation (i.e., team's evaluations was coded as '1' when the teams accurately evaluate the inherited and the correct hypothesis and coded as '0' when the teams incorrectly evaluate the inherited and correct hypothesis).	7, 8, and 9
4.	MDT performance in final judgment	Accuracy in identifying the actual cause (i.e., team's final judgment was coded as '1' when the teams correctly identify the actual cause and coded as '0' when the teams incorrectly identify the actual cause).	10
5.	TMM accuracy in hypothesis generation	The accuracy of MDT member's categorisation of 12 causal hypotheses to the referent model using card sorting (i.e., each pairing of cards was scored as '1' when the causal hypotheses were grouped together and '0' otherwise. This score was converted into a 12 x 12 similarity matrix. Each member's string of 0s and 1s was correlated to the referent model and then averaged to create a TMM accuracy score).	11a, 12a, 13a, 14a, 14b, 14c

Table 3.7. The Measures of Dependent Variables (Continued)

No.	Dependent Variables	Measures	Hypothesis
Measures for Primary Analyses			
6.	TMM similarity in hypothesis generation	The similarity of MDT member's categorisation of 12 causal hypotheses with other member using card sorting (i.e., each pairing of cards was scored as '1' when the causal hypotheses were grouped together and '0' otherwise. This score was converted into a 12 x 12 similarity matrix. Each member's string of 0s and 1s was correlated with their other team member to create a TMM similarity score).	11b, 12b, 13b, 15a, 15b, 15c
7.	TMM accuracy in hypothesis evaluation	The accuracy of the MDT's hypothesis evaluation task representation. The accuracy was coded as '1' when the teams shared a task representation in favour of an alternative (i.e., error) hypothesis and was coded as '0' when the teams shared the task representation in favour of the inherited hypothesis.	17a, 18a, 19a, 20a, 20b, 20c
8.	TMM similarity in hypothesis evaluation	The similarity of each MDT member's hypothesis evaluation task representation. The similarity was coded as '1' when the both members generate either an inherited or an alternative or error hypothesis in their hypothesis set. The similarity was coded as '0' when the team members generate dissimilar hypotheses (i.e., one member generates an inherited hypothesis but other member does not generate an inherited hypothesis.	17b, 18b, 19b, 21a, 21b, 21c
9.	TMS structure	The similarity of each MDT member's categorisation of 12 subtasks relating to working as a team in performing the analytical procedures task with the other member using card sorting (i.e., each pairing of cards was scored as '1' when the causal hypotheses were grouped together and '0' otherwise. This score was converted into a 12 x 12 similarity matrix. Each member's string of 0s and 1s was correlated with the other team member's to create a TMS structure score).	22, 23, 24, 25
Measures for Additional Analyses			
10.	Cognitive load	Participants' perceptions of task difficulty using a seven-point Likert-scale with end points labelled extremely easy and extremely difficult. This rating was then calculated relative to the standardised individual learning performance to obtain performance efficiency metrics. When performance is greater than cognitive load, the efficiency value is positive. When performance is lower than cognitive load, the efficiency is negative.	Additional analysis for Hypotheses 1, 2, and 3

Table 3.7. The Measures of Dependent Variables (Continued)

No.	Dependent Variables	Measures	Hypothesis
Measures for Additional Analyses			
11.	Individual knowledge structure	The accuracy of individual's categorization of twelve causal hypotheses to the referent model using card sorting (i.e., each pairing of cards was scored as '1' when the causal hypotheses grouped together and '0'otherwise. This score was converted into a 12 x 12 similarity matrix. Individual's string of 0s and 1s was correlated to the referent model to create an individual's knowledge structure score).	Additional analysis for Hypotheses 1, 2, and 3
12.	Team process gains	• The categorical measure of *process gains* when the actual MDT member performance was higher than the performance level of the team's most capable member and *no process gain* when the actual MDT performance was the same or below the performance level of the team's most capable member. • Comparison of performance of the team's most capable member and the actual team performance in each experimental condition.	Additional analysis for Hypotheses 4, 5, and 6
13.	Subjective team process	Team processes were indexed using nine items scales that correspond to Mark et al.'s (2001) superordinate team process categories, each with three items: transition, action and interpersonal (Mathieu et al., 2006).	Additional analysis for Hypotheses 4, 5, and 6
14.	Elaboration of task-relevant information	Two items of subjective team processes (Mathieu et al., 2006) that are comparable with a measure of information elaboration as used by Homan et al. (2008).	Additional analysis for Hypotheses 4, 5, and 6
15.	TMS processes	• The proportion of individual member hypotheses selected to be included as team hypotheses. • The proportion of assurance procedures to be tested by individual member(s) and the team.	Additional analysis for Hypotheses 22, 23, 24

CHAPTER 4

ANALYSIS OF DATA AND DISCUSSION OF RESULTS

4.1. Introduction

This chapter reports and discusses the test results for the hypotheses outlined in Chapter 2. Section 4.2 analyses the hypothesis testing data. The discussion of the results is presented in the last section.

4.2. Analysis of Data

This section presents the results of the research hypothesis tests. The section consists of four parts. First, Section 4.2.1 reports the results of tests relating to the use of the analogical encoding and collaborative learning techniques as an individual training intervention. The three hypotheses (Hypotheses 1, 2 and 3) explore the effect of these training techniques in improving individual performance in generating hypotheses (stage 1 of the analytical procedures task). Section 4.2.2 presents the results of tests on the effect on MDT performance during the analytical procedures task. Hypotheses 4, 5 and 6 test the hypothesis generation stage of the analytical procedures task, whereas Hypotheses 7, 8, and 9 test the hypothesis evaluation. Hypothesis 10 tests the final judgment stages of the analytical procedures task. Section 4.2.3 provides the results of tests relating to the impact of team training on the cognitive structures of MDTs (Hypotheses 11 to 25). Finally, Section 4.2.4 presents additional analyses relating to the effect of the training interventions on individual and MDT performance.

4.2.1. Results Relating to the Use of Analogical Encoding and Collaborative Learning Techniques as an Individual Training Intervention

This section reports the results of the testing of Hypotheses 1, 2 and 3, which relate to the effects of the training techniques on individual members' performance in generating hypotheses. The dependent variable measuring hypothesis generation performance for these hypotheses is the hypothesis quality score previously described in Chapter 3.

4.2.1.1. Testing of Hypotheses 1, 2 and 3: Individual Hypothesis Generation Performance

Hypothesis 1 predicts that the use of the analogical encoding technique (problem-category comparison) may not be effective as a training intervention in improving the performance of individual members of MDTs in a complex task such as an analytical procedures task. Therefore, Hypothesis 1 proposes that individuals who train using the analogical encoding technique will not outperform individuals who train without the analogical encoding technique when generating hypotheses. As more benefits are obtained by using collaborative learning, Hypothesis 2 predicts that individuals who train using the collaborative learning technique will outperform individuals who train without it when generating hypotheses. In addition, a combination of the two training techniques (analogical encoding and collaborative learning) will help satisfy the three learning principles (limited capacity, deep processing and memory organisation). This will improve individual performance during analytical procedures to a greater extent than either individual technique alone. The single intervention training techniques have potential limitations in satisfying the three principles in learning and transfer. Thus, Hypothesis 3 predicts that the performance of individuals will be highest when they train using a combination of the analogical encoding and collaborative learning techniques, lower when the individuals train only with the collaborative learning technique, and lowest when they train without the collaborative learning technique, regardless of whether they train with or without the analogical encoding technique.

Table 4.1 presents descriptive statistics, conventional ANOVA and the planned contrast results for the individual hypothesis generation using the hypothesis generation quality score. As shown in Panel A of Table 4.1, the mean hypothesis generation quality score of individuals who train using the analogical encoding technique is 6.92, while the mean hypothesis generation quality score of individuals who train without the analogical encoding technique is 6.31.[42] The insignificant difference between the two conditions is consistent with Hypothesis 1. To test Hypothesis 1, a conventional 2 x 2 ANOVA was conducted on individuals' hypothesis generation quality scores, with the two training techniques as between-subjects variables. Analogical encoding in Table 4.1, Panel B, has an insignificant effect on individuals' hypothesis generation quality score (F = 0.840, p-value = 0.361). These results provide support for Hypothesis 1.

---

[42] The means of quantity of hypotheses generated by participants are 6.13, 5.44, 5.40 and 5.50 in Conditions 1, 2, 3 and 4, respectively. The ANOVA results indicate that there are no significant main effects or interaction for the quantity of hypotheses generated.

Table 4.1. Individual Hypothesis Generation Quality Score by Training Techniques

Panel A: Means (Standard Deviations) of Individual Hypothesis Generation Quality Score Across Four Training Conditions

Factor	**No Analogical Encoding**	**Analogical Encoding**	**Row Means**
No Collaborative Learning	*Condition 1* **6.06** (3.98) *n* = 32	*Condition 2* **5.79** (3.97) *n* = 34	**5.92** (3.94) *n* = 66
Collaborative Learning	*Condition 3* **6.57** (3.89) *n* = 30	*Condition 4* **8.20** (4.83) *n* = 30	**7.38** (4.43) *n* = 60
Column Means	**6.31** (3.91) *n* = 62	**6.92** (4.52) *n* = 64	**6.62** (4.23) *n* = 126

Panel B: Conventional ANOVA Results

Independent Variable	***SS***	***d.f.***	***MS***	***F***	***p*-value**[a]
Analogical Encoding **(H1)**	14.632	1	14.632	0.840	0.361
Collaborative Learning **(H2)**	66.508	1	66.508	3.817	0.027
Analogical Encoding × Collaborative Learning	28.403	1	28.403	1.630	0.204
Error	2,125.600	122	17.423		

Panel C: Planned Contrast

Test of **H3**: Performance of individuals will be highest in the collaborative learning/analogical encoding technique condition, lower in the no analogical encoding/collaborative learning technique condition, and lowest in the two no collaborative learning technique conditions (contrast weights are +5, +1, -3 and -3, respectively).

Source of Variation	***SS***	***d.f.***	***MS***	***F***	***p*-value**[a]
Contrast	101.884	1	101.884	5.848	0.009
Residual[b]	7.659	2	15.318	0.879	0.418

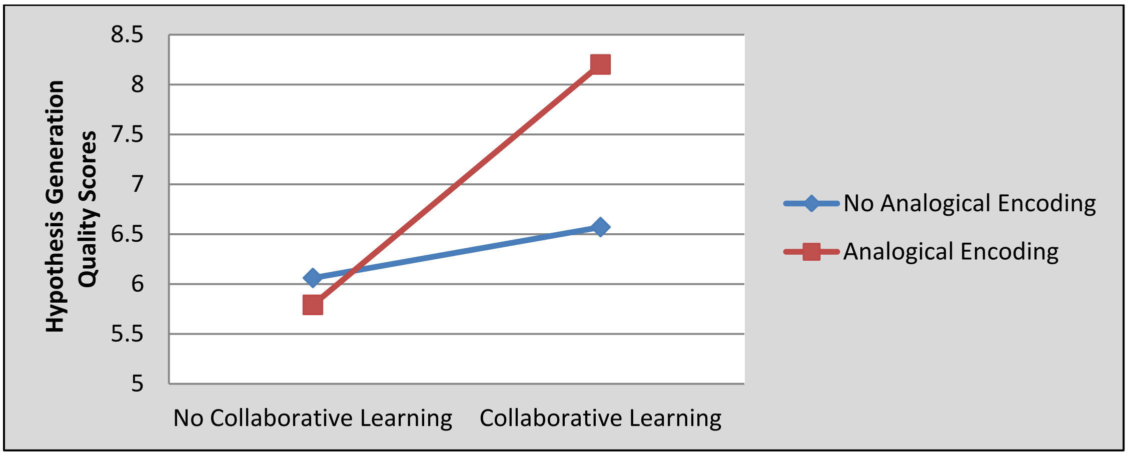
[a] *p*-values are one-tailed because there are directional expectations (expectations relating to H2 and H3). All other *p*-values are two-tailed.

[b] The residual sum of squares represents the between-group variance not explained by the contrast weights used to test the hypothesis. An insignificant *F*-statistic for the residual indicates that the specified contrast is a good fit (Hirst et al. 2007).

Table 4.1, Panel A, shows that the mean hypothesis generation quality score of individuals who train using the collaborative learning technique is 7.38 whereas the mean hypothesis generation quality score of individuals who train without the collaborative learning technique is 5.92. The direction of the difference is consistent with Hypothesis 2. The conventional ANOVA results in Panel B of Table 4.1 indicate that the main effect for the collaborative learning technique is significant (*F* = 3.817, *p*-value = 0.027). These results support Hypothesis 2.

Hypothesis 3 predicts that the mean of individuals' hypothesis generation quality scores in the analogical encoding/collaborative learning technique condition (Condition 4) will be highest; the mean in the no analogical encoding/collaborative learning technique condition (Condition 3) will be lower; and the means in both no collaborative learning technique conditions (i.e., Condition 1 and Condition 2) will be lowest. Descriptive statistics reported in Panel A of Table 4.1 show that condition means fall approximately into the pattern predicted (Condition 1 = 6.06, Condition 2 = 5.79, Condition 3 = 6.57, and Condition 4 = 8.20; see Figure 4.1).

Figure 4.1. Results Showing the Effect of Training Techniques on Individual Hypothesis Generation Quality Scores



Because Hypothesis 3 predicts an ordinal interaction, the hypothesis testing does not rely on the interaction terms from the conventional ANOVA model as such models allocate much of the variance of an ordinal interaction to simple main effects instead of the interaction term (Buckless and Ravenscroft 1990). Instead, this hypothesis is tested with a single planned contrast test. However, the conventional ANOVA result is presented for completeness.[43] As suggested by Buckless and Ravenscroft (1990), contrast coding requires a priori reasoning and explicit hypotheses that enable researchers to select appropriate weights. Based on the proposed relationship in Figure 2.3, presented in Chapter 2, contrast weights can be determined by subtracting the overall mean of all cells from the expected mean for each cell and then rounding to the nearest whole number. As in ANOVA, the contrast weights assigned to the experimental cells should sum to zero (Buckless and Ravenscroft 1990; Rosnow and

---

[43] In the conventional ANOVA model, contrast weights for the analogical encoding and collaborative learning main effect would be: -1, +1, -1, and +1 and -1, -1, +1, and +1, respectively. For the interaction, the contrast weight would be: +1, -1, -1, and +1 respectively (Buckless and Ravenscroft 1990).

Rosenthal 1995; Keppel and Wickens 2004).[44] The contrast weights that are used are as follows: +5 for Condition 4; +1 for Condition 3; and -3 for Conditions 1 and 2.

Panel B of Table 4.1 presents the conventional ANOVA with the default disordinal interaction test, where the interaction of the two training techniques is not significant (F = 1.630, p-value = 0.204). However, more appropriate hypothesis testing using the planned contrast is presented in Panel C, where the statistically significant results support the predicted pattern (F = 5.848, p-value = 0.009). Hypothesis 3 is therefore supported.[45]

4.2.2. Results Relating to the Effect of the Use of the Analogical Encoding and Collaborative Learning Techniques as Team Training Interventions

The foregoing sections provide results for testing hypotheses relating to the effect of the training techniques on the performance of individual members of a team. However, it is important to understand whether the training benefits accruing to individuals translate to team outcomes. Therefore, this section reports the results of hypothesis testing with regard to the effect on MDT performance of the two training techniques (analogical encoding and collaborative learning) as team-training interventions. Sections 4.2.2.1 and 4.2.2.2 present the results relating to hypothesis generation and hypothesis evaluation of the analytical procedures task, respectively. Finally, Section 4.2.2.3 reports the results relating to the final analytical procedures task judgment.

4.2.2.1. Testing Hypotheses 4, 5 and 6: MDT Hypothesis Generation Performance

This section reports the results of the testing of Hypotheses 4, 5 and 6, which regard to the effects of the use of training techniques on MDT performance in generating hypotheses. Hypothesis 4 predicts that when generating hypotheses, due to the complex nature of the task and the increased cognitive load when using this technique, MDTs whose members train

---

[44] A single planned contrast and the related weights were identified from the previous literature as appropriate for the predicted pattern of results (Rosnow and Rosenthal 1995). Studies in prior accounting research conduct similar tests (e.g., Kadous et al. 2003; Hirst et al. 2007; Lambert and Agoglia 2011).

[45] Given an aspect of a cause (i.e., its type) may be more critical compared to other aspects (i.e., its nature and direction), a sensitivity analysis was conducted to examine whether the results are inferentially the same when individual performance in generating hypotheses is measured using a weighted form. The weights that are used are as follows: 2 for type of a cause, 1 for its nature and 1 for its direction. The analysis shows that the results for Hypotheses 1, 2 and 3 are inferentially the same when the dependent variable is measured using a weighted form.

using the analogical encoding technique will not outperform MDTs whose members train without this technique. In contrast, Hypothesis 5 predicts that when generating hypotheses, MDTs whose members train using the collaborative learning technique will outperform MDTs whose members train without this technique. In addition, because many positive effects (such as reducing cognitive load, encouraging deep processing when learning, and facilitating the development of knowledge structure) can be obtained using a combination of these two training technique, Hypothesis 6 predicts an ordinal interaction between the two training techniques. Specifically, it is hypothesised that when generating hypotheses, MDT performance will be highest when MDT members train using a combination of the analogical encoding and collaborative learning techniques; lower when they train with only the collaborative learning technique; and lowest when they train without the collaborative learning technique, regardless of whether they train with or without the analogical encoding technique.

Table 4.2, Panel A, presents descriptive statistics, the conventional ANOVA results and the planned contrast for the hypothesis generation measure, team hypothesis generation quality score. As shown in Panel A of Table 4.2, the mean hypothesis generation quality score of MDTs whose members train using the analogical encoding technique is 8.13, while the mean of the hypothesis generation quality score of MDTs whose members train without the analogical encoding technique is 7.35. To test Hypothesis 3, a conventional 2 x 2 ANOVA on MDTs' hypothesis generation quality score with the two training techniques as between-subjects variables was performed. Table 4.2, Panel B, reports that the analogical encoding technique has an insignificant main effect on MDTs' hypothesis generation quality score (*F* = 0.665, *p*-value = 0.209). These results provide support for Hypothesis 4.[46]

Table 4.2, Panel A, also shows that the mean hypothesis generation quality scores of MDTs whose members train using the collaborative learning technique is 8.60, while the mean hypothesis generation quality score of MDTs whose members train without the collaborative learning technique is 6.97. The direction of the difference is consistent with Hypothesis 5. The conventional ANOVA results in Panel B of Table 4.2 reveal that the main effect for the collaborative learning technique is significant (*F* = 2.561, *p*-value = 0.058). These results support Hypothesis 5.

---

[46] The means of quantity of hypotheses generated by teams are 6.69, 6.00, 5.47 and 5.53 in Conditions 1, 2, 3 and 4, respectively. The ANOVA results indicate that there are no significant main effects or interaction for the quantity of hypotheses generated.

Table 4.2. Teams' Hypothesis Generation Quality Score by Training Technique

Panel A: Means (Standard Deviations) Of MDTs' Hypothesis Generation Quality Score Across Four Training Conditions

Factor	No Analogical Encoding	Analogical Encoding	Row Means
	Condition 1	*Condition 2*	
No Collaborative Learning	**6.94** (2.67) *n* = 16	**7.00** (2.26) *n* = 17	**6.97** (2.43) *n* = 33
	Condition 3	*Condition 4*	
Collaborative Learning	**7.80** (4.35) *n* = 15	**9.40** (6.03) *n* = 15	**8.60** (5.23) *n* = 30
Column Means	**7.35** (3.55) *n* = 31	**8.13** (4.53) *n* = 32	**7.75** (4.06) *n* = 63

Panel B: Conventional ANOVA Results

Independent Variable	*SS*	*d.f.*	*MS*	*F*	*p*-value[a]
Analogical Encoding **(H4)**	10.853	1	10.853	0.665	0.209
Collaborative Learning **(H5)**	41.797	1	41.797	2.561	0.058
Analogical Encoding × Collaborative Learning	9.283	1	9.283	0.569	0.227
Error	962.938	59	16.321		

Panel C: Planned Contrasts

Test of **H6**: MDT performance will be highest in the collaborative learning/analogical encoding techniques condition, lower in the no analogical encoding/collaborative learning technique condition, and lowest in the two no collaborative learning technique conditions (contrast weights are +7, +3, -5 and -5, respectively).

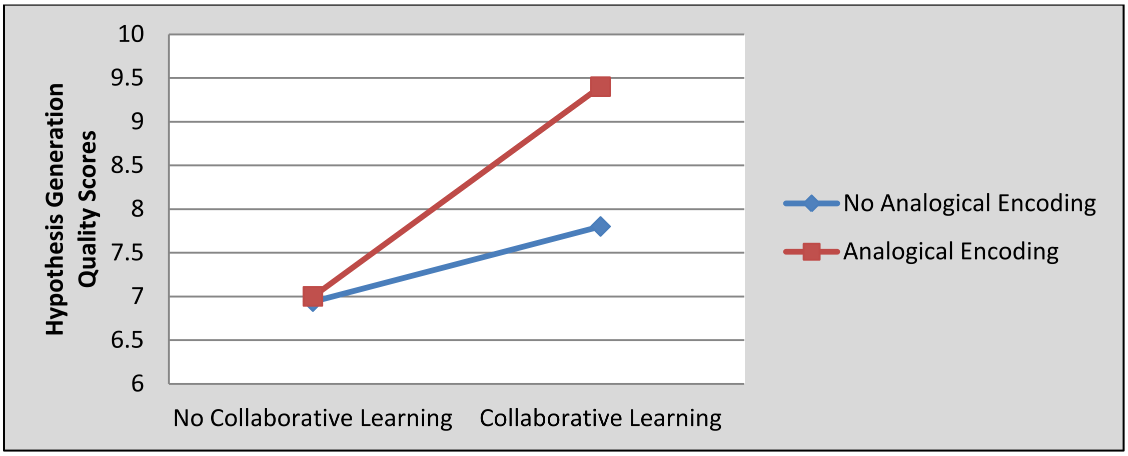
Source of Variation	*SS*	*d.f.*	*MS*	*F*	*p*-value[a]
Contrast	55.181	1	55.181	3.381	0.035
Residual[b]	6.752	2	3.376	0.207	0.814

[a] *p*-values are one-tailed because there are directional expectations (expectations relating to H5 and H6). All other *p*-values are two-tailed.

[b] The residual sum of squares represents the between-group variance not explained by the contrast weights used to test the hypothesis. An insignificant *F*-statistic for the residual indicates that the specified contrast is a good fit (Hirst et al. 2007).

Finally, Hypothesis 6 predicts that the mean of teams' hypothesis generation quality scores in the analogical encoding/collaborative learning techniques condition (Condition 4) will be highest; the mean in the no analogical encoding/collaborative learning technique condition (Condition 3) will be lower; and the means in both the no collaborative learning technique conditions (Condition 1) and analogical encoding/no collaborative learning technique [Condition 2) will be lowest. Descriptive statistics reported in Panel A of Table 4.2 show that condition means fall approximately into the pattern predicted (Condition 1 = 6.94, Condition 2 = 7.00, Condition 3 = 7.80, and Condition 4 = 9.40; see Figure 4.2).

Figure 4.2. Results Showing the Effect of Training Techniques on Team Hypothesis Generation Quality Scores



Similar to Hypothesis 3, Hypothesis 6 predicts an ordinal interaction; therefore, the hypothesis testing does not rely on the interaction terms from the conventional ANOVA model. This hypothesis is tested with a single planned contrast test. However, the conventional ANOVA result is presented for completeness. Consistent with the tests for individual hypothesis generation quality, following Buckless and Ravenscroft's (1990) suggestion, and based on the proposed relationship in Figure 2.4 presented in Chapter 2, contrast weights are determined by subtracting the overall mean of all cells from the expected mean for each cell and then rounding to the nearest whole number. As in ANOVA, the contrast weights assigned to the experimental cells should sum to zero (Buckless and Ravenscroft 1990; Rosnow and Rosenthal 1995; Keppel and Wickens 2004). The contrast weights that are used are as follows: +7 for Condition 4; +3 for Condition 3; and -5 for Conditions 1 and 2.

Panel B of Table 4.2 presents the conventional ANOVA with the default disordinal interaction test and shows that the interaction of the two training techniques is not significant (F = 0.569, *p*-value = 0.227). However, Panel C presents the more appropriate hypothesis testing using the planned contrast. Results support the predicted pattern and show a significant effect (F = 3.381, *p*-value = 0.035). Hypothesis 6 is therefore supported.[47]

---

[47] A sensitivity analysis was conducted to examine whether the results are inferentially the same when MDT performance in generating hypotheses is measured using a weighted form. The weights that are used are as follows: 2 for type of a cause, 1 for its nature and 1 for its direction. The analysis shows that the results for Hypotheses 4, 5 and 6 are inferentially the same when the dependent variable is measured using a weighted form.

4.2.2.2. Testing of Hypotheses 7, 8 and 9: MDT Hypothesis Evaluation Performance

This section reports the results of hypothesis testing for the effects of the training techniques on MDT performance in evaluating hypotheses. Hypothesis 7a (7b) predicts that MDT performance in evaluating the inherited hypothesis (the correct hypothesis) will be better when the MDT members train using the analogical encoding technique than when MDTs train without the analogical encoding technique. Hypothesis 8a (8b) predicts that MDT performance in evaluating the inherited hypothesis (the correct hypothesis) will be better when the MDT members train using the collaborative learning technique than when MDTs train without the collaborative learning technique. Hypothesis 9a (9b) proposes an ordinal interaction for the two training techniques. That is, MDT performance in evaluating the inherited hypothesis (the correct hypothesis) will be better when the MDT members train using a combination of the analogical encoding and the collaborative learning techniques than when they train with a single or no-training technique.

The results for these tests are presented below and are divided into two parts: tests relating to evaluating the inherited hypothesis (Hypotheses 7a, 8a and 9a) and tests relating to evaluating the correct hypothesis (Hypothesis 7b, 8b and 9b).

4.2.2.2.1. Testing of Hypotheses 7a, 8a and 9a: MDT Performance in Evaluation of the Inherited Hypothesis

Panel A of Table 4.3 provides the proportion (percentage) of MDTs correctly evaluating the inherited hypothesis. Data for the test are based on teams including the inherited hypothesis in their hypothesis set. Not all teams included the inherited hypothesis in their hypothesis set. The proportion of teams including the inherited hypothesis in their hypothesis set is 75% for Condition 1, 59% for Condition 2, 53% for Condition 3 and 73% for Condition 4.[48] The hypothesis testing presented in this section is based on the teams that actually included the inherited hypothesis in their set.

---

[48] The proportion of teams including the inherited hypothesis is not significantly different across conditions ($\chi^2 = 0.590$, p = 0.442).

Table 4.3. MDT Performance in Evaluating the Inherited Hypothesis

Panel A: Proportion (Percentage) of MDTs Correctly Evaluating the Inherited Hypothesis

Factor	No Analogical Encoding	Analogical Encoding	Row Proportion
No Collaborative Learning	*Condition 1* **1/12** (8.33)	*Condition 2* **1/10** (10.00)	**2/22** (9.09)
Collaborative Learning	*Condition 3* **0/8** (0.00)	*Condition 4* **6/11** (54.55)	**6/19** (31.58)
Column Proportion	**1/20** (5.00)	**7/21** (33.33)	**8/41** (19.51)

Panel B: Exact Method Logistic Regression Results

Variable	Prediction	Estimate (Standard Error)	*Z* Statistic	Exact *p*-value (one tail)
Analogical Encoding	**H7a** (+)	2.109 (1.127)	4.481	0.023
Collaborative Learning	**H8a** (+)	1.407 (0.917)	2.556	0.104
Analogical Encoding × Collaborative Learning	–	–	7.422	0.011

Panel C: Exact Method Planned Contrast

Test of **H9a**: Performance in evaluating the inherited hypothesis will be better for MDTs in the collaborative learning/analogical encoding technique condition than those in the no analogical encoding/collaborative learning technique condition, and in the two no collaborative learning technique conditions

Contrast	Prediction	Estimate (Standard Error)	*Z* Statistic	Exact *p*-value (one tail)
Condition 4 > Conditions 1, 2 and 3	**H9a** (+)	2.718 (0.925)	11.462	0.001

Of the 21 MDTs whose members trained using the analogical encoding technique, 7 MDTs (33%) correctly evaluated the inherited hypothesis, whereas only 1 of the 20 MDTs (5%) whose members trained without the analogical encoding technique correctly evaluated the inherited hypothesis. This result is consistent with the predictions of Hypothesis 7a. The hypotheses were tested using the exact method logistic regression and planned contrast as presented in Panel B and C of Table 4.3.[49] Panel B of Table 4.3 indicates that the main effect for the analogical encoding technique is significant ($Z = 4.481$, exact p-value = 0.023).

---

[49] The test of proportion differences using simple effects in a categorical model (Kadous et al. 2003), the simple chi-square tests or the maximum likelihood estimation were not feasible for Hypotheses 7a, 7b, 8a and 8b because of the small numbers of teams correctly evaluating the inherited and correct hypotheses. The appropriate statistical tests for small samples, as suggested by Stokes et al. (2009), is to use a methodology based on exact permutation distributions. A statistical program (i.e., SAS) provides exact logistic regressions for binary outcomes with an exact probability test and an exact score test for the hypotheses. Therefore, the hypothesis testing was conducted using this procedure.

Panel B of Table 4.3 reports that the exact parameter estimate for the analogical encoding technique is 2.109. This means that MDTs trained using the analogical encoding technique had 2.1 times the odds of correctly evaluating the inherited hypothesis as the odds of those MDTs trained without the analogical encoding technique. Thus, these results provide support for Hypothesis 7a.

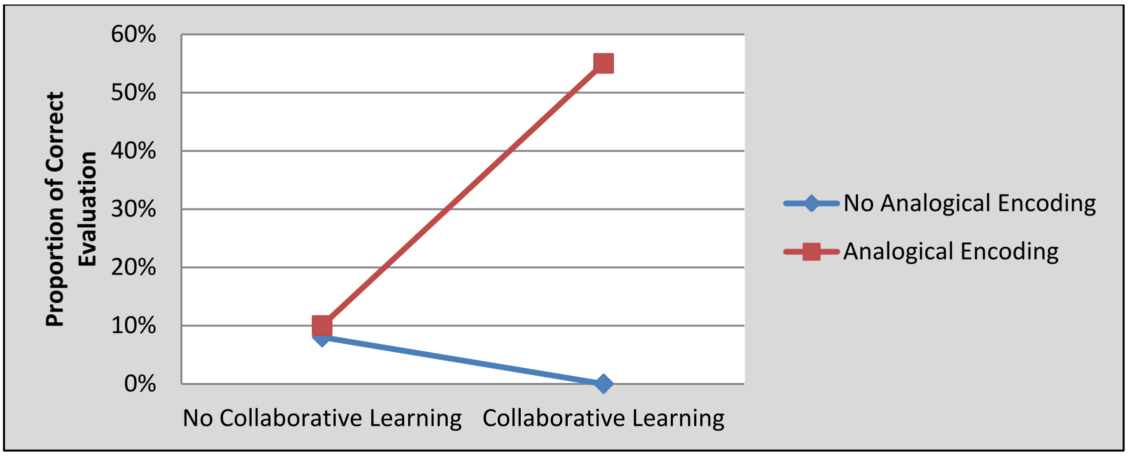
Panel A of Table 4.3 shows that from 19 MDTs whose members trained using the collaborative learning technique, six MDTs (32%) correctly evaluated the inherited hypothesis, while only two of 22 MDTs (9%) whose members trained without the collaborative learning technique correctly evaluated the inherited hypothesis. However, Panel B of Table 4.3 indicates an insignificant main effect for the collaborative learning technique (Z = 2.556, exact p-value = 0.104). Thus, Hypothesis 8a is not supported by these results.

Hypothesis 9a predicts that the proportion of MDTs correctly evaluating the inherited hypothesis in Condition 4 where MDTs train with both the analogical encoding and collaborative learning techniques will be higher than the proportion of MDTs in Condition 1, 2, and 3. Hypothesis 9a also predicts that there will be no difference in the proportion of MDTs correctly evaluating the inherited hypothesis between Conditions 1, 2 and 3. As shown in Panel A of Table 4.3, 55% of the MDTs in Condition 4 correctly evaluated the inherited hypothesis, as opposed to 8% in Condition 1, 10% in Condition 2, and none in Condition 3 (see Figure 4.3). This result is consistent with Hypothesis 9a. Panel B of Table 4.3 shows that the interaction effect of the two training techniques is significant (Z = 7.422, exact p-value = 0.011). Planned contrast results in Panel C of Table 4.3 provide evidence that the combined use of the two techniques has a significant effect (Z = 11.462, exact p-value = 0.001).[50] Panel C of Table 4.3 also indicates that MDTs trained using a combined analogical encoding and collaborative learning technique were 2.7 times more likely to correctly evaluate the inherited hypothesis than MDTs in other conditions. Therefore, these results also support Hypothesis 9a.

---

[50] The differences between the proportions in Conditions 1, 2 and 3 are not statistically significant (exact p-value = 0.805 for Condition 1 and 2; 0.600 for Conditions 1 and 3; and 0.556 for Condition 2 and Condition 3).

Figure 4.3. Results Showing the Effect of Training Techniques on MDT Evaluation of the Inherited Hypothesis



4.2.2.2.2. Testing of Hypothesis 7b, 8b and 9b: MDT Performance in Evaluation of the Correct Hypothesis

Table 4.4 reports the descriptive statistics, the exact method logistic regression and planned contrast results for MDT performance when evaluating the correct hypothesis. Data for the test is based on MDTs generating and including the correct hypothesis in their hypothesis set. Not all teams were able to generate and include the correct hypothesis in their hypothesis set. The number of MDTs that generated the correct hypothesis was 5 of 16 MDTs (31%) in Condition 1; 4 of 17 MDTs (24%) in Condition 2; 6 of 15 MDTs (40%) in Condition 3; and 6 of 15 MDTs (40%) in Condition 4.[51] The hypothesis testing presented in this section is based on teams that actually included the correct hypothesis in their set.

Table 4.4, Panel A, provides the proportion (percentage) of MDTs correctly evaluating the correct hypothesis. Of 10 MDTs whose members trained using the analogical encoding technique, 4 MDTs (40%) correctly evaluated the correct hypothesis, whereas only 1 of 11 MDTs (9%), whose members trained without the analogical encoding technique, correctly evaluated the correct hypothesis. However, the results reported in Panel B of Table 4.4 indicate that the main effect for the analogical encoding technique is not significant (Z = 2.829, exact p-value = 0.121); thus, Hypothesis 7b is not supported.

---

[51] The proportion of teams that generated the correct hypothesis in their hypothesis set is not significantly different across conditions (χ^2 = 0.394, p = 0.530).

Table 4.4. MDT Performance in Evaluating the Correct Hypothesis

Panel A: Proportion (Percentage) of MDTs Correctly Evaluating the Correct Hypothesis

Factor	No Analogical Encoding	Analogical Encoding	Row Proportion
	Condition 1	*Condition 2*	
No Collaborative Learning	**0/5** (0.00)	**0/4** (0.00)	**0/9** (0.00)
	Condition 3	*Condition 4*	
Collaborative Learning	**1/6** (16.67)	**4/6** (66.67)	**5/12** (41.67)
Column Proportion	**1/11** (9.09)	**4/10** (40.00)	**5/21** (23.81)

Panel B: Exact Method Logistic Regression Results

Variable	Prediction	Estimate (Standard Error)	*Z* Statistic	Exact *p*-value (one tail)
Analogical Encoding	**H7b** (+)	2.074 (1.304)	2.829	0.121
Collaborative Learning	**H8b** (+)	2.035 (0.000)	4.754	0.021
Analogical Encoding × Collaborative Learning	–	–	6.950	0.014

Panel C: Exact Method Planned Contrast

Test of **H9b**: Performance in evaluating the correct hypothesis will be higher for MDTs in the collaborative learning/analogical encoding techniques condition than those in the no analogical encoding/collaborative learning technique condition, and in the two no collaborative learning technique conditions.

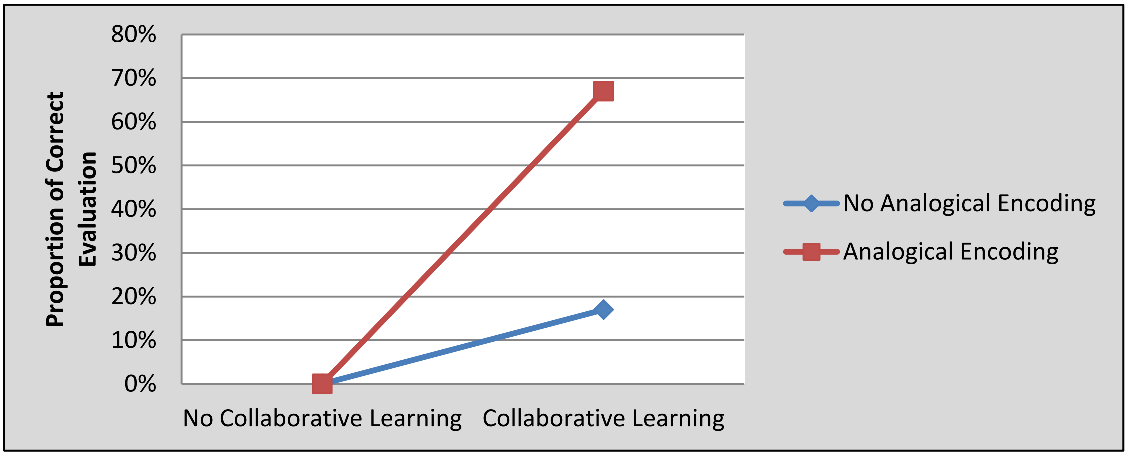
Contrast	Prediction	Estimate (Standard Error)	*Z* Statistic	Exact *p*-value (one tail)
Condition 4 > Conditions 1, 2 and 3	**H9b** (+)	3.071 (1.263)	8.100	0.006

Panel A of Table 4.4 also shows that out of 12 MDTs whose members trained using the collaborative learning technique, 5 MDTs (42%) correctly evaluated the correct hypothesis, while none of the 9 MDTs (0%) whose members trained without the collaborative learning technique did so. This result is consistent with the predictions of Hypothesis 8b. Panel B of Table 4.3 indicates that the main effect of the collaborative learning technique is significant ($Z = 4.754$, exact *p*-value = 0.021); thus, Hypothesis 8b is strongly supported.

Finally, Hypothesis 9b predicts that the proportion of MDTs correctly evaluating the correct hypothesis in Condition 4 will be higher than the proportion of MDTs in Conditions 1, 2 and 3, and that there will be no difference in the proportion of MDTs correctly evaluating the correct hypothesis among Conditions 1, 2 and 3. Panel A of Table 4.4 shows that 67% of the MDTs in Condition 4 correctly evaluated the correct hypothesis, compared to 0% in Conditions 1 and 2, and 17% in Condition 3 (see Figure 4.4). The interaction effect for the two training techniques, as shown in Panel B of Table 4.4, is significant ($Z = 6.950$, exact *p*-value =

0.014). Planned contrast results in Panel C show that the proportion of MDTs correctly evaluating the correct hypothesis in Condition 4 is significantly higher than the proportion of MDTs in Conditions 1, 2 and 3 ($Z = 8.100$, exact p-value = 0.006).[52] As indicated by the exact parameter estimate shown in Panel C of Table 4.3, MDTs trained using the combined techniques are three times more likely to correctly evaluate the correct hypothesis than MDTs in other conditions. Thus, these results support Hypothesis 9b.

Figure 4.4. Results Showing the Effect of Training Techniques on MDT Evaluation of the Correct Hypothesis



4.2.2.3. Testing of Hypothesis 10: MDT Final Judgment Performance

Hypothesis 10 predicts that MDT performance in selecting the correct causal hypothesis will be higher when MDTs train using a combination of the analogical encoding and collaborative techniques than when they train with only one or neither of these techniques.[53] In other words, Hypothesis 10 predicts that the proportion of MDTs that select the correct causal hypothesis in Condition 4 will be higher than the proportion of MDTs in Conditions 1, 2 and 3, and that there will be no difference in the proportion of MDTs correctly evaluating the correct hypothesis in Conditions 1, 2 and 3. The results are reported in Table 4.5.

---

[52] The differences between the proportions in Conditions 1, 2, and 3 are not statistically significant (exact p-value = 1.000 for Conditions 1 and 2, 0.595 for Conditions 1 and 3, and 0.600 for Conditions 2 and 3).

[53] As noted in Chapters 2 and 3, there are four training conditions: training with neither of the analogical encoding or the collaborative learning techniques (Condition 1); training with the analogical encoding technique only (Condition 2); training with the collaborative learning technique only (Condition 3); and training with a combination of the analogical encoding and collaborative learning techniques (Condition 4). The planned contrast, as predicted by Hypothesis 10, compares Condition 4 with the other conditions (Conditions 1, 2 and 3) and does not include the control condition (i.e., the condition that received no training in the analytical procedures task).

Table 4.5. MDT Performance in the Final Judgment

Panel A: Proportion (Percentage) of MDTs Correctly Nominating the Correct Hypothesis

Factor	No Analogical Encoding	Analogical Encoding	Row Proportion
No Collaborative Learning	*Condition 1*	*Condition 2*	**0/33** (0.00)
	0/16 (0.00)	**0/17** (0.00)	
Collaborative Learning	*Condition 3*	*Condition 4*	**5/30** (16.67)
	1/15 (6.67)	**4/15** (26.67)	
Column Proportion	**1/31** (3.23)	**4/32** (12.50)	**5/63** (7.94)

Panel C: Exact Method Logistic Regression Results

Variable	Estimate (Standard Error)	*Z* Statistic	Exact *p*-value (one tail)
Analogical Encoding	2.181 (0.000)	2.088	0.165
Collaborative Learning	1.576 (1.172)	6.069	0.009
Analogical Encoding × Collaborative Learning	–	7.804	0.004

Panel C: Exact Method Planned Contrast

Test of **H10**: Performance in selecting the correct causal hypothesis will be higher for MDTs in the collaborative learning/analogical encoding techniques condition than those in the no analogical encoding/collaborative learning technique condition, and in the two no collaborative learning technique conditions.

Contrast	Prediction	Estimate (Standard Error)	*Z* Statistic	Exact *p*-value (one tail)
Condition 4 > Conditions 1, 2 and 3	**H10** (+)	2.777 (1.155)	9.303	0.005

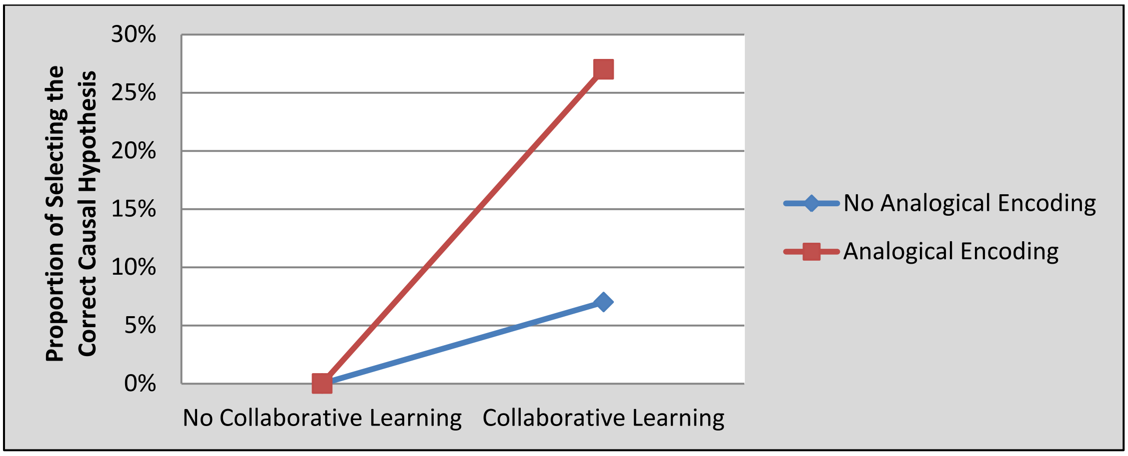
Panel A of Table 4.5 shows that out of 15 MDTs in Condition 4, 4 MDTs (27%) selected the correct hypothesis as the most likely cause of the noted fluctuation, as opposed to 0% in Conditions 1 and 2, and 7% in Condition 3 (See Figure 4.5). The interaction effect for the two training techniques as shown in Panel B of Table 4.5 is significant (Z = 7.804, exact p-value = 0.004). The planned contrast result in Panel C shows that the proportion of MDTs that selected the correct hypothesis in Condition 4 is significantly higher than the proportion of MDTs in Conditions 1, 2 and 3 (Z = 9.303, exact p-value = 0.005).[54] As indicated by the exact parameter estimate shown in Panel C of Table 4.5, MDTs trained using the combined techniques were 2.8 times more likely to select the correct hypothesis than MDTs in other conditions. Hence, these results support Hypothesis 10 in stating that MDTs trained with a

---

[54] The differences between the proportions in Conditions 1, 2, and 3 are not statistically significant (exact p-value = 1.000 for Conditions 1 and 2, 0.484 for Conditions 1 and 3, and 0.469 for Conditions 2 and 3).

combination of the analogical encoding and collaborative learning techniques are more likely to select the correct cause.

Figure 4.5. Results Showing the Effect of Training Techniques on MDT Final Judgments



4.2.3. Results Relating to the Effect of Training Interventions on Cognitive Structures and the Role of Cognitive Structures as the Mediator between Training Interventions and Team Performance in MDTs

This section reports the results relating to the effect of the training interventions on cognitive structures, and the mediating role of the cognitive structures in team functioning. The two cognitive structures examined are team mental models (TMMs) and transactive memory systems (TMSs). Two measures (accuracy and similarity) are used to examine the impacts of training interventions on TMMs. As noted in Chapter 3, TMM accuracy and similarity for the hypothesis generation stage are measured by using individual knowledge structures or mental models derived from the sorting of 12 cards, each containing a distinct hypothesis relating to the cause of a noted fluctuation in GHG emissions. Each dyad member's categorisation was correlated with that of the other member to create a TMM similarity score. In addition, each member's categorisation was correlated to the referent model provided during training and then averaged to create a TMM accuracy score. TMM accuracy and similarity during hypothesis evaluation are measured by classifying task representation during team discussions. TMM is coded as inaccurate when the MDT members shared the task representation in favour of the inherited hypothesis and as accurate when the MDTs shared a task representation in favour of an alternative (i.e., error) hypothesis. TMM is coded as similar when both members generate an inherited hypothesis, an alternative hypothesis, or an error hypothesis in their hypothesis set. TMM is coded as dissimilar when the MDT members generate dissimilar hypotheses. TMSs are measured by using the results of the card-sorting task for 12 subtasks relating to working as a team when performing the analytical procedures task. The categorisations of an individual team member were correlated with those of the other team member to create a TMS.

The first three subsections below (Sections 4.2.3.1, 4.2.3.2 and 4.2.3.3) provide the results relating to the effect of the training interventions on TMM accuracy and similarity. They also show results relating to the mediating role of TMMs in team functioning when conducting hypothesis generation. The next three subsections (Sections 4.2.3.4, 4.2.3.5 and 4.2.3.6) present the results in the same way but with regards to hypothesis evaluation. Finally, the last subsections (Sections 4.2.3.7 and 4.2.3.8) present the results relating to the effect of the training interventions on TMSs and the mediating role of TMSs in team functioning.

4.2.3.1. Results Relating to the Effect of Training Interventions on TMM Accuracy in Hypothesis Generation

This section presents the results of the testing of Hypotheses 11a, 12a and 13a, which relate to the effects of training interventions on TMM accuracy in hypothesis generation. Hypothesis 11a predicts that TMMs relating to generating hypotheses of MDTs that train using the analogical encoding technique are more accurate than TMMs of MDTs that train without the analogical encoding technique.

Hypothesis 12a predicts that TMMs relating to generating hypotheses of MDTs that train using the collaborative learning technique are not more accurate than TMMs of MDTs that train without the collaborative learning technique. Finally, Hypothesis 13a predicts that when generating hypotheses, the use of the analogical encoding technique does not interact with the collaborative learning technique, with the result that TMMs of MDTs that train with and without the collaborative learning technique are more likely to be more accurate when MDTs train using the analogical encoding technique.

Table 4.6 presents descriptive statistics for TMM accuracy and the ANOVA results. Panel A of Table 4.6 shows that the mean TMM accuracy of MDTs whose members trained using the analogical encoding technique is 0.24, whereas the mean TMM accuracy of MDTs whose members trained without the analogical encoding technique is 0.10. The direction of the difference is consistent with Hypothesis 11a. To test Hypothesis 11a, a 2 x 2 ANOVA on TMM accuracy was conducted with the two training techniques between-subjects variables was conducted. Table 4.6, Panel B, reports that the analogical encoding technique has a significant effect upon TMM accuracy (*F* = 5.616, *p*-value = 0.011). These results support Hypothesis 11a.

Table 4.6. Team Mental Model Accuracy in Hypothesis Generation by Training Technique

Panel A: Means (Standard Deviations) of Team Mental Model Accuracy in Hypothesis Generation Across Four Training Conditions

Factor	No Analogical Encoding	Analogical Encoding	Row Means
No Collaborative Learning	*Condition 1* **0.11** (0.31) *n* = 16	*Condition 2* **0.26** (0.40) *n* = 16[a]	**0.18** (0.36) *n* = 32
Collaborative Learning	*Condition 3* **0.09** (0.28) *n* = 15	*Condition 4* **0.23** (0.42) *n* = 15	**0.16** (0.36) *n* = 30
Column Means	**0.10** (0.29) *n* = 31	**0.24** (0.41) *n* = 31	**0.17** (0.36) *n* = 62

Panel B: Conventional ANOVA Results

Independent Variable	*SS*	*d.f.*	*MS*	*F*	*p*-value[b]
Analogical Encoding **(H11a)**	0.326	1	0.326	5.616	0.011
Collaborative Learning **(H12a)**	0.008	1	0.008	0.138	0.712
Analogical Encoding × Collaborative Learning	0.000	1	0.000	0.000	0.986
Error	3.369	58	0.058		

Panel C: Planned Contrasts

Test of **H13a**: When generating hypotheses, MDTs that train with the analogical encoding technique, either with or without the collaborative learning technique, are more likely to have more accurate TMMs for hypothesis generation than MDTs trained without the analogical encoding technique (contrast weights are +1 for Conditions 2 and 4, and -1 for Conditions 1 and 3).

Source of Variation	*SS*	*d.f.*	*MS*	*F*	*p*-value[b]
Contrast	0.326	1	0.326	5.624	0.010
Residual[c]	0.008	2	0.004	0.067	0.935

[a] Of the 17 teams In Condition 2, 1 did not complete the card-sorting task as a measure of TMM and therefore was dropped from data analyses involving TMMs in hypothesis generation.

[b] *p*-values are one-tailed when there is a directional expectation (expectations relating to the H11a). All other *p*-values are two-tailed.

[c] The residual sum of squares represents the between-group variance not explained by the contrast weights used to test the hypothesis. An insignificant *F*-statistic for the residual indicates that the specified contrast is a good fit (Hirst et al. 2007).

Panel A of Table 4.6 also shows that the mean TMM accuracy of MDTs whose members train using the collaborative learning technique is 0.16, whereas the mean TMM accuracy of MDTs whose members train without the collaborative learning technique is 0.18. The ANOVA results in Panel B of Table 4.6 reveal that the main effect for the collaborative learning technique is not significant (*F* = 0.138, *p*-value = 0.712). These results support Hypothesis 12a.

Hypothesis 13a examines whether an interaction exists between the analogical encoding and collaboration learning techniques. ANOVA results in Panel B of Table 4.6 show that there is an insignificant interaction between the two training techniques (*F* = 0.000, *p*-value = 0.986). However, Panel C presents the more appropriate hypothesis testing using the planned contrast. Consistent with the contrast testing outlined for earlier tests, and based on the proposed relationship in Figure 2.7 presented in Chapter 2, contrast weights were determined following the Buckless and Ravenscroft (1990) method by subtracting the overall mean of all cells from the expected mean for each cell and rounding to the nearest whole. As a result, the contrast weights are +1 for Conditions 2 and 4, and -1 for Conditions 1 and 3.[55] Results as shown in Panel C of Table 4.6 support the predicted pattern and show a significant effect (*F* = 5.624, *p*-value = 0.010). Thus, these results support Hypothesis 13a.

4.2.3.2. Results Relating to the Effect of Training Interventions on TMM Similarity in Hypothesis Generation

This section presents the results of the testing of Hypotheses 11b, 12b and 13b, relating to the effect of training interventions on TMM similarity in hypothesis generation. Hypothesis 11b predicts that TMMs relating to generating hypotheses for MDTs that train using the analogical encoding technique are not more similar than TMMs of MDTs that train without the analogical encoding technique. Hypothesis 12b predicts that TMMs relating to generating hypotheses for MDTs that train using the collaborative learning technique are not more similar than TMMs of MDTs that train without the collaborative learning technique. Finally, Hypothesis 13b predicts that the use of the analogical encoding technique interacts with the collaborative learning technique in such a way that TMMs relating to generating hypotheses for MDTs that train with (without) analogical encoding are less (more) similar when MDTs train using the collaborative learning technique. Table 4.7 presents the descriptive statistics for TMM similarity and the ANOVA results for 2 x 2 ANOVA, with TMM similarity as the dependent variable and the use of the two training techniques as the independent variables.

Panel A of Table 4.7 shows that the mean TMM similarity of MDTs whose members trained using the analogical encoding technique is 0.12, whereas the mean TMM similarity of MDTs whose members train without the analogical encoding technique is 0.20. Table 4.7, Panel B,

---

[55] The contrast weights for the interaction are similar to the contrast weights for the analogical encoding technique main effect because it was predicted that there was a significant main effect for the analogical encoding technique and an insignificant main effect for the collaborative learning technique as predicted by Hypotheses 11a and 12a.

reports that there is an insignificant effect for the analogical encoding technique on TMM similarity (*F* = 1.704, *p*-value = 0.197). These results support Hypothesis 11b.

Table 4.7. Team Mental Model Similarity in Hypothesis Generation by Training Technique

Panel A: Means (Standard Deviations) of Team Mental Model Similarity in Hypothesis Generation Across Four Training Conditions

Factor	No Analogical Encoding	Analogical Encoding	Row Means
No Collaborative Learning	*Condition 1* **0.22** (0.23) *n* = 16	*Condition 2* **0.19** (0.30) *n* = 16[a]	**0.20** (0.26) *n* = 32
Collaborative Learning	*Condition 3* **0.19** (0.28) *n* = 15	*Condition 4* **0.05** (0.22) *n* = 15	**0.12** (0.26) *n* = 30
Column Means	**0.20** (0.25) *n* = 31	**0.12** (0.27) *n* = 31	**0.16** (0.26) *n* = 62

Panel B: Conventional ANOVA Results

Independent Variable	*SS*	*d.f.*	*MS*	*F*	*p*-value[b]
Analogical Encoding **(H11b)**	0.113	1	0.113	1.704	0.197
Collaborative Learning **(H12b)**	0.114	1	0.114	1.718	0.195
Analogical Encoding × Collaborative Learning	0.052	1	0.052	0.785	0.379
Error	3.860	58	0.067		

Panel C: Planned Contrasts

Test of **H13b**: MDTs that train with (without) the analogical encoding technique have less (more) similar hypothesis generation TMMs than MDTs trained using the collaborative learning technique (contrast weights are: 0 for Conditions 1 and 2; +1 for Condition 3; and -1 for Condition 4).

Source of Variation	*SS*	*d.f.*	*MS*	*F*	*p*-value[b]
Contrast	0.155	1	0.155	2.312	0.067
Residual[c]	0.124	2	0.062	0.926	0.401

[a] Of the 17 teams in Condition 2, 1 did not complete the card-sorting task as a measure of TMM and therefore was dropped from data analyses involving TMMs in hypothesis generation.

[b] *p*-values are one-tailed when there is a directional expectation (expectations relating to the H13b). All other *p*-values are two-tailed.

[c] The residual sum of squares represents the between-group variance not explained by the contrast weights used to test the hypothesis. An insignificant *F*-statistic for the residual indicates that the specified contrast is a good fit (Hirst et al. 2007).

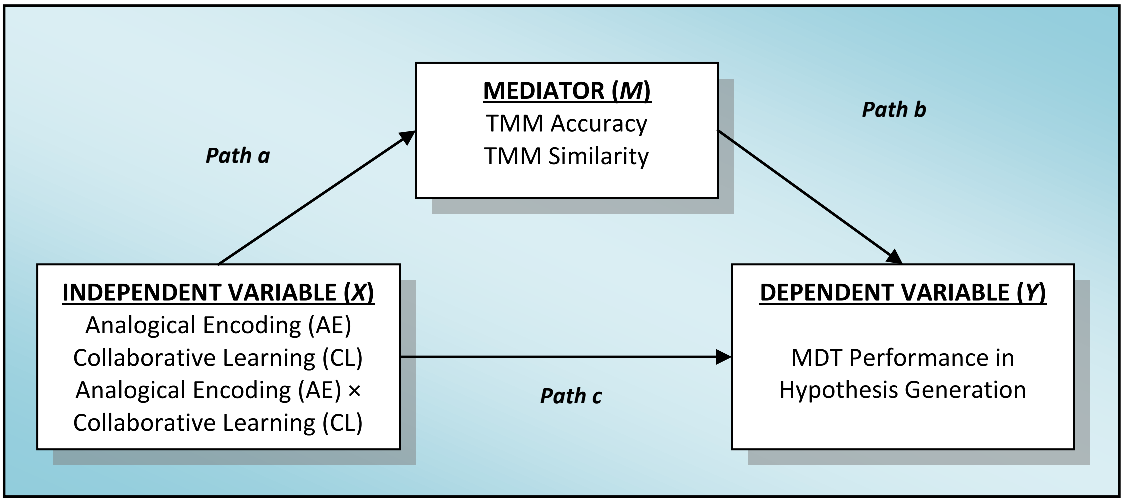
As shown in Panel A of Table 4.7, the mean TMM similarity of MDTs whose members trained using the collaborative learning technique is 0.12, whereas the mean TMM similarity of MDTs whose members trained without this technique is 0.20. The ANOVA results in Panel B of Table 4.7 reveal an insignificant effect for the collaborative learning technique (*F* = 1.718, *p*-value = 0.195). These results support Hypothesis 12b.

Finally, to test Hypothesis 13b, an investigation into the existence of an interaction between the analogical encoding technique and the collaborative learning technique was conducted. As shown in Panel B of Table 4.7, there is an insignificant interaction between the two training techniques (*F* = 0.785, *p*-value = 0.379). However, Panel C presents the more appropriate hypothesis testing using the planned contrast. Contrast weights used for the planned contrast were determined based on the proposed relationship in Figure 2.8, presented in Chapter 2, and using the method suggested by Buckless and Ravenscroft (1990). Accordingly, the contrast weights are: 0 for Conditions 1 and 2; +1 for Condition 3; and -1 for Condition 4. Results as shown in Panel C of Table 4.7 support the predicted pattern and show a significant effect (*F* = 2.312, *p*-value = 0.067). Thus, these results support Hypothesis 13b.

4.2.3.3. Results Relating to the Role of Team Mental Models as the Mediator between Training Interventions and MDT Performance in Hypothesis Generation

This section presents the results of the tests relating to the mediating role of team mental models. Specifically, TMM accuracy will mediate the link between the training interventions and MDT performance in generating hypotheses as predicted by Hypotheses 14a, 14b and 14c. Similarly, Hypotheses 15a, 15b and 15c predict such a mediating role for TMM similarity. Additionally, Hypothesis 16 predicts that the interaction of TMM properties (accuracy and similarity) will lead to higher MDT performance in generating hypotheses. Figure 4.6 depicts the link between the independent, the proposed mediator and the dependent variables.

Figure 4.6. Mediating Relationship of Team Mental Models in Hypothesis Generation



To test these hypotheses, this thesis uses a procedure for establishing mediation as recommended by Zhao et al. (2010) and Rucker et al. (2011). This procedure is a modified version of the traditional Baron and Kenny (1986) procedure and is recognised as a more appropriate procedure for testing mediation.[56] [57]

A step-by-step procedure for establishing mediation using the Zhao et al. (2010) method. The first step of a mediation test is to determine whether the indirect effect $a \times b$ is significant by running a bootstrapping procedure (Preacher and Hayes 2004, 2008).[58] If the confidence interval does not include zero, the indirect effect $a \times b$ is significant and mediation is established. However, if the confidence interval includes zero, $a \times b$ is not significant and the mediation hypothesis is not supported.

The second step is to classify the type of mediation by estimating the coefficients of *a*, *b* and *c.* Zhao et al. (2010) classify three patterns consistent with mediation and two with no mediation: (1) complementary mediation (i.e., mediated effect ($a \times b$) and direct effect (*c*) both exist and point at the same direction); (2) competitive mediation (i.e., mediated effect

---

[56] According to Baron and Kenny's (1986) procedure, four necessary conditions for a mediation test must be met. First, variations in levels of the independent variable significantly account for variations in the dependent variable (*Path c* as shown in Figure 4.6). Second, variations in levels of the independent variable must significantly account for variations in the presumed mediator (*Path a*). The third condition is that variations in the mediator must significantly account for variations in the dependent variable (*Path b*). Finally, when controlling for the effects of the mediator on the dependent variable, the effect of the independent variable on the dependent variable (*Path c*), a previously significant relation, is no longer significant. Fulfilling these conditions provides evidence of the mediation (Baron and Kenny 1986). However, the statistics literature has criticised some of these procedures based on at least two important points (e.g., Collins et al. 1998; MacKinnon 2000; MacKinnon et al. 2000; MacKinnon et al. 2002; Shrout and Bolger 2002; MacKinnon 2008; MacKinnon and Fairchild 2009; Judd and Kenny 2010). First, the strength of mediation should be measured by the size of the indirect effects ($a \times b$), not by the lack of the direct effect (Zhao et al. 2010; Rucker et al. 2011). Second, there need not be a significant 'effect to be mediated' as required by the first condition (path *c*). As argued by Zhao et al. (2010) and Rucker et al. (2011), there should be only one requirement to establish mediation, i.e., the indirect effect, $a \times b$, is significant.

[57] Studies in prior psychology and accounting research have conducted similar procedures (e.g., Cohen et al. 2011; Chang et al. 2013; Cryder et al. 2013; Paharia et al. 2013).

[58] The bootstrap test generates an empirical sampling distribution of $a \times b$. It takes the researcher's sample of size *N* and from it draws with the replacement *N* values of *X*, *M*, *Y* to create a new sample; values of *a*, *b*, and $a \times b$ are calculated for each bootstrap sample. This process is repeated many times (bootstrapping procedures typically allow users to request from 1,000 to 5,000 different samples). The program (the SPSS macros) estimates the indirect effect as the mean of these estimates (Preacher and Hayes 2004). The bootstrap test actually relies on the 95% confidence intervals from the empirical distribution of $a \times b$ estimates. The lower bound of the 95% confidence interval is at the 2.5% point on this cumulative distribution. The upper bound of the 95% confidence interval is at the 97.5% point (Preacher and Hayes 2004, 2008; Zhao et al. 2010; Warner 2013).

(*a* × *b*) and direct effect (*c*) both exist and point at opposite directions); (3) indirect-only mediation (mediated effect (*a* × *b*) exists but no direct effect (c)); (4) direct-only non-mediation (i.e., direct effect (*c*) exists but no indirect effect); and (5) no-effect non-mediation (i.e., neither direct effect nor indirect effect exists). Based on the estimated *a, b* and *c* coefficients, the following decision can be made: (1) if *a* × *b* is significant but *c* is not, it is indirect-only mediation; (2) if *a* × *b* is not significant but *c* is, it is direct-only non-mediation; (3) if neither *a* × *b* nor *c* is significant, it is no-effect non-mediation; and (4) if both *a* × *b* and *c* are significant, determine the sign of *a* × *b* × *c* by multiplying the three coefficients. If *a* × *b* × *c* is positive, it is complementary mediation; if *a* × *b* × *c* is negative, it is competitive mediation.

Table 4.8 reports the results of mediation tests for the mediating role of TMMs between training interventions and MDT performance in hypothesis generation.

Table 4.8. Regression Results of Mediation Tests in the Hypothesis Generation Stage

Panel A: Mediation Tests in Hypothesis Generation Stage

H	Independent, Proposed Mediator and Dependent Variables	*a*	*b*	*a* × *b*	Confident Interval		*c*	*a* × *b* × c
					Lower	Upper		
Mediation Tests of TMMA								
H14a	*AE* → *TMMA* → *TP*	0.144 **	3.085 *	0.445	-0.094	2.043	0.188 ns	0.083
H14b	*CL* → *TMMA* → *TP*	-0.024 ns	3.085 *	-0.073	-0.921	0.336	0.863 ns	-0.063
H14c	*AE* × *CL* → *TMMA* → *TP*	0.002 ns	3.085 *	0.007	-0.932	0.998	1.413 ns	0.010
Mediation Tests of TMMS								
H15a	*AE* → *TMMS* → *TP*	-0.028 ns	0.441 ns	-0.012	-0.614	0.376	0.188 ns	-0.002
H15b	*CL* → *TMMS* → *TP*	-0.028 ns	0.441 ns	-0.012	-0.632	0.311	0.863 ns	-0.011
H15c	*AE* × *CL* → *TMMS* → *TP*	-0.116 ns	0.441 ns	-0.051	-1.229	0.449	1.413 ns	-0.072

Panel B: The Effect of Interaction between TMMA and TMMS

H	Independent, Proposed Mediator and Dependent Variables			*a*	*b*	*a* × *b*	Confident Interval		*c'*
							Lower	Upper	
-	*AE* × *CL* →	*TMMA* →	*TP*	0.137 ns	4.796 ns	0.658	-0.148	3.176	0.990 ns
-		*TMMS*		0.004 ns	1.955 ns	0.007	-0.752	1.106	
-	*AE* →								0.035 ns
-	*CL* →								1.070 ns
H16	*TMMA* × *TMMS* →								-6.175 ns

* and ** indicate statistical significance at the 0.10 and 0.05 levels, respectively; one-tailed, 'ns' indicates a non-significant coefficient.

Because there are two potential mediators to be tested (TMM accuracy and similarity), which are shown as TMMA and TMMS in Table 4.8, examinations need to be conducted on two different paths as presented in Panel A of Table 4.8. From the first step of the mediation tests, it is found that all of the means of the indirect effect from the bootstrap analyses (drawn from 5,000 bootstrap samples using SPSS) are insignificant with the 95% confidence intervals including zero. The results of the second step of the mediation tests indicate that all of the direct effects (*c*) are also insignificant. Following the decision tree depicted in Figure 4.7, the results suggest that these are no-effect non-mediations. Based on the above mediation analyses, it is found that TMM accuracy and similarity do not mediate the relationship between training interventions and MDT performance in generating hypotheses. As a result, Hypotheses 14a, 14b, and 14c, and as well as Hypotheses 15a, 15b, and 15c are not supported.

Panel B of Table 4.8 reports the analysis testing the effect of the interaction of TMM accuracy and TMM similarity, as predicted by Hypothesis 16. The interaction of the mediators was entered into the regression which includes all variables. The results of the regression (*c'* in Table 4.8) show that the interaction of the mediators is not statistically significant (coefficient = -6.175, *t* = -0.777, *p*-value = 0.440). Therefore, Hypothesis 16 is not supported.

4.2.3.4. Results Relating to the Effect of Training Interventions on TMM Accuracy in Hypothesis Evaluation

This section reports on the results of the testing of Hypotheses 17a, 18a and 19a, which relate to the effect of training interventions on TMM accuracy in hypothesis evaluation. Hypothesis 17a predicts that TMMs relating to evaluating hypotheses of MDTs that train using the analogical encoding technique are more accurate than team mental models of MDTs that train without the analogical encoding technique. Hypothesis 18a predicts that TMMs relating to generating hypotheses of MDTs that train using the collaborative learning technique are not more accurate than team mental models of MDTs that train without the collaborative learning technique. Finally, Hypothesis 19a predicts an interaction effect such that TMM accuracy will be higher in the collaborative learning/analogical encoding techniques condition and lower in the no analogical encoding/collaborative learning technique condition, as well as in the two no collaborative learning technique conditions. Table 4.9 presents the descriptive statistics for TMM accuracy and the statistical testing results.

Panel A of Table 4.9 provides the proportion (percentage) of MDTs that have accurate TMMs. Of 32 teams whose members trained using the analogical encoding technique, 17 teams

(53%) have accurate TMMs, while only 6 of 31 teams (19%) whose members trained without the analogical encoding technique have accurate TMMs. This is consistent with Hypothesis 15a. Panel B of Table 4.9 indicates that when using the exact method logistic regression as a categorical data analysis, the analogical encoding technique has a significant main effect (*Z* = 7.965; exact *p*-value = 0.008). These results support Hypothesis 17a.

Table 4.9. Team Mental Model Accuracy in Hypothesis Evaluation by Training Technique

Panel A: Proportion (Percentage) of MDTs with Accurate TMMs

Factor	No Analogical Encoding	Analogical Encoding	Row Proportions
No Collaborative Learning	*Condition 1* **2/16** (13%)	*Condition 2* **7/17** (41%)	**9/33** (27%)
Collaborative Learning	*Condition 3* **4/15** (27%)	*Condition 4* **10/15** (67%)	**14/30** (47%)
Column Proportions	**6/31** (19%)	**17/32** (53%)	**23/63** (37%)

Panel B: Exact Method Logistic Regression Results

Source	Estimate (Standard Error)	*Z* Statistic	Exact *p*-value (one-tail)
Analogical Encoding **(H17a)**	0.974 (0.574)	7.954	0.008
Collaborative Learning **(H18a)**	1.598 (0.588)	2.968	0.102
Analogical Encoding × Collaborative Learning	–	10.268	0.005

Panel C: Exact Method Planned Contrast

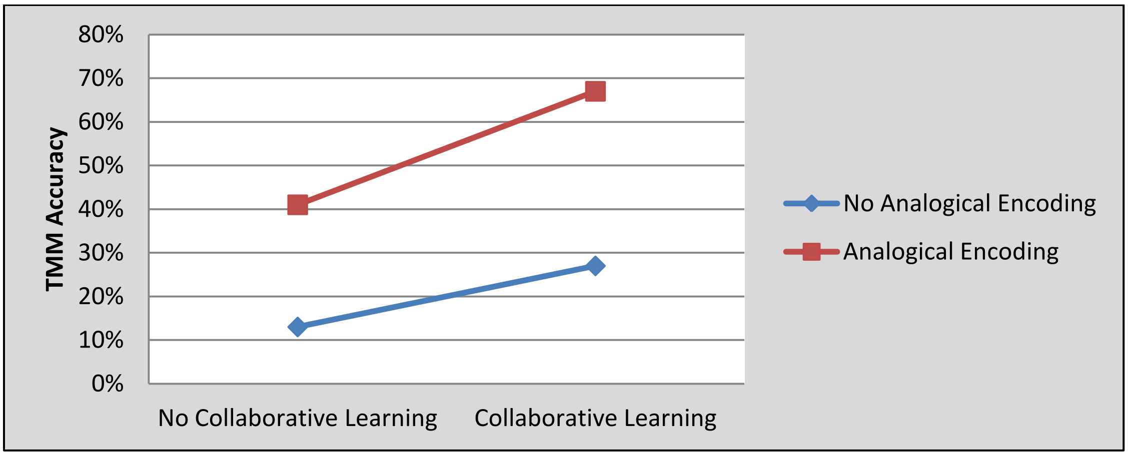
Test of **H19a**: TMM accuracy in hypothesis evaluation is higher in the collaborative learning/ analogical encoding techniques condition and is lower in the no analogical encoding/ collaborative learning technique condition and in the two no collaborative learning technique conditions.

Contrast	Estimate (Standard Error)	*Z* Statistic	Exact *p*-value (one-tail)
Condition 4 > Conditions 1, 2 and 3	1.653 (0.630)	7.603	0.004

Panel A of Table 4.9 also shows that of 30 teams whose members trained using the collaborative learning technique, 14 (47%) teams have an accurate TMM while only 9 of 33 (27%) teams whose members trained without the collaborative learning technique have an accurate TMM. However, as shown in Panel B, this technique has an insignificant main effect (*Z* = 2.968; exact *p*-value = 0.102). These results indicate that Hypothesis 18a is supported.

Finally, Hypothesis 19a predicts that TMM accuracy will be higher in the analogical encoding/collaborative learning techniques condition (Condition 4); lower in the no analogical encoding/collaborative learning technique condition (Condition 3) as well as in both of the no collaborative learning technique conditions (Conditions 1 and 2). As shown in Panel A of Table 4.9, condition proportions fall approximately into the pattern predicted (Condition 1 = 13%;, Condition 2 = 41%, Condition 3 = 27%, and Condition 4 = 67%; see Figure 4.8).

Figure 4.7. Results Showing the Effect of Training Techniques on TMM Accuracy in Hypothesis Evaluation



Hypothesis 19a predicts an ordinal interaction. The interaction effect for the two training techniques as shown in Panel B of Table 4.9 is significant (Z = 10.268, exact p-value = 0.005). The planned contrast result in Panel C shows that the proportion of MDTs that have an accurate TMM in Condition 4 is significantly higher than the proportion of MDTs in Conditions 1, 2 and 3 (Z = 7.603, exact p-value = 0.004). As indicated by the exact parameter estimate shown in Panel C of Table 4.9, MDTs trained using a combined analogical encoding and collaborative learning technique were 1.7 times more likely to select the correct hypothesis than the MDTs in other conditions. As such, Hypothesis 19a is supported.

4.2.3.5. Results Relating to the Effect of Training Interventions on TMM Similarity in Hypothesis Evaluation

This section presents the results of testing Hypotheses 17b, 18b and 19b, which relate to the effect of training interventions on TMM similarity in hypothesis evaluation. Hypothesis 17b predicts that when evaluating hypotheses, TMMs of MDTs that train using the analogical encoding technique are more likely to be more similar than TMMs of MDTs that train without the analogical encoding technique. Hypothesis 18b predicts that TMMs relating to evaluating hypotheses for MDTs that train using the collaborative learning technique are more similar than TMMs of MDTs that train without the collaborative learning technique. Hypothesis 19b predicts that when evaluating hypotheses, the use of the analogical encoding technique does not interact with the collaborative learning technique, with the result that the TMMs of MDTs that train with and without the analogical encoding technique are more similar when MDTs train using the collaborative learning technique. Table 4.10 presents the descriptive statistics for TMM similarity and the statistical testing results.

Table 4.10. Team Mental Model Similarity in Hypothesis Evaluation by Training Technique

Panel A: Proportion (Percentage) of MDTs with Similar TMMs

Factor	No Analogical Encoding	Analogical Encoding	Row Proportions
No Collaborative Learning	*Condition 1* **6/16** (38%)	*Condition 2* **10/17** (59%)	**16/33** (48%)
Collaborative Learning	*Condition 3* **8/15** (53%)	*Condition 4* **6/15** (40%)	**14/30** (47%)
Column Proportions	**14/31** (45%)	**16/32** (50%)	**30/63** (47%)

Panel B: Exact Method Logistic Regression Results

Source	Estimate (Standard Error)	*Z* Statistic	Exact *p*-value (one-tail)
Analogical Encoding **(H17b)**	-0.187 (0.497)	0.142	0.804
Collaborative Learning **(H18b)**	0.068 (0.498)	0.019	1.000
Analogical Encoding × Collaborative Learning	–	0.164	0.925

Panel C: Exact Method Planned Contrast

Test of **H19b**: TMMs in hypothesis evaluation of MDTs that train with and without the analogical encoding technique are more similar when MDTs train using the collaborative learning technique.

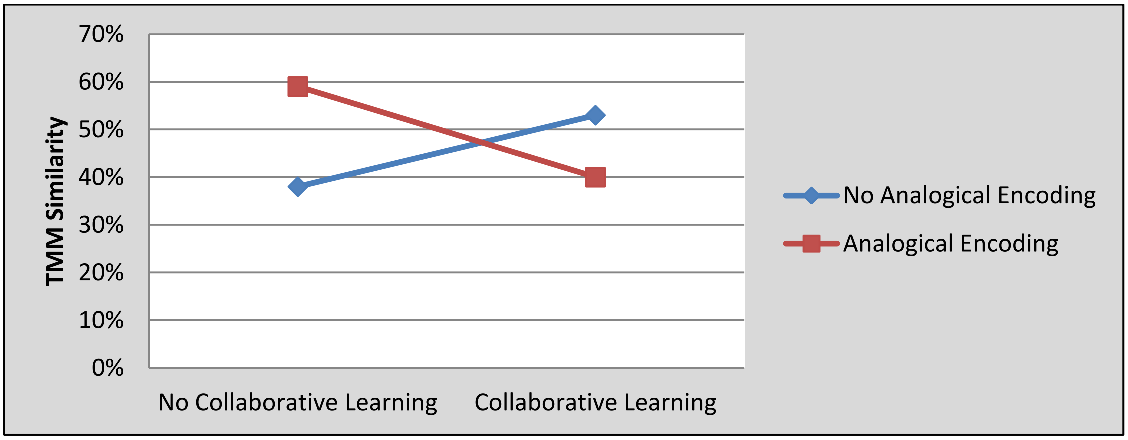
Contrast	Estimate (Standard Error)	*Z* Statistic	Exact *p*-value (one-tail)
Cond. 3 = Cond. 4 > Cond. 1 = Cond. 2	-0.072 (0.501)	0.021	1.000

Panel A of Table 4.10 provides the proportion (percentage) of teams that have similar TMMs. Of the 32 MDTs whose members trained using the analogical encoding technique, 16 MDTs (50%) have similar TMMs, while 14 of 31 MDTs (45%) whose members trained without the analogical encoding technique have similar TMMs. This proportion is inconsistent with the predictions of Hypothesis 17b. Panel B of Table 4.10 indicates that the analogical encoding technique has an insignificant main effect (Z = 0.142, exact p-value = 0.804). These results also indicate that Hypothesis 17b is not supported.

Panel A of Table 4.10 shows that of the 30 MDTs whose members trained using the collaborative learning technique, 14 MDTs (47%) have similar TMMs, while 16 of 33 MDTs (48%) whose members trained without the collaborative learning technique have accurate TMMs. As shown in Panel B, this technique has an insignificant main effect (Z = 0.019, exact p-value = 1.000). These results indicate that Hypothesis 18b is not supported.

Finally, Hypothesis 19b predicts that there is no interaction in which TMMs in hypothesis evaluation for MDTs that trained with and without the analogical encoding technique are more similar when MDTs trained using the collaborative learning technique. As shown in Panel A of Table 4.10, the proportions between the conditions are not very different (see Figure 4.9). Panel B of Table 4.10 shows that the interaction effect is insignificant (Z = 0.164, exact p-value = 0.925). Similarly, the planned contrast in Panel C reports that the contrast is insignificant (Z = 0.021, exact p-value = 1.000). Therefore, Hypothesis 19b is not supported.

Figure 4.8. Results Showing the Effect of Training Techniques on TMM Similarity in Hypothesis Evaluation



4.2.3.6. Results Relating to the Role of Team Mental Models as the Mediator between Training Interventions and MDT Performance in Hypothesis Evaluation

This section provides the results of the tests relating to the mediating role of team mental models in hypothesis evaluation. Specifically, this section examines whether TMM accuracy mediates the link between training interventions and MDT performance in evaluating hypotheses as predicted by Hypotheses 20a, 20b and 20c. This section also reports the testing of Hypotheses 21a, 21b and 21c, which predict such a mediating role for TMM similarity. Table 4.11 provides the results of the mediation tests using logistic regressions.

Table 4.11. Exact Method Logistic Regression Results of Mediation Tests in the Hypothesis Evaluation Stage

H	Independent, Proposed Mediator and Dependent Variables	*a*	*b*	*a* × *b*	Confidence Interval		*c*	*a* × *b* × c
					Lower	Upper		
H20a	*AE* → *TMMA* → *TP*	1.598 **	2.488 **	3.976	1.017	6.934	2.109 **	8.385
H20b	*CL* → *TMMA* → *TP*	0.974 *	2.488 **	2.423	-0.464	5.311	1.407 ns	3.410
H20c	*AE* × *CL* → *TMMA* → *TP*	1.653 **	2.488 **	4.112	0.942	7.279	2.718 **	11.176
H21a	*AE* → *TMMS* → *TP*	-0.187 ns	-1.172 ns	0.219	-1.198	1.940	2.109 **	0.462
H21b	*CL* → *TMMS* → *TP*	0.068 ns	-1.172 ns	-0.080	-1.695	1.427	1.407 ns	-0.112
H21c	*AE* × *CL* → *TMMS* → *TP*	-0.399 ns	-1.172 ns	0.468	-1.135	2.693	2.718 **	1.271

* and ** indicate statistical significance at the 0.10 and 0.05 levels, respectively; one-tailed, 'ns' indicates a non-significant coefficient.

The results relating to the mediating role of TMM accuracy (*TMMA*) indicate that the mean indirect effect of the analogical encoding technique (*AE*) is positive and significant ($a \times b$ = 3.976), with a 95% confidence interval excluding zero (1.017 to 6.934). The direct effect *c* (2.109) is also significant (*p*-value = 0.039). Since $a \times b \times c$ is positive, it is a complementary mediation. Similarly, the mean indirect effect of an interaction of the analogical encoding and collaborative learning techniques (*AE* × *CL*) is also positive and significant ($a \times b$ = 4.112), with a 95% confidence interval excluding zero (0.942 to 7.279). The direct effect *c* (2.718) is also significant (*p*-value = 0.002). This mediation is also a complementary mediation because $a \times b \times c$ is positive. In contrast, the results show that the indirect and the direct effect of the collaborative learning technique are insignificant ($a \times b$ = 2.423, *CI* -0.464 to 5.311; *c* = 1.407, *p*-value = 0.114), suggesting a no-effect non-mediation. Thus, TMM accuracy mediates the relationship between the analogical encoding technique, a combination of the analogical encoding and collaborative learning techniques, and MDT performance. However, TMM accuracy does not mediate the relationship between the collaborative learning technique and MDT performance. As a result, Hypotheses 20a and 20c are supported but Hypothesis 20b is not supported.

Table 4.11 also reports the results relating to the mediating role of TMS similarity (*TMSS*). The mean indirect effect of the analogical encoding technique (*AE*), is insignificant, with a 95% confidence interval including zero (-1.198 to 1.940) but the direct effect *c* is significant (2.109, *p*-value = 0.039), indicating a direct-only non-mediation. In contrast, the mean indirect effect and the direct effect of the collaborative learning technique is not significant ($a \times b$ = -0.080, *CI* -1.695 to 1.427; *c* = 1.407, *p*-value = 0.114). The mean indirect effect of a combination of analogical encoding and collaborative learning techniques (*AE* × *CL*) is negative and insignificant ($a \times b$ = -0.468, *CI* -1.135 to 2.693) but the direct effect *c* is significant (2.718, *p*-value = 0.002), indicating a direct-only non-mediation. Therefore, TMM similarity does not mediate the relationship between training interventions and MDT performance in evaluating hypotheses. Accordingly, Hypotheses 21a, 21b and 21c are not supported.

4.2.3.7. Results Relating to the Effect of Training Interventions on Transactive Memory Systems

This section provides the results of the tests relating to the effect of training interventions on the second type of cognitive structure, TMSs. Hypothesis 22 predicts that the TMSs of MDTs that train using the analogical encoding technique will not be more developed than the TMSs of MDTs that train without the analogical encoding technique. Hypothesis 23 predicts that the TMSs of MDTs that train using the collaborative learning technique will be more developed than the TMSs of MDTs that train without the collaborative learning technique. Finally, Hypothesis 24 proposes that the use of the analogical encoding technique will not interact with the collaborative learning technique on the development of TMSs.

Table 4.12 provides the results of descriptive statistics and ANOVA results relating to these hypotheses. Panel A of Table 4.12 shows that, across the four conditions, the means of TMSs were similar and quite low. Panel B of Table 4.12 reports the results of an ANOVA using the level of TMSs structure as the dependent variable and the two training techniques as the independent variables. There were no significant main effects for the analogical encoding technique (*F* = 0.014, *p*-value = 0.907), which supports Hypothesis 22. However, inconsistent with Hypothesis 23, the collaborative learning technique has an insignificant main effect (*F* = 0.520, *p*-value = 0.237).

Finally, there is no support for Hypothesis 24. As shown in Panel B of Table 4.12, a conventional ANOVA interaction between the two training techniques is not significant (*F* = 0.160; *p-value* = 0.690). Panel C of Table 4.12 presents the more appropriate hypothesis testing using the planned contrast. Contrast weights used for the planned contrast were determined based on the proposed relationship in Figure 2.13, presented in Chapter 2, and using the Buckless and Ravenscroft (1990) method. The contrast weights are -1 for Conditions 1 and 2 and +1 for Conditions 3 and 4. Results as shown in Panel C of Table 4.12 indicate that the contrast is not significant (*F* = 0.518, *p*-value = 0.237). These results suggest that there was no impact on the development of TMSs from either of the training techniques.

Table 4.12. TMSs across the Four Training Conditions

Panel A: Means (Standard Deviations) of TMSs Across Four Training Conditions

Factor	No Analogical Encoding	Analogical Encoding	Row Means
No Collaborative Learning	*Condition 1*	*Condition 2*	**0.15** (0.17) *n* = 33
	0.15 (0.20) *n* = 16	**0.16** (0.15) *n* = 17	
Collaborative Learning	*Condition 3*	*Condition 4*	**0.12** (0.19) *n* = 30
	0.13 (0.20) *n* = 15	**0.11** (0.19) *n* = 15	
Column Means	**0.14** (0.20) *n* = 31	**0.14** (0.17) *n* = 32	**0.14** (0.18) *n* = 63

Panel B: Conventional ANOVA Results

Independent Variable	*SS*	*d.f.*	*MS*	*F*	*p*-value^{a}
Analogical Encoding **(H22)**	0.000	1	0.000	0.014	0.907
Collaborative Learning **(H23)**	0.018	1	0.018	0.520	0.237
Analogical Encoding × Collaborative Learning	0.005	1	0.005	0.160	0.690
Error	1.992	59	0.034		

Panel C: Planned Contrasts

Test of **H24**: TMSs of MDTs that train with and without the analogical encoding technique are more developed when MDTs train using the collaborative learning technique (contrast weights are: -1 for Conditions 1 and 2 and +1 for Conditions 3 and 4).

Source of Variation	*SS*	*d.f.*	*MS*	*F*	*p*-value^{a}
Contrast	0.017	1	0.017	0.518	0.237
Residual^{b}	0.006	2	0.003	0.079	0.924

[a] *p*-values are one-tailed when there is a directional expectation. All other *p*-values are two-tailed.

[b] The residual sum of squares represents the between-group variance not explained by the contrast weights used to test the expectation. An insignificant *F*-statistic for the residual indicates that the specified contrast is a good fit (Hirst et al. 2007).

4.2.3.8. Results Relating to the Role of Transactive Memory Systems as the Mediator between Training Interventions and MDT Performance in Hypothesis Generation

This section presents the results of the tests relating to the mediating role of TMSs, which suggest that TMSs will mediate the link between training interventions and MDT performance as predicted by Hypotheses 25a, 25b, and 25c. Mediation tests using multiple regressions are provided in Table 4.13.

Table 4.13. Regression Results of Mediation Tests of TMSs

H	Independent, Proposed Mediator and Dependent Variables	*a*	*b*	*a* × *b*	Confidence Interval		*c*	*a* × *b* × c
					Lower	Upper		
H25a	*AE* → *TMSs* → *TP*	0.131 ^{ns}	-0.991 ^{ns}	-0.130	-0.591	0.276	0.063 ^{ns}	-0.008
H25b	*CL* → *TMSs* → *TP*	-0.015 ^{ns}	-0.991 ^{ns}	0.015	-0.313	0.647	0.863 ^{ns}	0.013
H25c	*AE* × *CL* → *TMSs* → *TP*	-0.037 ^{ns}	-0.991 ^{ns}	0.037	-0.350	1.051	1.538 ^{ns}	0.056

'ns' indicates a non-significant coefficient.

As reported in Table 4.13, the results from the bootstrap analyses (drawn from 5,000 bootstrap samples using SPPS) indicate that the mean indirect effect of the analogical encoding technique (*AE*) is negative and insignificant ($a \times b$ = -0.130), with a 95% confidence interval including zero (*CI* = -0.591 to 0.276). The direct effect *c* (0.063, *p*-value = 0.482) is also insignificant indicating a no-effect non-mediation. Similarly, the mean indirect and direct effect of the collaborative learning technique are also insignificant ($a \times b$ = -0.130, *CI* -0.313 to 0.647; *c* = 0.863, *p*-value = 0.277). Similar insignificant results are also shown in the mean indirect effect and the direct effect of an interaction of the analogical encoding and collaborative learning techniques (*AE* × *CL*) ($a \times b$ = 0.037, *CI* -0.350 to 1.051; *c* = 1.538, *p*-value = 0.227). Thus, TMSs do not mediate the relationship between training interventions and MDT performance. Therefore, Hypotheses 25a, 25b and 25c are not supported.

4.2.4. Additional Analyses Relating to the Use of Analogical Encoding and Collaborative Learning Techniques as an Individual Training Intervention

To understand the results with regard to the effect of training techniques on the individual and MDT performance, it is important to examine underlying factors that may affect these results. The additional analyses examine a number of other potential variables and are divided into two parts: those relating to individual training interventions and those relating to team-training interventions. This section provides four additional analyses with regard to the relationship of the use of training techniques as an individual training intervention with several variables, with the results of the second set of additional analyses relating to team-training interventions presented in section 4.2.5. The additional individual variables considered in this section include perceived cognitive load, the development of knowledge structure, an individual's prior knowledge (how it affects an individual's ability to generate hypotheses), and participant cognitive ability as proxied by the results of the distractor task.

4.2.4.1. The Effect of Training Techniques on Perceived Cognitive Load

As outlined in Chapter 2, the two training techniques have different abilities in satisfying the three learning principles needed to improve individual learning performance. As suggested in Section 2.2.1, the collaborative learning technique may be superior to the analogical encoding technique in satisfying the limited capacity principle. That is, the use of this technique minimises cognitive load and uses the remaining processing capacity, freed up at the individual level, for germane load (Clark et al. 2006; Kirschner et al. 2009a). The additional analysis, therefore, examines whether the use of this technique affects the perceived cognitive load.

Consistent with studies in educational psychology (Paas and van Merriënboer 1993; Kirschner et al. 2009b; Kirschner, Paas, and Kirschner 2011; Kirschner, Paas, Kirschner, et al. 2011), in this thesis an analysis of performance efficiency was also conducted to understand the effect of training on cognitive resources. Cognitive load theory defines performance efficiency in terms of two variables: learner performance and learner cognitive load. Instructional or training techniques that result in higher learning outcomes with less cognitive load are more efficient than techniques that lead to lower outcomes with greater cognitive load (Paas et al. 2003, 2004; Clark et al. 2006). Educational researchers use the efficiency metric to quantify the efficiency of an instructional technique. As outlined in Chapter 3, performance efficiency was calculated for the transfer tests, using the Paas and van Merriënboer (1993) computational approach, by standardising each of the participant's scores for individual learning performance and the cognitive load invested in the learning phase.[59] The calculation was conducted by subtracting the perceived cognitive load from the performance outcomes. When performance is greater than cognitive load, the efficiency value is positive. When performance is lower than cognitive load, the efficiency value is negative.

A 2 x 2 ANOVA on individual performance efficiency was conducted for the analysis with the two training techniques as between-subjects variables; the results are reported in Table 4.14.

---

[59] As outlined in Chapter 3, perceived cognitive load is measured by participants providing their perceptions of task difficulty using a seven-point Likert-scale with the end points labelled extremely easy and extremely difficult.

Table 4.14. Performance Efficiency by Training Technique

Panel A: Means (Standard Deviations) of Performance Efficiency Across Four Training Conditions

Factor	No Analogical Encoding	Analogical Encoding	Row Means
No Collaborative Learning	*Condition 1* **0.09** (091) *n* = 32	*Condition 2* **-0.56** (0.84) *n* = 34	**-0.24** (0.93) *n* = 66
Collaborative Learning	*Condition 3* **0.37** (0.99) *n* = 30	*Condition 4* **0.16** (1.06) *n* = 30	**0.27** (1.02) *n* = 60
Column Means	**0.23** (0.95) *n* = 62	**-0.22** (1.00) *n* = 64	**0.00** (1.00) *n* = 126

Panel B: Conventional ANOVA Table

Factor	*SS*	*d.f.*	*MS*	*F*	*p*-value[a]
Analogical Encoding	5.865	1	5.865	6.509	0.006
Collaborative Learning	7.898	1	7.898	8.766	0.002
Analogical Encoding × Collaborative Learning	1.495	1	1.495	1.660	0.200
Error	109.919	122	0.901		

Panel C: Planned Contrast

Performance efficiency will be lowest in the analogical encoding/no collaborative learning techniques condition, higher in the no analogical encoding/no collaborative learning technique condition, higher in analogical encoding/collaborative learning technique condition and highest in the no analogical encoding/collaborative learning technique condition (contrast weights are: -6, +1, +2, and +3, respectively).

Factor	*SS*	*d.f.*	*MS*	*F*	*p*-value[a]
Contrast	14.352	1	14.352	15.930	0.000
Residual [b]	0.906	2	1.811	2.010	0.138

[a] *p*-values are one-tailed because there are directional expectations (expectations relating to analogical encoding, collaborative learning and the planned contrast). All other *p*-values are two-tailed.

[b] The residual sum of squares represents the between-group variance not explained by the contrast weights used to test the expectation. An insignificant *F*-statistic for the residual indicates that the specified contrast is a good fit (Hirst et al. 2007).

Panel A of Table 4.14 provides the means (standard deviations) for performance efficiency across the four training conditions. It shows that individuals who trained with the analogical encoding technique exhibited lower and negative performance efficiency (mean = -0.22) compared to individuals who trained without the analogical encoding technique (positive performance efficiency, mean = 0.23). Panel A of Table 4.14 shows that the mean of performance efficiency is positive (mean = 0.27) when team members learn collaboratively, as opposed to a negative mean of efficiency (mean = -0.24) when team members learn individually.

The pattern of results is consistent with the prediction that the use of the collaborative learning technique improves performance efficiency during learning as suggested by prior studies (Kirschner et al. 2009a, 2009b; Kirschner, Paas, and Kirschner 2011; Kirschner, Paas, Kirschner, et al. 2011). As shown in Table 4.14, Panel B, the ANOVA results indicate that there are significant main effects for both the analogical encoding and the collaborative learning techniques (*F* = 6.509, *p*-value = 0.006 and *F* = 8.766, *p*-value = 0.002, respectively).

As outlined in Chapter 2 (Section 2.2.4 and Table 2.1), each training condition has a different impact on the levels of optimisation of cognitive resources (i.e., performance efficiency). The third column of Table 2.1 suggests that this level is lowest (i.e., cognitive load is highest) when individuals train with the analogical encoding and no collaborative learning technique (Condition 2); higher when trained with no analogical encoding and no collaborative learning techniques (Condition 1); higher again when trained with both the analogical encoding and collaborative learning techniques (Condition 4); and highest when trained without the analogical encoding technique but with the collaborative learning technique (Condition 3). Based on these proposed levels, and using the Buckless and Ravenscroft (1990) method, the contrast weights determined for testing the planned contrast are: -6 for Condition 2; +1 for Condition 1; +2 for Condition 4; and +3 for Condition 3. Results as shown in Panel C of Table 4.14 support the predicted pattern and show a significant effect (*F* = 15.930, *p*-value = 0.000). Thus, these predictions are supported.

To examine whether a MDT member's prior knowledge as an accountant or a scientist leads to different levels of performance efficiency, the results in Table 4.14 were re-analysed using the prior knowledge of the participants as a covariate. The results indicate that prior knowledge is not a significant covariate (*F* = 0.682, *p*-value = 0.411). Thus, these results suggest that MDT members from both backgrounds perceived the cognitive load in a similar way.

4.2.4.2. The Effect of Training Techniques on the Development of Knowledge Structures

As suggested in Chapter 2, Section 2.2.3, the presence of memory organisation is important in enabling efficient and effective retrieval processes from long-term memory. The use of the analogical encoding technique, through comparing examples, satisfies the memory organisation principle because with this technique the structural features of the worked examples are made explicit and a common relational structure is mapped. As a result of this, the learner can organise the instructional information in a breadth-first, hierarchically organised manner (Eylon and Reif 1984; Zeitz and Spoehr 1989; Gentner and Markman 1997; Gentner et al. 2003). Conversely, the use of the collaborative learning technique may not be helpful in developing the knowledge structure, due to the possibility that it may both facilitate and inhibit development (Andersson and Rönnberg 1995; Weldon and Bellinger 1997; Jeong and Chi 2007; Rajaram and Pereira-Pasarin 2010; Rajaram 2011). A further analysis was conducted to examine whether the use of the training techniques affects the development of knowledge structures. This analysis also examines whether MDT members with different backgrounds develop different knowledge structures.

To test the effects of training techniques on the development of knowledge structures, a 2 x 2 x 2 ANOVA on individual knowledge structures was conducted with the two training techniques and prior knowledge operating as between-subjects variables. The knowledge structure score is based on the card-sorting task completed during Phase 1, Stage 2 of the experiment. The knowledge structure score was calculated as outlined in Chapter 3, Section 3.6.7.2. The results of this analysis are provided in Table 4.15.

The ANOVA results reported in Panel B of Table 4.15 reveal that there is a significant main effect for the analogical encoding technique (F = 5.338, p-value = 0.012). As shown in Panel A of Table 4.15, individuals who trained with the analogical encoding technique developed a knowledge structure more closely aligned to the referent model provided during training (mean = 0.24), compared to individuals who trained without the analogical encoding technique (mean = 0.10). A higher score means closer alignment. Thus, these results support the prediction that individuals trained with the analogical encoding technique (which compares problem categories) will be more likely to develop knowledge structures that are more closely aligned with the referent model provided in the training material than individuals who trained without the analogical encoding technique.

Panel B of Table 4.15 shows that the main effect for the use of the collaborative learning technique on learner knowledge structures is not significant (F = 0.131, p-value = 0.718). Panel A of Table 4.15 reports that the mean of the knowledge structure is 0.16 when an individual learned collaboratively with other team members and 0.18 when individuals learned individually. These results confirm that individuals who trained with the collaborative learning technique are not more likely to develop a knowledge structure more closely aligned with the referent model than individuals who trained without the collaborative learning technique. As discussed in Chapter 2, this is probably due to team interactions disrupting the development of knowledge structure.

Table 4.15. Individual Knowledge Structure by Training Technique and Prior Knowledge

Panel A: Means (Standard Deviations) of Knowledge Structure Across Four Training Conditions

Factor	**No Analogical Encoding**		**Analogical Encoding**		**Row Means**	
	Acc.	*Sci.*	*Acc.*	*Sci.*	*Acc.*	*Sci.*
No Collaborative Learning	0.05 (0.26) *n* = 16	0.17 (0.34) *n* = 16	0.23 (0.42) *n* = 16 [a]	0.28 (0.40) *n* = 16 [a]	0.14 (0.35) *n* = 33	0.23 (0.37) *n* = 33
	$\mu 1$: **0.11** (0.31) *n* = 32		$\mu 2$: **0.26** (0.40) *n* = 34		**0.18** (0.36) *n* = 66	
Collaborative Learning	0.00 (0.19) *n* = 15	0.17 (0.33) *n* = 15	0.07 (0.26) *n* = 15	0.40 (0.48) *n* = 15	0.04 (0.23) *n* = 30	0.29 (0.43) *n* = 30
	$\mu 3$: **0.09** (0.28) *n* = 30		$\mu 4$: **0.23** (0.42) *n* = 30		**0.16** (0.36) *n* = 60	
Column Means	0.03 (0.23) *n* = 31	0.17(0.33) *n* = 31	0.15 (0.35) *n* = 32	0.34 (0.44) *n* = 32	**0.09** (0.30) *n* = 63	**0.25** (0.40) *n* = 63
	0.10 (0.29) *n* = 62		**0.24** (0.41) *n* = 64		0.17 (0.36) *n* = 126	

Panel B: Conventional ANOVA Table

Source of Variation	***SS***	***d.f.***	***MS***	***F***	***p*-value**[b]
Analogical Encoding	0.652	1	0.652	5.338	0.012
Collaborative Learning	0.016	1	0.016	0.131	0.718
Prior Knowledge	0.866	1	0.866	7.082	0.005
Analogical Encoding × Collaborative Learning	0.000	1	0.000	0.000	0.986
Analogical Encoding × Prior Knowledge	0.013	1	0.013	0.103	0.745
Collaborative Learning × Prior Knowledge	0.211	1	0.211	1.725	0.192
Analogical Encoding × Collaborative Learning × Prior Knowledge	0.094	1	0.094	0.771	0.382
Error	14.179	116	0.122		

Panel C: Planned Contrasts

Source of Variation	***SS***	***d.f.***	***MS***	***F***	***p*-value**[b]
Overall					
Contrast (contrast weights are -1, +1, +1, and +1)	0.652	1	0.652	5.097	0.013
Residual [c]	0.016	2	0.031	0.244	0.622
For Accountant Team Members					
Contrast (contrast weights are -3, +5, +3, and +1)	0.410	1	0.410	4.660	0.017
Residual [c]	0.048	2	0.096	1.088	0.343
For Scientist Team Members					
Contrast (contrast weights are -5, +3, -5, and +7)	0.518	1	0.518	3.299	0.037
Residual [c]	0.011	2	0.022	0.141	0.869

[a] Of the 34 participants in Condition 2, 2 (an accountant and a scientist) did not complete the card-sorting task and were therefore dropped from data analyses.

[b] *p*-values are one-tailed because there are directional expectations (i.e., expectations relating to the analogical encoding, prior knowledge and planned contrasts). All other *p*-values are two-tailed.

[c] The residual sum of squares represents the between-group variance not explained by the contrast weights used to test the expectation. An insignificant *F*-statistic for the residual indicates that the specified contrast is a good fit (Hirst et al. 2007).

Prior knowledge of auditing may also affect the development of knowledge structures, as suggested in Chapter 2, Section 2.2.3. Individuals who have prior auditing knowledge (accountants) may be less likely to develop a knowledge structure closely aligned with the referent model than individuals who have no prior auditing knowledge (scientists). This is because of the context of the MDTs in this study. Each team member may possess a different pre-existing knowledge structure (or way of organising information in memory), which may not match or be similar to the other team member's knowledge structure. The knowledge structure of an accountant, for example, which develops from prior education or experience in auditing (and is structured according to audit assertions or objectives (Frederick et al. 1994)) will be different from, or have little similarity to, the knowledge structure of a scientist who has no prior knowledge of categorising this type of information. As noted above, when these individuals learn collaboratively, one team member's organisation structure may disrupt the other's structure, thereby impairing the encoding process for the induced knowledge structure supplied in the training material.

As shown in Panel B of Table 4.15, there is a significant main effect for prior knowledge in auditing on learner development of the referent model knowledge structure (F = 7.082, p-value = 0.005). The mean knowledge structure of individuals with prior auditing knowledge (accountants), as reported by Panel A of Table 4.15, is 0.09, compared to 0.25 for individuals with no prior auditing knowledge (scientists). Thus, these results support the prediction that incompatibility between the pre-existing knowledge structures that a learner brings to the training and the knowledge structures in the learning material will have an effect on the acquisition of the referent knowledge structures.

As outlined in Chapter 2 (Section 2.2.4 and Table 2.1), each training condition has a different impact on facilitation of memory organisation (i.e., development of knowledge structures). The fifth column of Table 2.1 suggests that this development is lower when individuals train with no analogical encoding technique (Conditions 1 and 3) compared to when individuals train with the analogical encoding technique (Conditions 2 and 4). Contrast weights for the planned contrast are: -1 for Conditions 1 and 3 and +1 for Conditions 2 and 4. Furthermore, Table 2.1 also implies that the impact of the analogical encoding technique on the development of knowledge structure will be different. This also depends on an individual's pre-existing knowledge structure (i.e., whether or not individuals possess an incompatible knowledge structure) and whether or not individuals learn collaboratively. The use of the analogical encoding technique without collaboration (Condition 2) improves the development of knowledge structure for both the accountant and scientist team members. Although accountant members have an incompatible knowledge structure (compared to the structure provided in the learning material), learning individually allows them to develop the structure according to the training material without disruption from other team members. Scientist members are also able to develop the knowledge structure at the same level as the accountant members. However, when training is undertaken in collaboration with other team members (Condition 4), the use of this collaborative learning technique has a beneficial effect for the scientist members but not for the accountant members. This is because collaborative inhibition, via disruption from the other team member, prevents accountant members from being able to discard their prior structure in favour of developing the structure according to the training material. As they have no prior structure, the scientist members have no prior structure are not affected in this way. Based on these predictions, the contrast weights determined for testing the planned contrast for accountant members are: -3 for Conditions 1 and 3; +5 for Condition 2; and +1 for Condition 4. For scientist members, the contrast weights are: -5 for Conditions 1 and 3; +3 for Condition 2; and +7 for Condition 4.

Results of the planned contrasts, as shown in Panel C of Table 4.15, support the predicted pattern. For the overall team, the planned contrast shows a significant effect (*F* = 5.097, *p*-value = 0.013). Similarly, significant effects are found for both accountant members (*F* = 4.660, *p*-value = 0.017) and scientist members (*F* = 3.299, *p*-value = 0.037). The predictions relating to the effect of training techniques and prior knowledge on the development of knowledge structures are therefore supported.

In addition to the analysis on the effect of prior knowledge on the development of the referent knowledge structures reported above, a further analysis was conducted to examine whether the training techniques have different effects on the development of knowledge structures for the accountant and scientist members of the teams. An independent *t*-test, to compare the means of knowledge structures of accountant and scientist members was conducted for each condition. Table 4.16 provides the results and shows that participants with different backgrounds in the collaborative learning technique conditions (Conditions 3 and 4) developed different knowledge structures.

As shown in Table 4.16, when learning collaboratively, accountant members are less likely to develop the referent knowledge structure (mean = 0.00 in Condition 3 and 0.07 in Condition 4) than scientist members (mean = 0.17 in Condition 3 and 0.40 in Condition 4). The difference between accountant knowledge structures and scientist knowledge structures in Condition 3 is significant (*t* = -1.763, *p*-value = 0.045). Similarly, the difference in Condition 4 is significant (*t* = -2.273, *p*-value = 0.017). In contrast, under individual learning conditions (Conditions 1 and 2), the knowledge structures developed by accountants and scientists are not significantly different (*t* = -1.103, *p*-value = 0.140 for Condition 1; *t* = -0.346, *p*-value = 0.366 for Condition 2). These results indicate that learning collaboratively is detrimental to the development of the referent knowledge structures, particularly for accountant members with incompatible pre-existing knowledge structures.

Table 4.16. Comparison between Accountant and Scientist Knowledge Structure across the Four Training Conditions: Means (Standard Deviations)

Condition 1 Individual Learning/ No Analogical Encoding		**Condition 2** Individual Learning/ Analogical Encoding		**Condition 3** Collaborative Learning/ No Analogical Encoding		**Condition 4** Collaborative Learning/ Analogical Encoding	
Acc. (n= 16)	*Sci.* (n = 16)	*Acc.* (n = 16)[a]	*Sci.* (n = 16)[a]	*Acc.* (n = 15)	*Sci.* (n = 15)	*Acc.* (n = 15)	*Sci.* (n = 15)
0.05 (0.26)	0.17 (0.34)	0.23 (0.42)	0.28 (0.40)	0.00 (0.19)	0.17 (0.33)	0.07 (0.26)	0.40 (0.49)
Mean Difference: - 0.12		Mean Difference: - 0.05		Mean Difference: - 0.17		Mean Difference: - 0.33	
t = - 1.103 *p*-value = 0.140 (one-tailed)		*t* = - 0.346 *p*-value = 0.366 (one-tailed)		*t* = - 1.763 *p*-value = 0.045 (one-tailed)		*t* = - 2.273 *p*-value = 0.017 (one-tailed)	

[a] Of the 34 participants in Condition 2, 2 (1 accountant and 1 scientist) did not complete the card-sorting task and therefore these participants were dropped from data analyses involving knowledge structure.

As noted in Chapter 3, participants were asked to perform the card-sorting task (a knowledge structure measure) only once, in order to reduce the possibility of demand effects. Therefore, in order to assess whether there was indeed a learning effect from the training materials, a control condition was included. This design choice allows a comparison to be made between the knowledge structure of the control condition and the training conditions, and thus to evidence learning.

Table 4.17 reports the comparison of means for the knowledge structures for the control condition and the four training conditions. As shown in Table 4.17, in the control condition, the mean of the knowledge structure developed by accountant members (0.19) is higher than that of scientist members (0.09), although this mean difference (0.10) between the knowledge structures of accountant and scientist members not significant (*t* = 0.744, *p*-value

= 0.464). This knowledge structure is similar to the knowledge structure examined in the individual learning conditions (Conditions 1 and 2).

Table 4.17. Comparison between Participants in Training Conditions and Control Condition: Means (Standard Deviations)

Control Condition *(Condition 0)*		**Training Conditions**							
		No Collaborative / No Analogical *(Condition 1)*		**No Collaborative/ Analogical** *(Condition 2)*		**Collaborative/ No Analogical** *(Condition 3)*		**Collaborative/ Analogical** *(Condition 4)*	
Acc.	Sci.	Acc.	Sci.	Acc.	Sci.	Acc.	Sci.	Acc.	Sci.
(n = 11)[a]	(n = 14)[a]	(n = 16)[b]	(n = 16)[b]	(n = 16)	(n = 16)	(n = 15)	(n = 15)	(n = 15)	(n = 15)
0.19 (0.34)	0.09 (0.33)	0.05 (0.26)	0.17 (0.34)	0.23 (0.42)	0.28 (0.40)	0.00 (0.19)	0.17 (0.33)	0.07 0.26	0.40 (0.49)
Mean Diff.: 0.10 *t* = 0.744 *p*-value = 0.232 (one-tailed)		Mean Diff.: - 0.12 *t* = - 1.103 *p*-value = 0.140 (one-tailed)		Mean Diff.: - 0.05 *t* = - 0.346 *p*-value = 0.366 (one-tailed)		Mean Diff.: - 0.17 *t* = - 1.763 *p*-value = 0.045 (one-tailed)		Mean Diff.: - 0.33 *t* = - 2.273 *p*-value = 0.018 (one-tailed)	
0.14 (0.33) *n* = 25		**0.11** (0.31) *n* = 32		**0.26** (0.40) *n* = 32		**0.09** (0.28) *n* = 30		**0.23** (0.42) *n* = 30	

Comparisons between Control Condition and Training Conditions	$\mu0$	$\mu1$ / $\mu2$ / $\mu3$ / $\mu4$	Mean difference	*t*	*p*-value (one-tailed)
For All Team Members					
$\mu0$ vs. $\mu1$ [c]	0.14	0.11	-0.03	-0.315	0.377
$\mu0$ vs. $\mu2$	0.14	0.26	0.12	1.173	0.123
$\mu0$ vs. $\mu3$	0.14	0.09	-0.05	-0.612	0.272
$\mu0$ vs. $\mu4$	0.14	0.23	0.09	0.922	0.181
For Accountant Team Members					
$\mu0$ vs. $\mu1$	0.19	0.05	-0.14	-1.228	0.116
$\mu0$ vs. $\mu2$	0.19	0.23	0.04	0.236	0.408
$\mu0$ vs. $\mu3$	0.19	0.00	-0.19	-1.854	0.055
$\mu0$ vs. $\mu4$	0.19	0.07	-0.12	-1.048	0.153
For Scientist Team Members					
$\mu0$ vs. $\mu1$	0.09	0.17	0.08	0.624	0.269
$\mu0$ vs. $\mu2$	0.09	0.28	0.19	1.372	0.091
$\mu0$ vs. $\mu3$	0.09	0.17	0.08	0.654	0.260
$\mu0$ vs. $\mu4$	0.09	0.40	0.31	1.933	0.031

[a] There were not an equal number of accountant and scientist participants in the control condition. Further, they were not paired into groups of two as they did not perform the team task.

[b] Of the 34 participants in Condition 2, 2 (1 accountant and 1 scientist) did not complete the card-sorting task and therefore these participants were dropped from data analyses involving knowledge structure.

[c] $\mu0$ = mean for Condition 0; $\mu1$ = mean for Condition 1; $\mu2$ = mean for Condition 2; $\mu3$ = mean for Condition 3; and $\mu4$ = mean for Condition 4.

Several comparisons conducted between the mean of the control condition with the means of the training conditions are reported in Table 4.17. Comparisons with all training conditions for all team members indicate that none of the mean differences are significant. In addition, when the comparisons between the control condition and the training conditions were conducted for accountant team members, none of the mean differences are significant. In contrast, when the comparisons between the control condition and training conditions are conducted for scientist members, there is a significant difference between the control condition and Condition 4. These results indicate that there is a learning effect for scientist members when they use a combined technique to develop knowledge structure.

4.2.4.3. The Effect of Prior Knowledge on an Individual's Ability to Generate Hypotheses

The effect of prior knowledge on an individual's ability to generate hypotheses was tested by a 2 x 2 x 2 ANOVA, with individual ability to generate hypotheses as the dependent variable and the two training techniques and prior knowledge as the independent variables (see Table 4.18). The results, as shown in Panel A of Table 4.18, report that across the four training conditions, accountant members of teams consistently have a higher ability in generating hypotheses. In addition, Panel B of Table 4.18 indicates that the main effect of prior knowledge in auditing is significant (F = 3.406, p-value = 0.034).

To investigate the performance differences between the accountant and scientist members of teams, similar planned contrast and contrast weights were conducted to those used in analysing individual performance in generating hypotheses as presented in Section 4.2.1. Panel C of Table 4.18 reports the planned contrasts for the accountant and scientist members of the teams. For the accountant members, the planned contrast shows an insignificant effect (F = 1.616, p-value = 0.103). These results suggest that for the accountants, the use of either or both of these training techniques did not contribute to an improvement in generating hypotheses. In contrast, for the scientist members of MDTs, the planned contrast shows a significant effect (F = 5.360, p-value = 0.011). Thus, for the scientist members, the predicted pattern was supported, indicating that scientists trained with the analogical encoding and collaborative learning techniques had an improved ability to generate hypotheses.

Table 4.18. Individual Hypothesis Generation by Training Technique and Prior Knowledge

Panel A: Means (Standard Deviations) of Individual Hypothesis Generation Across Four Training Conditions

Factor	No Analogical Encoding		Analogical Encoding		Row Means	
	Acc.	*Sci.*	*Acc.*	*Sci.*	*Acc.*	*Sci.*
No Collaborative Learning	6.88 (4.35) *n* = 16	5.25 (3.51) *n* = 16	6.76 (4.48) *n* = 17	4.82 (3.23) *n* = 17	6.82 (4.35) *n* = 33	5.03 (3.32) *n* = 33
	$\mu1$: **6.06** (3.98) *n* = 32		$\mu2$: **5.79** (3.97) *n* = 34		5.92 (3.94) *n* = 66	
Collaborative Learning	6.93 (5.04) *n* = 15	6.20 (2.40) *n* = 15	8.80 (4.90) *n* = 15	7.60 (4.85) *n* = 15	7.87 (4.90) *n* = 30	6.90 (3.83) *n* = 30
	$\mu3$: **6.57** (3.89) *n* = 30		$\mu4$: **8.20** (4.83) *n* = 30		7.38 (4.43) *n* = 60	
Column Means	6.90 (4.61) *n* = 31	5.71 (3.01) *n* = 31	7.72 (4.72) *n* = 32	6.13 (4.24) *n* = 32	7.32 (4.65) *n* = 63	5.92 (3.66) *n* = 63
	6.31 (3.91) *n* = 62		6.92 (4.52) *n* = 64		6.62 (4.23) *n* = 126	

Panel B: Conventional ANOVA Table

Factor	*SS*	*d.f.*	*MS*	*F*	*p*-value[a]
Analogical Encoding	14.632	1	14.632	0.839	0.362
Collaborative Learning	66.508	1	66.508	3.814	0.027
Prior Knowledge	59.383	1	59.383	3.406	0.034
Analogical Encoding × Collaborative Learning	28.403	1	28.403	1.629	0.204
Analogical Encoding × Prior Knowledge	1.203	1	1.203	0.069	0.793
Collaborative Learning × Prior Knowledge	5.235	1	5.235	0.300	0.585
Analogical Encoding × Collaborative Learning × Prior Knowledge	0.044	1	0.044	0.003	0.960
Error	2,057.613	118	17.437		

Panel C: Planned Contrasts

Performance of individuals will be highest in the collaborative learning/analogical encoding techniques condition, lower in the no analogical encoding/collaborative learning technique condition, and lowest in the two no collaborative learning technique conditions (contrast weights are +5, +1, -3, and -3, respectively).

Source of Variation	*SS*	*d.f.*	*MS*	*F*	*p*-value[a]
For Accountant Team Members					
Contrast	35.496	1	35.496	1.616	0.103
Residual [b]	9.178	2	18.356	0.836	0.362
For Scientist Team Members					
Contrast	69.171	1	69.171	5.360	0.011
Residual [b]	2.182	2	4.365	0.338	0.562

[a] *p*-values are one-tailed because there are directional expectations (expectations relating to the H2 and H3). All other p-values are two-tailed.

[b] The residual sum of squares represents the between-group variance not explained by the contrast weights used to test the expectation. An insignificant *F*-statistic for the residual indicates that the specified contrast is a good fit (Hirst et al. 2007).

4.2.4.4. Participants' Cognitive Ability as Measured by the Results of the Distractor Task

As outlined in Chapter 3, participants were asked to individually complete a task that acted as a distractor task (i.e., stage 3 in Figure 3.2). In addition to functioning as a distraction between the training and test phases of the experiment, the problem-solving scenario was intended to be used as a measure of cognitive ability or 'practical' problem solving ability (PPSA) in a manner consistent with Devolder (1993). Prior studies in auditing provide evidence that this measure is useful in predicting the performance of both accounting students and experienced auditors for both analytical procedures and internal-control evaluation tasks (Bierstaker and Wright 2001). Using the Devolder (1993) PPSA scoring scheme, the score for an individual's ability to solve complex problems was measured on a scale of zero to seven. This scoring scheme includes whether the individual: (1) realises the problem(s); (2) suggests a solution(s); (3) makes effective use of available resources; (4) avoids future negative consequences; (5) references relevant information; (6) formulates how to carry out the action required; and (7) provides a solution that is specific and complete. The results of the PPSA score for each training condition are presented in Table 4.19.

Table 4.19. Distractor Task Results (Practical Problem Solving Ability)

Panel A: Means (Standard Deviations) of Practical Problem Solving Ability			
Factor	**No Analogical Encoding**	**Analogical Encoding**	**Row Means**
No Collaborative Learning	*Condition 1* **3.41** (1.46) *n* = 32	*Condition 2* **2.32** (1.61) *n* = 34	**2.85** (1.62) *n* = 66
Collaborative Learning	*Condition 3* **3.17** (1.51) *n* = 30	*Condition 4* **2.57** (1.48) *n* = 30	**2.87** (1.51) *n* = 60
Column Means	**3.29** (1.48) *n* = 62	**2.44** (1.54) *n* = 64	**2.86** (1.56) *n* = 126

Panel B: Conventional ANOVA Table					
Factor	***SS***	***d.f.***	***MS***	***F***	***p*-value**[a]
Analogical Encoding	22.238	1	22.238	9.666	0.002
Collaborative Learning	0.000	1	0.000	0.000	0.995
Analogical Encoding × Collaborative Learning	1.830	1	1.830	0.795	0.374
Error	280.693	122	2.301		

[a] All *p*-values are two-tailed.

As shown in Panel A of Table 4.19, participants trained with the analogical encoding technique have a lower PPSA score (mean = 2.44) compared to participants trained without the analogical encoding technique (mean = 3.29). This suggests that participants who previously trained with the analogical encoding technique performed worse in the distractor task. Panel B of Table 4.19 reports that the analogical encoding technique has a significant main effect (*F* = 9.666, *p*-value = 0.002). A possible explanation for this result could be that the higher cognitive load imposed on participants that trained with the analogical encoding technique during the previous training stage made it difficult for participants to perform well in the distractor task. Given that cognitive ability of the participants has been controlled through randomisation (as indicated by no difference in academic performance scores across training conditions as reported in Chapter 3 Section 3.3), these results suggest that PPSA scores cannot be used as a measure of cognitive ability. On the other hand, the results of this measure indicate the important role of cognitive load during training. This affected individual performance both in a related task, consistent with the findings reported in Section 4.2.4.1, and in an unrelated task as reported in this section.

4.2.5. Additional Analyses Relating to the Use of Analogical Encoding and Collaborative Learning Techniques as a Team-Training Intervention

The results of the second set of additional analyses relating to team-training interventions are presented in this section. Four additional analyses relating to the use of the training techniques as team-training interventions are provided: team process gains, team process measured by a subjective team process measure, team process measured by a subjective information elaboration measure, and TMSs processes.

4.2.5.1. The Effect of Team-Training Interventions on Team Process Gains

As outlined in Chapter 2, one of the benefits of training with a combination of analogical encoding and collaborative learning techniques is that the combination enables team members to process information effectively. The extent of the improved team process can be indicated by the team exhibiting process gains in hypothesis generation. To measure these process gains, the performance level of the team's most capable member is compared with the actual MDT performance in the hypothesis generation stage (Kerr and Tindale 2004; Tindale and Starkel 2010). The performance level of the team's most capable member was determined from a comparison of the hypothesis generation performance level (as discussed in Chapter 3 Section 3.6.7.3) between the two members of a team and selecting whoever had the higher score. As noted in Chapter 3, two possible categories can be derived from this comparison: *process gains,* when the actual MDT performance is higher than the performance level of a team's most capable member; and *no process gains*, when the performance level of the team is either the same or below the performance of the most capable member (i.e., a process loss). Table 4.20 provides the proportion (percentage) of MDTs that exhibited process gains and the results of the exact method logistic regression.

Table 4.20. Team Process Gains in Hypothesis Generation

Panel A: Proportions (Percentage) of MDTs that Exhibited Process Gains in Hypothesis Generation across the Four Training Conditions

Factor	No Analogical Encoding	Analogical Encoding	Row Proportions
No Collaborative Learning	*Condition 1*	*Condition 2*	**5/33** (15.2%)
	2/16 (12.5%)	**3/17** (17.6%)	
Collaborative Learning	*Condition 3*	*Condition 4*	**7/30** (23.3%)
	1/15 (6.7%)	**6/15** (40.0%)	
Column Proportions	**3/31** (9.7%)	**9/32** (28.1%)	**12/63** (19.0%)

Panel B: Exact Method Logistic Regression Results

Source	Estimate (Standard Error)	*Z* Statistic	Exact *p*-value (one-tail)
Analogical Encoding	1.279 (0.718)	3.447	0.108
Collaborative Learning	0.566 (0.659)	0.749	0.515
Analogical Encoding × Collaborative Learning	–	4.138	0.128

Panel C: Exact Method Planned Contrast

MDTs that train with a combination of analogical encoding and collaborative learning techniques are more likely to exhibit process gains than MDTs that train in other conditions.

Contrast	Estimate (Standard Error)	*Z* Statistic	Exact *p*-value (one-tail)
Condition 4 > Conditions 1, 2, and 3	1.509 (0.676)	5.516	0.028

As shown in Panel A of Table 4.20, out of 32 MDTs whose members trained using the analogical encoding technique, 9 MDTs (28.1%) exhibit process gains, whereas only 3 of 31 MDTs (9.7%) trained without the analogical encoding technique exhibit process gains. However, Panel B of Table 4.20 indicates that, when using the exact method logistic regression, the analogical encoding technique has an insignificant main effect (Z = 3.447; exact p-value = 0.108). Similarly, although more MDTs exhibit process gains when trained with the collaborative learning technique (23.3%) compared to MDTs trained without the collaborative learning technique (15.2%), the collaborative learning technique has an insignificant main effect (Z = 0.749; exact p-value = 0.515). The results of the planned contrast, however, show that the contrast for exhibiting process gains between MDTs where members trained with a combination of the two training techniques and MDTs trained with any of the other conditions is significant (Z = 5.516; exact p-value = 0.028). These results support the prediction that a combination of analogical encoding and collaborative learning techniques enables MDT members to process information more effectively.

The process gains measure used above is a categorical measure based on a comparison between the team's highest productivity potential, measured as the hypothesis generation quality of the team's most capable member, and the teams' actual hypothesis generation quality. Process gain can also be measured directly from that comparison as a continuous variable. Using this alternative measure, a further analysis was conducted to examine whether process gains occur in all training conditions. The highest productivity potential and the MDT's actual hypothesis generation quality were compared using *t*-tests for each training condition and are reported in Table 4.21.

Table 4.21. Comparison across the Four Training Conditions: Means (Standard Deviations), Team's Highest Productivity Potential and MDTs' Actual Hypothesis Quality

Condition 1 Individual Learning/No Analogical Encoding		**Condition 2** Individual Learning/ Analogical Encoding		**Condition 3** Collaborative Learning/No Analogical Encoding		**Condition 4** Collaborative Learning/ Analogical Encoding	
(n = 16)		(n = 17)		(n = 15)		(n = 15)	
Highest Productivity Potential **(1)**	Teams' Hypothesis Quality **(2)**	Highest Productivity Potential **(1)**	Teams' Hypothesis Quality **(2)**	Highest Productivity Potential **(1)**	Teams' Hypothesis Quality **(2)**	Highest Productivity Potential **(1)**	Teams' Hypothesis Quality **(2)**
8.75 (3.57)	6.94 (2.67)	8.41 (3.34)	7.00 (2.26)	9.13 (3.48)	7.80 (4.35)	10.13 (5.01)	9.40 (6.03)
Mean Difference: -1.81		Mean Difference: -1.41		Mean Difference: - 1.33		Mean Difference: -0.73	
t = 1.627 *p*-value = 0.057 (one-tailed)		*t* = 1.444 *p*-value = 0.080 (one-tailed)		*t* = 0.927 *p*-value = 0.181 (one-tailed)		*t* = 0.362 *p*-value = 0.360 (one-tailed)	
Correlation between (1) and (2) (*r*) = **0.51***		Correlation between (1) and (2) (*r*)= **0.69****		Correlation between (1) and (2) (*r*) = **0.75****		Correlation between (1) and (2) (*r*) = **0.91****	

***** and ****** indicate statistical significance at the 0.05 and 0.01 level respectively.

Table 4.21 shows that the mean differences are significant for Conditions 1 and 2 (individual learning conditions) (mean difference = -1.81, *t* = 1.627, *p*-value = 0.057 for Condition 1 and mean difference = -1.41, *t* = 1.444, *p*-value = 0.080 for Condition 2), suggesting that MDTs in these conditions suffered negative process gains (i.e., a process loss). In contrast, the mean differences for Conditions 3 and 4 (the collaborative learning conditions) are insignificant (mean difference = -1.33, *t* = 0.927, *p*-value = 0.181 for Condition 1 and mean difference = -0.73, *t* = 0.362, *p*-value = 0.360 for Condition 2), indicating that while the MDTs in these conditions also exhibit negative process gains, these are of a smaller magnitude than for Conditions 1 and 2. In addition, although the correlation between the team's highest productivity potential and their actual hypothesis quality is significant for each condition, the correlation is highest (0.91) in Condition 4. These results provide additional support for the prediction that a combination of analogical encoding and collaborative learning techniques enables team members to show less reduction in potential hypothesis generation quality.

4.2.5.2. The Effect of Team-Training Interventions on Team Process when Team Process is Measured by a Subjective Team Process Measure

In the organisational psychology literature, team process can be measured either objectively, by independent coders through observation from videos or audiotapes of actual team processes, or subjectively, by the research participants. In this study, in addition to the process gains measure used as a proxy for team process described in the preceding section, an alternative subjective team process measure was employed. This measure is derived from the perceptions of the team members and uses the nine items developed by Mathieu et al. (2006), which were in turn based on the team process dimension in Marks et al. (2001).[60] Chapter 3, Section 3.8.3.1 provides a detailed description of this measure.

Table 4.22 presents the results of a 2 x 2 ANOVA, with a subjective team process measure as the dependent variable and the two training techniques as the independent variables. Panel A of Table 4.22 shows that participants in the collaborative learning conditions perceived lower team process (mean = 5.00) than participants in the no collaborative learning conditions (mean = 5.54). The conventional ANOVA results in Panel B of Table 4.22 show that this main effect for collaborative learning is significant (F = 5.033, p-value = 0.015). In addition, although participants who trained as individuals without the analogical encoding technique perceived higher team process (mean = 5.34) compared to participants who trained in the analogical encoding technique (mean = 5.23), the ANOVA results show this difference is not significant. In addition, the interaction between analogical encoding and collaborative learning is significant (F = 3.562, p-value = 0.064).

---

[60] As noted in Chapter 3 Section 3.6.7.4, team processes were measured using scales that correspond to Marks et al.'s (2001) three superordinate categories, each with three items: (i) transition (i.e., how team members plan out what they will do in later stages, how they set their goals, and how they plan their strategy); (ii) action (i.e., how team members concentrate on task accomplishments, how they monitor progress and systems, and how they coordinate team members, as well as how they monitor and back-up their fellow team members); and (iii) interpersonal (i.e., how team members manage conflict, how they manage motivation and confidence building, and how they conduct affect management (i.e., how they think in terms of what is best for the team) (Mathieu et al. 2006).

Table 4.22. Subjective Team Processes by Training Technique

Panel A: Means (Standard Deviations) of Subjective Team Processes Measure

Factor	No Analogical Encoding	Analogical Encoding	Row Means
No Collaborative Learning	*Condition 1* **5.38** (1.09) n = 16	*Condition 2* **5.68** (0.69) n = 17	**5.54** (0.90) n = 33
Collaborative Learning	*Condition 3* **5.30** (0.95) n = 15	*Condition 4* **4.71** (0.99) n = 15	**5.00** (0.90) n = 30
Column Means	**5.34** (1.01) n = 31	**5.23** (0.97) n = 32	**5.28** (0.98) n = 63

Panel B: Conventional ANOVA Table

Factor	*SS*	*d.f.*	*MS*	*F*	p-value[a]
Analogical Encoding	0.316	1	0.316	0.360	0.551
Collaborative Learning	4.403	1	4.403	5.003	0.015
Analogical Encoding × Collaborative Learning	3.135	1	3.135	3.562	0.064
Error	51.925	59	0.880		

Panel C: Planned Contrast

Team processes of MDTs that train with a combination of the analogical encoding and collaborative learning techniques will be higher than team processes of MDTs that train in other conditions (contrast weights are: -1 for Conditions 1, 2, and 3; and +3 for Condition 4).

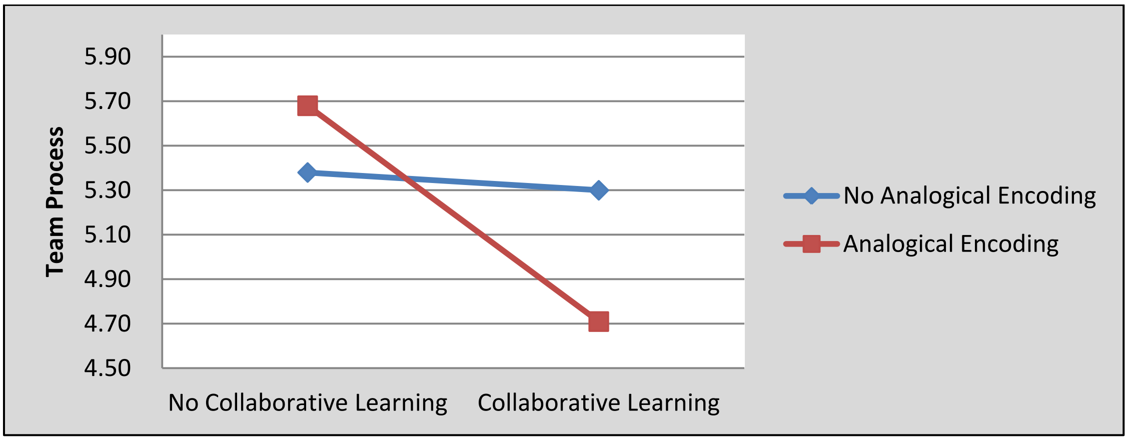
Factor	*SS*	*d.f.*	*MS*	*F*	p-value[a]
Contrast	6.342	1	6.342	7.207	0.005
Residual [b]	1.512	2	3.023	3.436	0.038

[a] p-values are one-tailed because there are directional expectations (expectations relating to collaborative learning and the planned contrast). All other p-values are two-tailed.

[b] The residual sum of squares represents the between-group variance not explained by the contrast weights used to test the expectation. An insignificant F-statistic for the residual indicates that the specified contrast is a good fit (Hirst et al. 2007).

As outlined in Chapter 2, one of the benefits of training with a combination of analogical encoding and collaborative learning techniques is that the combination enables team members to process information effectively. In other words, the team process of MDTs trained with a combination of these two training techniques will be higher than the team process in other conditions. Based on this prediction, the contrast weights are: +3 for Condition 4; and -1 for Conditions 1, 2 and 3. The planned contrasts in Panel C of Table 4.22 indicate that the contrast is significant (F = 7.207, p-value = 0.005) but in the opposite direction. Team process in Condition 4 is lower compared to the other conditions. As shown in Panel A of Table 4.22 and Figure 4.10 below, the subjective team process measure in Condition 4 is lower (mean = 4.71) compared to those in other conditions. Figure 4.10 also shows that the interaction is not ordinal as predicted. In addition, as indicated by the significant residual sum of squares (F = 3.436, p-value = 0.038), the contrast weights used do not explain the between-group variance. The specified contrast is not a good fit.[61] Therefore, using this measure of team process, the results show that the use of the two training techniques significantly affects the perceived team process (measured as a subjective team process measure), albeit in the opposite direction to expectations, and thus resulting in lower team process.

Figure 4.9. Results Showing the Effect of Training Techniques on Subjective Team Process



4.2.5.3. The Effect of Team-Training Interventions on Elaboration of Task-Relevant Information

As explained in Chapter 3, the subjective team process measure proposed by Mathieu et al. (2006) includes the dimension of information elaboration that was used by Homan et al. (2008). In this study, two items relating to subjective team process were used as a proxy for information elaboration (i.e., how team members discussed the analysis of the information provided to achieve their goals and how team members took the time needed to share task-related information). Table 4.23 reports the descriptive statistics and the results of a 2 x 2 ANOVA, with information elaboration as the dependent variable and the two training techniques as the independent variables. Panel A of Table 4.23 shows that participants in the collaborative learning conditions rated their elaboration lower (mean = 5.00) than participants in the no collaborative learning conditions (mean = 5.45). Participants who trained with the analogical encoding technique also perceived lower information elaboration (mean = 5.18) compared to participants who trained without the analogical encoding technique (mean = 5.30). The conventional ANOVA results in Panel B of Table 4.23 show that

---

[61] Based on the results in Panel A of Table 4.22, a post-hoc analysis was conducted to determine the specified contrast. The contrast weights that are a good fit for this data are: -4 for Condition 4; +1 for Conditions 1 and 3; and +2 for Condition 2 (contrast *F* = 8.188 *p* = 0.003, residual *F* = 1.475, *p* = 0.237).

the main effect for the analogical encoding technique is insignificant (*F* = 0.296, *p*-value = 0.588) and the main effect for the collaborative learning technique is significant (*F* = 3.043, *p*-value = 0.043). Contrary to the prediction, these results suggest that participants who learned collaboratively perceived that they conducted less elaboration in completing the team task.

Table 4.23. Elaboration of Task-Relevant Information

Panel A: Means (Standard Deviations) of Elaboration of Task-Relevant Information

Factor	No Analogical Encoding	Analogical Encoding	Row Means
No Collaborative Learning	*Condition 1* **5.36** (1.03) *n* = 16	*Condition 2* **5.54** (0.85) *n* = 17	**5.45** (0.93) *n* = 33
Collaborative Learning	*Condition 3* **5.23** (1.16) *n* = 15	*Condition 4* **4.77** (1.05) *n* = 15	**5.00** (1.12) *n* = 30
Column Means	**5.30** (1.08) *n* = 31	**5.18** (1.02) *n* = 32	**5.24** (1.04) *n* = 63

Panel B: Conventional ANOVA Table

Factor	*SS*	*d.f.*	*MS*	*F*	*p*-value[a]
Analogical Encoding	0.312	1	0.312	0.296	0.588
Collaborative Learning	3.205	1	3.205	3.043	0.043
Analogical Encoding × Collaborative Learning	1.666	1	1.666	1.582	0.213
Error	62.142	59	1.053		

Panel C: Planned Contrast

Elaboration of MDTs that train with a combination of analogical encoding and collaborative learning techniques will be higher than elaboration of MDTs that train in other conditions (contrast weights are: -1 for Conditions 1, 2 and 3; and +3 for Condition 4).

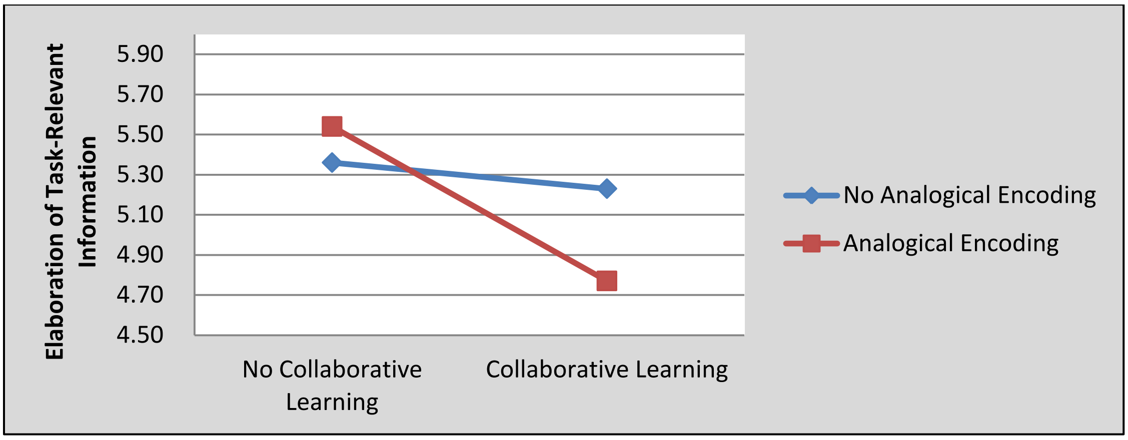
Factor	*SS*	*d.f.*	*MS*	*F*	*p*-value[a]
Contrast	4.282	1	4.282	4.066	0.024
Residual [b]	0.901	2	1.803	1.712	0.189

[a] *p*-values are one-tailed because there are directional expectations (expectations relating to collaborative learning and the planned contrast). All other *p*-values are two-tailed.

[b] The residual sum of squares represents the between-group variance not explained by the contrast weights used to test the expectation. An insignificant *F*-statistic for the residual indicates that the specified contrast is a good fit (Hirst et al. 2007).

Using similar contrast weights as used in the analysis of a subjective team process measure, the planned contrasts in Panel C of Table 4.23 indicate that the contrast is significant (*F* = 4.066, *p*-value = 0.024) but in the opposite direction. Information elaboration in Condition 4 is not higher but rather it is lower compared to the other conditions. As shown in Panel A of Table 4.23 and Figure 4.11 below, elaboration in Condition 4 is lower (mean = 4.77) compared to those in all other conditions. Thus, using the subjective measure of elaboration, the results show that the use of the two training techniques significantly affects perceived information elaboration, albeit in an opposite direction to expectation, and thus resulting in lower elaboration.

Figure 4.10. Results Showing the Effect of Training Techniques on Elaboration of Task-Relevant Information



4.2.5.4. The Effect of Team-Training Interventions on TMSs Processes

As outlined in Chapters 2 and 3, transactive memory systems (TMSs) have two components: an organised store of knowledge (TMSs structure) and a set of knowledge-relevant transactive processes (encoding, storage and retrieval processes) that occur among team members (Wegner et al. 1985; Lewis and Herndon 2011). The TMS structure is a knowledge representation of each member's unique and shared knowledge (including their shared understanding of who knows what) (Lewis and Herndon 2011). TMS processes are the mechanisms by which the team coordinates the two individual members' learning and retrieval of knowledge, so that the knowledge can be applied to team tasks (Lewis and Herndon 2011). In this section, the first of two proxy mechanisms from the analytical procedures task is used to analyse how the groups coordinate learning and retrieval of knowledge. The application of this to team tasks is analysed by examining how team members select hypotheses from the individual member sets of generated hypotheses to be included in the team's hypothesis set.

Table 4.24 reports the proportion and comparison of individual team member hypotheses selected for a team's hypothesis set across the four training conditions. As shown in Table 4.24, Panel A, teams in Conditions 1, 2 and 4 selected the hypotheses generated by each team member in approximately the same equal proportion. In contrast, the teams in Condition 3 selected more hypotheses generated by the accountant team members (63.8%)

than those generated by the scientist members. MDTs trained using the collaborative learning technique selected more hypotheses from the accountant members (55.8%) compared to MDTs trained without the collaborative learning technique (49.8%). MDTs trained using the analogical encoding technique selected fewer hypotheses from the accountant members (48.1%) than MDTs trained without the analogical encoding technique (56.7%).

Table 4.24. Proportion of Individual MDT Member Hypotheses Selected for the Team Hypothesis Set across the Four Training Conditions

Panel A: Proportions (Percentage) of Accountant Members' Hypotheses Selected for the Teams' Hypothesis Set across the Four Training Conditions

Factor	No Analogical Encoding	Analogical Encoding	Row Proportions
No Collaborative Learning	*Condition 1* **55/107** (51.4%)	*Condition 2* **49/102** (48.0%)	**104/209** (49.8%)
Collaborative Learning	*Condition 3* **51/80** (63.8%)	*Condition 4* **40/83** (48.2%)	**91/163** (55.8%)
Column Proportions	**106/187** (56.7%)	**89/185** (48.1%)	**195/372** (52.4%)

Panel B: Logistic Regression Results

Source	Estimate (Standard Error)	χ^2	*p*-value
Analogical Encoding	-0.135 (0.277)	0.236	0.627
Collaborative Learning	-21.259 (4,493.711)	0.000	0.498
Analogical Encoding × Collaborative Learning	21.265 (4,493.711)	0.000	0.996

Panel C: Planned Contrast

TMSs of MDTs that train with and without the analogical encoding technique are more developed when MDTs train using the collaborative learning technique.

Contrast	Estimate (Standard Error)	χ^2	*p*-value
Cond. 3 = Cond. 4 > Cond. 1 = Cond. 2	0.244 (0.210)	1.350	0.245

However, the results of logistic regression in Panel B show that neither the analogical encoding nor collaborative learning techniques have a significant main effect. These results provide additional support to Hypothesis 22, which predicts that TMSs of MDTs trained using the analogical encoding technique would not be more developed than TMSs of MDTs trained without the analogical encoding technique. However, these results do not support Hypothesis 23, which predicts that TMSs of MDTs trained using the collaborative learning technique would be more developed than TMSs of MDTs that trained without the collaborative learning technique. Similarly, the results do not support Hypothesis 24 which predicts no interaction effect for these two training technique such that TMSs of MDTs that trained with or without the analogical encoding technique are more developed when MDTs trained using the collaborative learning technique. The results of the planned contrast reported in Panel C show that the contrast has no significant effect (χ^2 = 1.350, *p*-value = 0.245). Therefore, the testing of hypotheses relating to TMSs using this measure support the results found using the TMSs structure measure.

The second mechanism of TMS processes examined in this study relates to how the group coordinates learning and retrieval of knowledge and how this is applied to team tasks. This mechanism is how the team members allocate the required assurance procedures between the team members in the hypothesis evaluation stage. An analysis of how team members allocate assurance tests is reported in Table 4.25 with regard to their completion by individual team members or by the team acting together.

Table 4.25. Proportion of Assurance Tests Allocated across the Four Training Conditions

Panel A: Proportions (Percentage) of Assurance Procedures Allocated to Individual Members Across Four Training Conditions

Factor	No Analogical Encoding	Analogical Encoding	Row Proportions
No Collaborative Learning	*Condition 1* **68/107** (63.6%)	*Condition 2* **54/102** (52.9%)	**122/209** (58.4%)
Collaborative Learning	*Condition 3* **52/82** (63.4%)	*Condition 4* **43/82** (52.4%)	**95/164** (57.9%)
Column Proportions	**120/189** (63.5%)	**97/184** (52.7%)	**217/373** (58.2%)

Panel B: Logistic Regression Results

Source	Estimate (Standard Error)	χ^2	*p*-value
Analogical Encoding	0.438 (0.282)	2.409	0.121
Collaborative Learning	-20.647 (4,438.571)	0.000	0.498
Analogical Encoding × Collaborative Learning	20.667 (4,438.571)	0.000	0.996

Panel C: Planned Contrast

TMSs of MDTs that train with and without the analogical encoding technique are more developed when MDTs train using the collaborative learning technique.

Contrast	Estimate (Standard Error)	χ^2	*p*-value
Cond. 3 = Cond. 4 > Cond. 1 = Cond. 2	0.018 (0.211)	0.008	0.466

Panel A of Table 4.25 shows that MDTs trained without the analogical encoding technique allocated more assurance procedures to be tested by individual members than to be performed together as a team (63.6%). In contrast, the MDTs trained with the analogical encoding technique allocated more assurance procedures to be tested by the team than by its individual members (52.4%). There is no difference in the proportion of assurance procedures allocated to individual team members between MDTs trained without the collaborative learning technique (58.4%) and MDTs trained with the collaborative learning technique (57.9%). However, the results of logistic regression in Panel B of Table 4.25 show that neither the analogical encoding nor the collaborative learning technique has a significant main effect. The results using this measure provide additional support for Hypothesis 22; however they do not support Hypothesis 23. In addition, the results do not support Hypothesis 24, which predicts that there would be no interaction effect for these two training techniques. The results of planned contrasts reported in Panel C show that the contrast has no significant effect (χ^2 = 0.008, *p*-value = 0.466). Therefore, the testing of hypotheses relating to TMSs using this measure provides the same results as found using the TMSs structure, as reported in Section 4.2.3.7.

4.2.6. Summary of Results

The results reported in the previous sections are summarised in Table 4.26.

Table 4.26. Summary of Results of Tests of the Research Hypotheses

Hypotheses	Prediction	Result
Hypothesis 1	Performance in generating hypotheses will not differ between individuals trained using the analogical encoding technique and those trained without this technique.	Supported
Hypothesis 2	Performance in generating hypotheses will be better for those individuals trained using the collaborative learning technique than those trained without this technique.	Supported
Hypothesis 3	Individual performance will be highest when the individuals train using a combination of analogical encoding and collaborative learning techniques; lower when the individuals train with only the collaborative learning technique; and lowest when they train without the collaborative learning technique, regardless of whether they train with or without the analogical encoding technique.	Supported
Hypothesis 4	MDTs whose members train using the analogical encoding technique will not perform hypothesis generation better than those MDTs whose members train without the analogical encoding technique.	Supported

Table 4.26. Summary of Results of Tests of the Research Hypotheses (Continued)

Hypotheses	Prediction	Result
Hypothesis 5	MDTs whose members train using the collaborative learning technique will have a higher performance in hypothesis generation than MDTs whose members train without the collaborative learning technique.	Supported
Hypothesis 6	MDT performance will be highest when team members train using a combination of analogical encoding and collaborative learning techniques; lower when team members train with only the collaborative learning technique; and lowest when team members train without the collaborative learning technique, regardless of whether they train with or without the analogical encoding technique.	Supported
Hypothesis 7a	Performance in evaluating the inherited hypothesis will be higher for MDTs where team members trained using the analogical encoding technique than those trained without the analogical encoding technique.	Supported
Hypothesis 7b	Performance in evaluating the correct hypothesis will be higher for MDTs where team members trained using the analogical encoding technique than those trained without the analogical encoding technique.	Supported
Hypothesis 8a	Performance in evaluating the inherited hypothesis will be higher for MDTs whose team members train using the collaborative learning technique than for MDTs whose members train without the collaborative learning technique.	Supported
Hypothesis 8b	Performance in evaluating the correct hypothesis will be higher for MDTs whose team members train using the collaborative learning technique than for MDTs whose members train without the collaborative learning technique.	Supported
Hypothesis 9a	Performance in evaluating the inherited hypothesis will be higher for MDTs whose team members train using a combination of analogical encoding and collaborative learning techniques than for those MDTs whose members train with one or neither of these techniques.	Supported
Hypothesis 9b	Performance in evaluating the correct hypothesis will be higher for MDTs whose team members train using a combination of analogical encoding and collaborative learning techniques than for those MDTs whose members train with one or neither of these techniques.	Supported
Hypothesis 10	Performance in selecting the correct causal hypothesis will be higher for MDTs trained using a combination of analogical encoding and collaborative learning techniques than for those MDTs trained with one or neither of these techniques.	Supported

Table 4.26. Summary of Results of Tests of the Research Hypotheses (Continued)

Hypotheses	Prediction	Result
Hypothesis 11a	MDTs that train using the analogical encoding technique have more accurate hypothesis generation TMMs than MDTs that train without the analogical encoding technique.	Supported
Hypothesis 11b	MDTs that train using the analogical encoding technique do not have more similar hypothesis generation TMMs than MDTs that train without the analogical encoding technique.	Supported
Hypothesis 12a	MDTs that train using the collaborative learning technique do not have more accurate hypothesis generation TMMs than MDTs that train without the collaborative learning technique.	Supported
Hypothesis 12b	MDTs that train using the collaborative learning technique do not have more similar hypothesis generation TMMs than MDTs that train without the collaborative learning technique.	Supported
Hypothesis 13a	When generating hypotheses, MDTs that train with the analogical encoding technique, either with or without the collaborative learning technique, are more likely to have more accurate TMMs for hypothesis generation than MDTs trained without the analogical encoding technique.	Supported
Hypothesis 13b	MDTs that train with (without) the analogical encoding technique have less (more) similar hypothesis generation TMMs than MDTs that train using the collaborative learning technique.	Supported
Hypothesis 14a	TMM accuracy mediates the link between the analogical encoding technique and MDT performance in generating hypotheses.	Not Supported
Hypothesis 14b	TMM accuracy mediates the link between the collaborative learning technique and MDT performance in generating hypotheses.	Not supported
Hypothesis 14c	TMM accuracy mediates the link between a combination of analogical encoding and collaborative learning techniques and MDT performance in generating hypotheses.	Not supported
Hypothesis 15a	TMM similarity mediates the link between the analogical encoding technique and MDT performance in generating hypotheses.	Not Supported
Hypothesis 15b	TMM similarity mediates the link between the collaborative learning technique and MDT performance in generating hypotheses.	Not supported
Hypothesis 15c	TMM similarity mediates the link between a combination of analogical encoding and collaborative learning techniques and MDT performance in generating hypotheses.	Not supported

Table 4.26. Summary of Results of Tests of the Research Hypotheses (Continued)

Hypotheses	Prediction	Result
Hypothesis 16	The interaction of TMM properties (accuracy and similarity) is positively related to MDT performance in generating hypotheses.	Not supported
Hypothesis 17a	MDTs that train using the analogical encoding technique have more accurate hypothesis evaluation TMMs than MDTs that train without the analogical encoding technique.	Supported
Hypothesis 17b	MDTs that train using the analogical encoding technique have more similar hypothesis evaluation TMMs than MDTs that train without the analogical encoding technique.	Not supported
Hypothesis 18a	MDTs that train using the collaborative learning technique do not have more accurate hypothesis evaluation TMMs than MDTs that train without the collaborative learning technique.	Supported
Hypothesis 18b	MDTs that train using the collaborative learning technique have more similar hypothesis evaluation TMMs than MDTs that train without the collaborative learning technique.	Not supported
Hypothesis 19a	TMM accuracy in hypothesis evaluation is higher in the combined collaborative learning/analogical encoding techniques condition and is lower in the no analogical encoding/collaborative learning techniques condition and in the two no collaborative learning technique conditions.	Supported
Hypothesis 19b	TMMs in hypothesis evaluation for MDTs that train with and without the analogical encoding technique are more similar when MDTs train using the collaborative learning technique.	Not supported
Hypothesis 20a	TMM accuracy mediates the link between the analogical encoding technique and MDT performance in evaluating hypotheses.	Supported
Hypothesis 20b	TMM accuracy mediates the link between the collaborative learning technique and MDT performance in evaluating hypotheses.	Not supported
Hypothesis 20c	TMM accuracy mediates the link between a combination of analogical encoding and collaborative learning techniques and MDT performance in evaluating hypotheses.	Supported
Hypothesis 21a	TMM similarity mediates the link between the analogical encoding technique and MDT performance in evaluating hypotheses.	Not supported
Hypothesis 21b	TMM similarity mediates the link between the collaborative learning technique and MDT performance in evaluating hypotheses.	Not supported

Table 4.26. Summary of Results of Tests of the Research Hypotheses (Continued)

Hypotheses	Prediction	Result
Hypothesis 21c	TMM similarity mediates the link between a combination of the analogical encoding and collaborative learning techniques and MDT performance in evaluating hypotheses.	Not supported
Hypothesis 22	TMSs of MDTs that train using the analogical encoding technique are not more developed than TMSs of MDTs that train without the analogical encoding technique.	Supported
Hypothesis 23	TMSs of MDTs that train using collaborative learning are more developed than TMSs of MDTs that train without the collaborative learning technique.	Not supported
Hypothesis 24	TMSs of MDTs that train with and without the analogical encoding technique are more developed than MDTs that train using the collaborative learning technique.	Not supported
Hypothesis 25a	TMSs mediate the link between the analogical encoding technique and MDT performance.	Not supported
Hypothesis 25b	TMSs mediate the link between the collaborative learning technique and MDT performance.	Not supported
Hypothesis 25c	TMSs mediate the link between a combination of the analogical encoding and collaborative learning techniques and MDT performance.	Not supported

4.3. Discussion of Results

The experiment conducted in this thesis sought to examine the use of two training techniques – the analogical encoding and collaborative learning techniques – in improving the performance of individual members, as well as MDTs, in an analytical procedures task. In addition, the thesis sought to explore the role of cognitive structures in MDT performance. The discussion of the results presented in this section is divided into three parts. Section 4.3.1 presents the discussion of findings relating to the use of the training techniques in improving the ability of individual participants. Section 4.3.2 discusses the findings relating to the use of these training techniques in MDT training and their effects on MDT performance. Section 4.3.3 provides a discussion of the role of cognitive structures on team functioning.

4.3.1. Discussion of Results Relating to the Use of Training Techniques in Enhancing Individual Performance

Results for Hypotheses 1, 2 and 3 provide evidence relating to the first aim of this thesis, that is, to examine whether one (or a combination) of two training techniques, the analogical encoding and collaborative learning techniques, are effective in improving individual learning performance in the context of MDTs performing an analytical procedures task in a GHG assurance setting. Hypothesis 1 predicts that individuals who train using an analogical encoding technique will not outperform those who train without the analogical encoding technique, in generating hypotheses. In contrast, Hypothesis 2 predicts that individuals who train using the collaborative learning technique will outperform individuals who train without the collaborative learning technique in generating hypotheses. It is argued that combining the two training interventions may overcome the limitations of a single training intervention in satisfying the three learning principles identified from the educational psychology literature (limited capacity, the deep processing and the memory organisation (Gentner et al. 2003; Clark et al. 2006; Chi 2009), which are important in enhancing learning outcomes, thereby leading to the improvement of an individual's performance. Hypothesis 3 predicts an ordinal interaction, such that individual performance will be highest when individuals train using a combination of the analogical encoding and collaborative learning techniques; lower when they train with only the collaborative learning technique; and lowest when they train without the collaborative learning technique, regardless of whether they train with or without the analogical encoding technique. Results reported in this chapter support these predictions in that individuals trained with a combination of the analogical encoding (problem-category comparison) and the collaborative learning techniques outperformed individuals who trained with only one or neither of these techniques.

The results of tests of Hypothesis 1, which relate to the use of the analogical encoding technique, support the argument that the use of this technique by individuals in learning a complex task (such as that performed by MDTs in analytical procedures for GHG assurance) may not lead to higher learning outcomes. Although previous studies have found that the analogical encoding technique leads to superior learning outcomes in simple learning tasks, this technique imposes high cognitive load on working memory (Renkl 2011). When this technique is used in learning to perform complex tasks, the explicit prompt to compare and contrast the worked examples may impose too much processing demand (cognitive overload) in the organising process (constructing internal connections among many incoming elements from the to-be-compared worked examples), therefore, leaving limited available working memory capacity for the encoding process (that is, placing knowledge constructed in working memory into long-term memory) (Sweller et al. 1998; Clark et al. 2006; Renkl 2011).

Consistent with arguments in cognitive load theory (Sweller et al. 1998), the findings reported in this thesis show that the more information elements there are within a task, and the more interaction between them, as in the analogical encoding technique, the higher the load and the more cognitive capacity it requires. As shown by the significant main effect of the analogical encoding technique in the ANOVA reported in Table 4.14, simultaneously comparing two examples in the analogical encoding technique appears to impose a higher intrinsic load (that is, the mental work imposed by the complexity of the content of the training material), and also increases germane load (cognitive load relevant in learning), thereby affecting performance efficiency.

Prior studies in educational psychology suggest that the use of an analogical encoding technique is beneficial because it encourages deep processing (Chi 2009) and development of knowledge structure (Gentner et al. 2003). The results reported in this thesis extend our understanding by providing evidence that the beneficial effect of this technique is more likely to occur when individuals have compatible pre-existing knowledge structures. The unique setting investigated in this thesis, where diverse-background members of MDTs who have different pre-existing knowledge structures or mental models, learn and work together, provides an opportunity to test the benefits of this technique for heterogeneous learners. The results reported in this chapter support the view that when the pre-existing knowledge structures activated during learning do not match or are not compatible with the structure of the training material, individuals often restructure the task or the learning material to create a problem representation matching their pre-existing knowledge structures (Nelson et al. 1995; Bonner et al. 1996; Bonner et al. 1997; Vera-Munoz 1998; Vera-Munoz et al. 2001; Borthick et al. 2006). Consequently, deep processing through creating processes (the mechanisms of inference generation and mental model repair (Chi 2009)) might not occur. This hinders learning. As shown by the additional analysis in Section 4.2.4.1, accountant team members, who have pre-existing accounting knowledge structures that differ to the referent structures provided in the case material, exhibited better performance efficiency when they trained without the analogical encoding technique and lower performance efficiency when they trained using the analogical encoding technique.

The results reported in this chapter provide other explanations as to why this technique may not lead to higher learning outcomes. As outlined in Chapter 2, the beneficial effect of using analogical encoding in facilitating the development of knowledge structures is only realised when the individual's pre-existing knowledge structure is not incompatible with the structure of the training material. The second additional analysis in Section 4.2.4.2 shows that scientist team members who do not have pre-existing knowledge structures relating to the task (and therefore do not have incompatible structures with the structure of the training material) were more likely to develop their knowledge structure according to the training material. As shown in Table 4.15, the mean knowledge structure of individuals who had prior knowledge in auditing (accountants) was 0.09, compared to 0.25 for individuals who had no prior knowledge in auditing (scientists).

The results of tests of Hypothesis 2, which related to the use of the collaborative learning technique, support the contention that the use of this technique leads to better individual learning outcomes. It is beneficial to learning because the processing of information necessary for carrying out the learning task can be distributed to group members, creating a large reservoir of cognitive capacity (Kirschner et al. 2009a). By sharing the cognitive load among members of the group, the remaining processing capacity can be freed up at the individual level for the relevant load (germane load) necessary in learning (Kirschner et al. 2009a; Kirschner, Paas, and Kirschner 2011; Kirschner, Paas, Kirschner, et al. 2011). The results also support the argument that this technique is suitable for complex tasks, where additional cognitive loads associated with initiating and maintaining communication and coordination between the group members are imposed (Kirschner et al. 2009a; Kirschner, Paas, and Kirschner 2011; Kirschner, Paas, Kirschner, et al. 2011). For high-complexity tasks, the additional cognitive load, as argued by Kirschner et al. (2009a), could be considered relatively low compared to the load distribution advantage. The results of the additional analysis in Section 4.2.4.1 support the prediction that the use of the collaborative learning technique improves performance efficiency (increased learning performance and decreased cognitive load) during learning. Specifically, the mean performance efficiency is positive (mean = 0.27) when team members learn collaboratively, whereas it is negative (mean = -0.24) when they learn individually (significant main effect for collaborative learning, *F* = 8.761, *p*-value = 0.004; see Table 4.14).

These results support the contention that the collaborative learning technique brings more benefits in terms of substantial deep processing resulting from joint dialogue. Although disruption from the other members may concurrently inhibit memory organisation around the provided structure, the results confirm that more facilitating factors occur with this technique (reduced cognitive load and deeper processing) than inhibiting factors (disruption from collaboration that inhibits the development of knowledge structure). Section 4.2.4.2 reports that the main effect of the use of the collaborative learning technique on learner knowledge structure is not significant, suggesting that individuals who trained with the collaborative learning technique are not more likely to develop a knowledge structure more closely aligned with the referent model than individuals who trained without the collaborative learning technique. The inhibiting factor in the collaborative learning technique is particularly salient for individuals who have incompatible knowledge structures. In the context of the current study, where MDTs learn to categorise causal hypotheses in an analytical procedures task, each team member may possess a different pre-existing knowledge structure due to their differing education and experience. This may disrupt the individual's organisation structure and may therefore impair the encoding process for the knowledge structure supplied in the training material. The findings from the additional analysis in Section 4.2.4.2 support this argument. Despite the potential limitations indicated by these results, this technique helps learners improve their learning outcome as shown by the main analysis in Section 4.2.1, where the main effect for the collaborative learning technique on individuals' performance is significant.

The results of this thesis support Hypothesis 3, which predicts that the use of a combination of the analogical encoding and collaborative learning technique leads to better learning outcomes for individuals than the use of other training conditions involving only one or neither of these techniques. The results reported in this chapter confirm that improvement in the utilisation of limited cognitive capacity is possible when a training technique that fosters germane load (cognitive load relevant in learning) is used simultaneously with another technique that can reduce the cognitive load imposed upon working memory.

The findings of this thesis are also consistent with prior studies in educational psychology that propose the use of the collaborative learning technique as a mechanism for minimising cognitive load (Kirschner et al. 2009a; Kirschner, Paas, and Kirschner 2011; Kirschner, Paas, Kirschner, et al. 2011). This is supported by findings in Section 4.2.4.1, where the planned contrasts indicate that the performance efficiency of individuals who trained using the combined techniques is not significantly different from those individuals who trained with neither of these techniques. Panel C of Table 4.14 also indicates that the performance efficiency of individuals who trained using the combined techniques is significantly higher than for those who trained using only the analogical encoding technique. In addition, the performance efficiency of individuals who trained using the combined techniques was not significantly different from those of individuals who trained using only the collaborative learning technique. These results suggest that the addition of the analogical encoding technique did not improve performance efficiency, due to the greater cognitive load it imposes upon learners. However, the addition of collaborative learning significantly improved performance efficiency, due to the benefit of reduced cognitive load through use of this technique.

The results also confirm that the combination of the collaborative learning and analogical encoding techniques may be beneficial in facilitating deep processing, as it allows interactions between team members, contributing to learning through the discussion of issues that group members may have been unable to conceive of individually (Chi 2009). The difficulty that an individual faces when he or she has pre-existing incompatible knowledge structures can be reduced because learning collaboratively with a partner enables individuals to produce a shared understanding or representation of the information (Jeong and Chi 2007). Additionally, the results of this study suggest that the benefits of the other member's contributions through additional information, a new perspective, corrective feedback and a new path or line of reasoning may strengthen the encoding process (Chi 2009). The results also suggest that there are more positive effects from using a combined technique compared to using the collaborative learning technique alone. This is because the use of the analogical encoding technique is beneficial in facilitating the development of knowledge structures, particularly when the individual's pre-existing knowledge structure is not incompatible with the training structure.

The additional analysis reported in Section 4.2.4.3 provides further evidence that the ability of individual members is related to their prior auditing knowledge. Not surprisingly, given their prior knowledge regarding analytical procedures, the findings from this additional analysis show that accountants had a consistently higher ability to generate hypotheses. In particular, accountant members, possibly due to their familiarity with recognising errors in financial statements, were better able to generate hypotheses than scientists in a GHG engagement context. This result provides further evidence that an individual member's ability in this task is related to his or her prior auditing knowledge.

There are several distinguishing features between this thesis and prior studies in educational psychology. First, prior studies have usually involved homogenous learners (with no prior knowledge of the new area), so these studies did not address the effect of a pre-existing knowledge structure on learning a new knowledge structure. Second, prior studies examined some learning principles in isolation, and in different lines of research. The current study includes three learning principles that have not previously been integrated into a single study: optimisation of limited capacity, facilitation of deep processing, and structuring memory organisation.

The results relating to training interventions to improve individual performance suggest that a combination of the analogical encoding and collaborative learning techniques as a potential training intervention can be used to enhance both the ability of individual members and MDT performance. The advantage of a combination of the two techniques, compared to a single technique, lies in its ability to satisfy all three key principles found to be important in learning. However, the results also suggest that the use of a combined technique requires several considerations because of the complex nature of analogical encoding, which imposes a high cognitive load on learners, and the impact of the incompatibility of pre-existing knowledge on the effectiveness of collaboration. In order to make effective use of a combined technique in the context of MDTs, it is important for further research to consider ways of overcoming these factors.

4.3.2. Discussion of Results Relating to Team Training Interventions to Improve Multidisciplinary Team Performance in an Analytical Procedures Task

This section discusses the results relating to team-training interventions. The section is divided into several parts, based on the stages of an analytical procedures task. In Section 4.3.2.1, discussion relating to the effect of the use of training techniques on MDT performance at the hypothesis generation stage is presented. The discussion in Section 4.3.2.2 relates to the effect of training interventions on the hypothesis evaluation and final judgment stages.

4.3.2.1. Discussion of Results Relating to the Effect of the Use of Training Techniques on MDT Performance in Hypothesis Generation

The results reported for Hypotheses 4, 5 and 6 provide evidence relating to the second aim of this thesis, which is to determine whether the combination of two techniques as a team-training input can improve MDT performance in analytical procedures.

Results reported in this chapter support Hypothesis 4, which states that MDTs whose members train using the analogical encoding technique will not outperform MDTs whose members train without this technique in generating hypotheses. At the individual level, as outlined previously, the use of this technique alone may not lead to superior individual performance in a complex learning task, such as an analytical procedures task, because of the cognitive load it imposes. Testing this technique at the team level, the findings support the argument that the perceptions of higher levels of difficulty (perceptions of the mental effort necessary for task execution) lead to lower levels of MDT performance (Funke and Galster 2009). As outlined in Chapter 2, this happens because tasks characterised as mentally difficult use resources that leave individuals (and teams) with reduced available resources (such as information-processing capacity) for additional team demands (Funke and Galster 2009; Funke et al. 2012; Bedwell et al. 2014). As a result, the use of the analogical encoding technique, which is more likely to be perceived as difficult, may also be ineffective as a team-training intervention for improving performance of MDTs in a complex task such as an analytical procedures task. In this thesis, the perceived level of difficulty for the task is used as a measure of cognitive load. As indicated by the results of the additional analysis reported in Section 4.2.41, participants found this task very difficult.

The results relating to Hypothesis 5 provide support for the prediction that MDTs whose members train using the collaborative learning technique will outperform MDTs whose members train without it in generating hypotheses. The use of collaborative learning brings beneficial effects to team processes, through bridging diversity and enhancing elaboration, which in turn helps MDTs achieve higher performance. To examine this argument, additional analyses on team process gains were undertaken because the improved process can be indicated by greater process gains in hypothesis generation. Contrary to expectations, the analyses (presented in Section 4.2.5.1) comparing the performance level of the team's most capable member and actual MDT performance failed to provide insights on team process. In order to provide an explanation for these results, a further analysis was conducted comparing the highest productivity potential of the team and the MDTs' actual hypothesis quality as presented in Section 4.2.5.1. These results suggest that the use of the collaborative learning technique improved team processes in such a way that team members were able to recognise which team member is most capable of generating the correct hypotheses. The participants in the collaborative learning technique conditions were better able to identify and select the correct hypotheses from the lists they generated individually. This advantage is obtained through the development of social ties with increased familiarity among team members. This, in turn, brought benefits in enhancing process gains in elaboration, such as error correction, when discussing and integrating the processed information on the consistency of hypotheses (van Knippenberg et al. 2004; Mannix and Neale 2005).

Additionally, the existence of social ties enabled teams to reduce process losses, such as the tendency to conform and suppress alternative perspectives in teams (Gruenfeld et al. 1996).

An explanation for why MDT members trained using the collaborative learning technique outperform MDTs whose members were not trained with this technique when generating hypotheses can be obtained by examining an alternative, subjective measure of team process. An additional analysis (presented in Section 4.2.5.2) shows that the main effect for the collaborative learning technique is significant and that the interaction between the analogical encoding and collaborative learning techniques, and the collaborative learning technique and prior knowledge, is also significant. These results suggest that team members perceived lower team process when learning and working collaboratively. Similar results are also found for analyses presented in Section 4.2.5.3 using a subjective information elaboration measure based on two items in the subjective team process measure which capture the element of elaboration. A possible explanation for the lower level of perceived team process is that the collaborative learning technique imposes an additional cognitive load associated with initiating and maintaining communication and coordination between group members (called transactional activities) (Kirschner et al. 2009a; Kirschner, Paas, and Kirschner 2011; Kirschner, Paas, Kirschner, et al. 2011). A process in which members of a group share and discuss the learning task, the relevant information elements, the task solution and communication intended to reach common ground may be too difficult for individuals. These difficulties may be escalated in the context of MDTs. Collaborating with others with different perspectives and prior knowledge, using a complex learning task, make the transactional activities even harder to perform because of the high possibility of disagreements and cognitive conflicts. Although disagreements are encouraged to enhance elaboration of task-relevant information (van Knippenberg et al. 2004), the process of resolving disagreement and conflict uses up considerable cognitive and emotional resources. In turn, these difficulties affect not only cognitive functioning during learning, but also cognitive functioning and perceptions of the team process performed in the actual task (in the test phase in the experiment).

The results provide support for Hypothesis 6, which predicts an ordinal interaction between the two training techniques. Specifically, MDT performance is highest when team members train using a combination of the analogical encoding and collaborative learning techniques; lower when they train only with the collaborative learning technique; and lowest when they train without the collaborative learning technique, regardless of whether they train with or without the analogical encoding technique. These results are supported by the results of an additional analysis presented in Section 4.2.5.1 which provides evidence that MDTs trained with a combined technique compared to MDTs trained with other conditions were more likely to exhibit process gains. This led to performance.

However, the findings using this alternative measure of team process and information elaboration (as reported in the additional analysis in Section 4.2.5.2 and 4.2.5.3) provide conflicting results to those reported in Section 4.2.5.1 (i.e., that the MDTs trained with a combination of the two training techniques (Condition 4) were more likely to exhibit process gains). This implies that using these two techniques improves team process. These conflicting results may have arisen due to the subjective nature of the measurement employed. This possibility is further discussed in Chapter 5.

These findings, however, also need to be viewed by considering an additional factor that may influence the results, i.e., the specific design constraints of the experiment. The participants in this study were not able to add new hypotheses during their discussion with other members. As a result, potential process gains due to cognitive interstimulation did not occur in the current study. As discussed in Chapters 2 and 3, this design was imposed to limit this study to the consistency-checking stage of plausibility assessment in hypothesis generation. Future research can explore whether even higher beneficial effects are possible if the design includes the estimation of hypotheses (that is, the generation of additional hypotheses).

In summary, the results relating to training interventions to improve MDT performance suggest that a combination of the analogical encoding and collaborative learning techniques as training interventions can be used to enhance MDT performance. The advantage of the analogical encoding technique in improving the ability of team members to generate hypotheses can be realised when combined with the collaborative learning technique. When MDTs train using an analogical encoding technique without the collaborative learning technique, there is no MDT performance improvement due to the increased cognitive load outweighing the deeper understanding achieved by this technique. However, when collaborative learning is employed, the collaboration facilitates an improvement in MDT performance by reducing cognitive load for each member through the sharing of their individual knowledge. This allows the team to realise process gains.

4.3.2.2. Discussion of Results Relating to the Effect of the Use of Training Techniques as Team-Training in Improving MDT Performance in Hypothesis Evaluation and Final Judgment

Hypotheses 7, 8, 9 and 10 examine the effect of team training on performance in the hypothesis evaluation and final judgment stages of the task. To test these hypotheses, MDT performance of hypothesis evaluation for two distinct hypotheses was examined: the inherited explanation and the correct cause.

Reported results support Hypothesis 7a, which predicts that MDT performance in evaluating the inherited hypothesis will be better when team members train using the analogical encoding technique compared to when they train without it. The findings suggest that the use of the analogical encoding technique can improve MDT performance in the hypothesis evaluation stage by encouraging members to be less biased in favour of an inherited explanation. It is likely that the use of the analogical encoding technique can facilitate team members to counterexplain (Koonce 1992) and perform sufficiency checks (Anderson and Koonce 1998) when learning. The results suggest that the use of worked examples by the analogical encoding technique aids understanding of the underlying principles of balanced hypothesis evaluation. This translates into an ability to evaluate hypotheses effectively.

Hypothesis 7b, which predicts that MDT performance in evaluating the correct hypothesis will be better when team members train using the analogical encoding technique is supported by the results. However, these results must be considered in light of the small number of correct evaluations performed by teams. This affects the statistical power of hypothesis testing in this study.

The results of testing Hypothesis 8a, which predicts that MDT performance in evaluating the inherited hypothesis will be better when the team members train using the collaborative learning technique shows marginal significance. Conversely, testing of Hypothesis 8b, which predicts that MDT performance in evaluating the correct hypothesis will be better when the team members train using the collaborative learning technique shows a significant result. A possible explanation for this result is that this technique leads to superior MDT performance due to the social ties that are able to develop between team members. Members who become familiar with each other are able to conduct an elaboration of task-relevant information and perspectives in the task performance phase. The other benefit of the collaborative learning technique is a reduced cognitive load that allows team members to optimise available team resources (information-processing capacity) for necessary team task demands such as elaboration (Funke and Galster 2009; Funke et al. 2012; Bedwell et al. 2014). The deep processing facilitated by using this technique also enables team members to develop a better understanding of the principles involved in the task (Chi 2009). It also allows them to generate, discuss and integrate multiple perspectives when conducting elaboration. However, collaborating with other learner(s) may also impose additional cognitive loads associated with transactional activities (initiating and maintaining communication and coordination between the team members) (Kirschner et al. 2009a), which may affect individual and team learning and performance.

The results support Hypothesis 9a (and 9b), which proposes an ordinal interaction such that MDT performance in evaluating the inherited hypothesis (and the correct hypothesis) will be better when MDTs train using a combination of analogical encoding and collaborative learning techniques than when they train with only one or neither of these techniques. The results indicate that the MDTs that trained with a combination of analogical encoding and collaborative learning techniques outperformed other teams in the hypothesis evaluation stage. It appears that this training combination benefits from shared experience during training. Specifically, the results show that, consistent with Hypotheses 9a and 9b, when evaluating the inherited and the correct hypothesis, MDTs training with a combination of analogical encoding and collaborative learning techniques are more likely to correctly evaluate both the inherited and the correct hypothesis than those who trained with only one or neither of these techniques. The results are consistent with the findings of prior research, which suggest that social ties are created through collaborative learning, allowing integration among team members as well as other benefits (Mannix and Neale 2005). This condition invites an elaboration of task-relevant information and perspectives that are important in realising the potential advantages of the broad knowledge and backgrounds implicit in multidisciplinary teams (van Knippenberg et al. 2004). Creating an environment that encourages alternative ways of thinking, new perspectives and different interpretations to be exchanged, discussed and integrated appears to mitigate the tendency to be insensitive to other ways that the problem might have been framed or interpreted when inheriting an hypothesis (Koehler 1991; Koonce 1992). Therefore, elaboration of task-relevant information is likely to make alternative hypotheses more prominent, resulting in individuals being less biased in favour of inherited explanations (Nemeth 1986; van Knippenberg et al. 2004).

The use of the compare and contrast activity in the analogical encoding technique probably facilitated members in conducting counterexplanations and sufficiency checks, which are important in mitigating this biased evaluation (Koonce 1992; Anderson and Koonce 1998). As outlined in Chapter 2, comparing two problems with respective possible causes, the correct cause, and its explanation, seems to encourage members to make the alternative hypothesis more prominent and to develop a task representation where evaluation of the hypotheses must be performed in a balanced manner.

The beneficial effect of the use of a combination of training techniques in the final stage of analytical procedures, as predicted by Hypothesis 10, is also supported. The MDTs that trained with a combination of the analogical encoding and collaborative learning techniques are more likely to select the correct causal hypothesis than MDTs that trained with only one or neither of these techniques. These results suggest that the benefits of training with a combination of problem-category comparison and collaborative learning techniques throughout the previous stages were also carried through to this final stage of the analytical procedures task. This technique is therefore likely to be beneficial for similar complex or multi-stage tasks.

4.3.3. Discussion of Results Relating to the Role of Team Cognitive Structures

This section discusses the effect of the training interventions on two types of team cognitive structures: TMMs and TMSs. Sections 4.3.3.1 and 4.3.3.2 discuss results relating to the effect of training interventions on TMMs and the role of TMMs in two stages of an analytical procedures task. Section 4.3.3.3 discusses the effect of the development and role of TMSs.

4.3.3.1. Discussion of Results Relating to Training Interventions to Enhance the Development of Team Mental Models of MDTs in Performing Hypothesis Generation, and the Role of Team Mental Models as a Mediator between Training Intervention and MDT Performance

From the testing of hypotheses relating to the effects of the training techniques on TMM accuracy and similarity (Hypotheses 11a and 11b, 12a and 12b and 13a and 13b), it was found that the use of these techniques did not affect TMM accuracy and TMM similarity, except for the effect of the analogical encoding technique on TMM accuracy. The effects noted for the analogical encoding technique stem from its use of problem-category comparison, which involves comparing examples of different problem categories with attention to the distinguishing features of each category. This comparison technique seems to help individuals learn to better distinguish problem categories (Cummins 1992; VanderStoep and Seifert 1994; Day et al. 2010). When applied to a setting in which team members learn an analytical procedures task, this technique enables the knowledge of causal hypotheses to be structured in the form of a taxonomic structure in individual mental models (Markman 1999; Anderson 2010).

The results relating to Hypotheses 14, 15 and 16 provide evidence that TMMs do not mediate the between-team-training input and MDT performance in hypothesis generation. Several explanations may account for this. The first explanation is the unique setting investigated in this thesis, in which diverse-background members of MDTs with differing pre-existing knowledge structures or mental models learned and worked together. A higher level of TMM similarity is difficult to achieve in this setting. The different pre-existing individual mental models also made it difficult to develop similar and accurate TMMs. Second, accountant members, due to their familiarity with finding errors in financial statements, were better able to generate hypotheses than scientist members in a GHG engagement context. Although they have 'inaccurate' mental models according to the training referent model (which affected TMM accuracy and TMM similarity), they had a consistently higher ability to generate hypotheses. As their inputs contribute to MDT performance, recognising who the most capable members are in a team is a more important mechanism in team functioning than developing a more similar and/or accurate TMM. This helps explain why TMMs did not play an important role in this setting. The potential impact on TMMs of the imposed referent model is also discussed in Chapter 5.

4.3.3.2. Discussion of Results Relating to Training Interventions to Enhance the Development of Team Mental Models of MDTs in Performing Hypothesis Evaluation, and the Role of Team Mental Models as a Mediator between Training Interventions and MDT Performance

Hypotheses 17a, 17b, 18a, 18b, 19a and 19b address whether training interventions affect the development of TMMs in hypothesis evaluation. Hypotheses 20a, 20b and 20c, 21a, 21b and 21c address whether TMMs mediate the relationship between training input and MDT performance in evaluating hypotheses. The results indicate that only five of these hypotheses are supported. These include Hypothesis 17a, which predicts the positive effect of the analogical encoding technique on TMM accuracy, Hypothesis 18a, which predicts the no effect of collaborative learning on TMM accuracy, and Hypothesis 19a, which predicts that

TMM accuracy is higher in a combined analogical encoding and collaborative learning technique condition, and lower in the three other conditions. In addition, the hypothesised mediation role of TMM accuracy as predicted by Hypotheses 20a and 20c is supported by the research findings.

It was hypothesised that the role of TMMs is perhaps relatively more important in the hypothesis evaluation stage than in the hypothesis generation stage. As outlined in Chapter 2, TMMs in hypothesis evaluation, unlike TMMs in hypothesis generation, are structured as a schema. A schema is defined as a representation of categorical knowledge that contains particular types of objects, the parts of those objects and their typical attributes (Anderson 2010). A TMM in hypothesis evaluation is not accurate when knowledge of a general solution method that contains a balanced evaluation of hypotheses is not organised as a schema. In addition, given that there is no particular schema in their mental models, team members may take a default position with a decision bias when evaluating hypotheses that can act as a mental model. For example, the mental model that contains the current formulation or understanding of the problem situation is updated once information pertaining to the inherited hypothesis has been obtained and evaluated. The inherited hypothesis may be established as a focal hypothesis and then adopted as a conditional reference frame in which the focal hypothesis is temporarily accepted as true (Koehler, 1991). In turn, through this process, team members may become more biased in favour of an inherited explanation when evaluating hypotheses. The use of the analogical encoding technique is useful in overcoming this tendency, because a mental model containing the schema of a balanced evaluation of hypotheses can be developed using this technique.

The findings that TMM accuracy mediates the relationship between training input and MDT performance in evaluating hypotheses, while TMM similarity did not mediate those relationships were unexpected. Several explanations can be proposed for these findings. First, the small number of correct responses (correct evaluations of the inherited and the correct hypotheses) affect the statistical power of the hypothesis testing. As shown in Table 4.3, only 8 of 41 MDTs (20%) correctly evaluated the inherited hypothesis. When evaluating the correct hypothesis, only 5 of 21 MDTs correctly evaluated this hypothesis, and the number of correct responses was below five, in three of four conditions. The second factor that can explain the findings is the method used for TMM measurement in hypothesis evaluation. In this thesis, TMM is measured using a qualitative method and then determined by reviewing the extent to which team members have the same view or evaluation for each specific hypothesis. After reviewing written documentation for the individual and team decisions during the hypothesis evaluation stage, team responses were classified into a simple categorical measure. A TMM is inaccurate if the team members shared the task representation in favour of the inherited hypothesis (or other explanations characterised as a non-error hypothesis), and accurate if the team members shared the task representation in favour of an alternative (error) hypothesis. These measures may not fully capture the dimension of TMMs in this setting.

4.3.3.3. Discussion of Results Relating to Training Intervention to Enhance the Transactive Memory Systems of MDTs in Performing Hypothesis Generation, and the Role of Transactive Memory Systems as a Mediator between Training Intervention and MDT Performance

Hypotheses 22, 23 and 24 address whether training interventions affect the development of TMSs, while Hypotheses 25a, 25b and 25c address whether TMSs mediate the relationship between training inputs and MDT performance in generating hypotheses. The results indicate that training inputs in this study have no impact on the development of TMSs. TMSs did not mediate the relationship between training input and MDT performance in generating and evaluating hypotheses. Two factors may explain these results. First, training inputs in this study may have no impact on the development of TMSs because these interventions do not provide sufficient opportunity for team members to learn about one another’s expertise as members interact during task processing when they are trained together. Prior studies on TMSs suggest that TMSs begins to develop when members learn something about one another’s expertise. As they interact during task processing when they are trained together, more information about the depth and validity of the other member’s knowledge can be obtained. This assists their understanding of who knows what to become more refined, accurate and similar across members. As found in prior studies, group training with learning by doing can increase the efficiency of transactive processes by providing members with diagnostic feedback about the functioning of retrieval and communication activities, and by helping to establish routines for interacting in the future. Conversely, the results of this study suggest that learning from the worked examples in a time-restricted experimental setting did not provide sufficient information about the individual team member’s expertise and roles. Learning the text collaboratively appears not to have provided diagnostic feedback about the functioning of retrieval and communication activities.

However, the additional analyses performed on two TMSs processes (i.e., how teams select individual team member hypotheses for inclusion in the team hypothesis set and how teams allocate the assurance tests to individual members or to both team members) as reported in Section 4.2.5.4 provide some evidence that the collaborative learning conditions enabled team members to obtain information about the depth and validity of each other's knowledge at least to some extent. This was shown by the finding that the MDTs in Condition 3 selected more hypotheses generated by accountant members than those of scientist members. This indicates that team members in this condition were better able to select the hypotheses from their most capable member.[62] However, the mechanism used in the hypothesis selection of MDTs in Condition 4 was similar to other MDTs in the conditions with no collaborative learning techniques. Further analysis on how team members allocated the required assurance procedures in the hypothesis evaluation stage shows that the mechanism of allocating assurance procedures was affected by perceived difficulties during training (measured by the level of cognitive load during training). MDTs in the analogical encoding technique conditions (higher-level difficulties) were more likely to allocate the task to the team than to individual members.

The second factor that may have affected the role of TMSs is the type of task investigated in this study. As noted in Chapter 2, existing literature recognises that TMSs do not always have strong relationships with performance for all types of tasks (Lewis and Herndon, 2011). As argued in Chapter 2, another possible explanation is that TMSs may be less relevant for tasks categorised as conceptual and unitary optimising tasks, as used in this study. Further research is needed to investigate the relevance of TMSs in these types of tasks.

---

[62] Additional analyses presented in Section 4.2.4.3 provide evidence that the accountants had a consistently higher ability to generate hypotheses.

CHAPTER 5

SUMMARY AND CONCLUSION

5.1. Introduction

This chapter reviews the aims and findings of this thesis and its contribution to knowledge. The chapter also discusses the implications of the findings for practice and future research. The aims of the thesis and the findings are presented in Section 5.2. Section 5.3 discusses the contributions made by the thesis and its implications. The limitations of the thesis are considered in Section 5.4. Finally, Section 5.5 outlines future research opportunities.

5.2. Aims of the Thesis and Research Findings

This thesis sought to explore mechanisms that might improve the quality of judgment and decision-making in the GHG assurance setting. In order to improve the performance of the multidisciplinary teams (MDTs) that typically provide GHG assurance services, it is important to pay adequate attention to potential problems related to the diverse expertise of team members. The objective of this thesis is to provide evidence relating to possible training interventions that aim to improve the performance of individual team members and MDTs in this context.

The first aim of the thesis, addressed by Hypotheses 1, 2 and 3, is to examine whether one or a combination of two training techniques, analogical encoding and collaborative learning, can improve individual learning performance in the context of MDTs performing a GHG assurance analytical procedures task. Although, previous research has indicated that both techniques can enhance individual learning, the techniques have also been found ineffective in certain situations such as complex learning tasks (Cummins 1992; VanderStoep and Seifert 1994; Basden et al. 1997; Barber et al. 2010; Rajaram and Pereira-Pasarin 2010; Rajaram 2011). Hypothesis 1 predicts that a single intervention using the analogical encoding technique may not lead to better learning outcomes. It is suggested that this result is due to increases in cognitive load when the technique is used in a complex learning task (Renkl 2011) and because the beneficial effect of analogical encoding can only occur when an individual's pre-existing knowledge structure is compatible with the structure of the training material (Nelson et al. 1995; Bonner et al. 1996; Bonner et al. 1997; Vera-Munoz 1998; Vera-Munoz et al. 2001; Borthick et al. 2006). Specifically, due to the increased cognitive load incurred, it is suggested that the performance of individuals trained using analogical encoding will not differ to those trained without this technique when generating hypotheses. In contrast, Hypothesis 2 predicts that the performance of individuals trained using the collaborative learning technique will be higher than those trained without this technique. Although the use of the collaborative learning technique may inhibit the development of knowledge structures due to constant disruptions from other team members, the technique nevertheless facilitates a more optimal use of cognitive resources as well as deep processing, thereby allowing improvement in individual learning outcomes. Given that both the assurance of GHG emissions and analytical procedures in this setting are complex tasks, this thesis explores whether there are benefits in combining the analogical encoding and collaborative learning techniques. Specifically, the thesis examines whether combining the two techniques can enable both the advantage of decreased cognitive load gained through the use of collaborative learning and the deeper understanding of the task gained through the use of analogical encoding, thereby improving individual performance. Thus, Hypothesis 3 predicts an ordinal interaction such that the performance of individuals will be highest when the individuals train using a combined analogical encoding and collaborative learning technique; lower when the individuals train with only collaborative learning; and lowest when they train without collaborative learning, regardless of whether they train with or without the analogical encoding technique.

The findings from the experiment conducted in this thesis support the above predictions. A single intervention training technique may have potential limitations in improving the ability of the individual to perform a complex task such as an analytical procedures task. When analogical encoding was used in isolation, it did not lead to improved learning performance. Although the use of collaborative learning improved individual performance, the combined use of analogical encoding and collaborative learning techniques resulted in the highest learning outcomes for individuals. The results show that improvement in an individual's performance is possible when a training technique that fosters germane load (i.e., cognitive load relevant to learning) is used simultaneously with another technique that can reduce the cognitive load imposed upon working memory. The contention that the combination of collaborative learning and analogical encoding techniques may be beneficial in facilitating deep processing is also supported by the findings reported in this thesis. A combination of these techniques allows interaction between team members, contributing to learning through the discussion of issues that group members may have been unable to conceive of individually (Chi 2009). The results also suggest that using a combined technique is beneficial in facilitating development of knowledge structures, particularly when the individual's pre-existing knowledge structure is compatible with the knowledge structure developed by the training material.

The second aim of the thesis, addressed by Hypotheses 4 to 10, is to examine whether one (or a combination of) analogical encoding and collaborative learning is effective as a team training intervention to improve MDT performance. Given that GHG assurance is conducted by MDTs, it is important to understand not only how individual members of the team can best learn the knowledge needed to complete such tasks, but also how these teams can best combine their individual knowledge to enable high quality performance of the task. Prior studies in group decision-making have indicated that the elaboration of task-relevant information is an important means of allowing different viewpoints to be heard (van Knippenberg et al. 2004). It is therefore important to create an environment that is tolerant of divergent perspectives and disagreement in order to improve the performance of MDTs. As suggested by prior studies, disagreement is beneficial to the extent that it helps teams to focus on evidence inconsistent with tentative or preliminary conclusions (e.g., Nemeth and Kwan 1987; Favere-Marchesi 2006). Looking at the hypothesis generation stage of analytical procedures, Hypothesis 4 predicts that use of the analogical encoding technique (i.e., problem-category comparison) may not be effective as a team-training intervention for improving MDT performance in a complex task. This technique is more likely to be perceived as difficult. Tasks characterised as mentally difficult use up resources leaving individuals (and teams) with a reduction in available resources (e.g., information-processing capacity) for additional team task demands (Funke and Galster 2009; Funke et al. 2012; Bedwell et al. 2014).

Hypothesis 5 predicts that performance in hypothesis generation will be higher for MDTs whose members train using the collaborative learning technique than for MDTs whose members train without it. This occurs because individual team members become familiar with other members when using collaborative learning. This creates social ties between members and enhances process gains in elaboration. In the context of hypothesis generation, this elaboration results in process gains such as cognitive interstimulation during information exchange as well as error correction when discussing and integrating the processed information with regard to the consistency of hypotheses (Bedard et al. 1998; van Knippenberg et al. 2004; Mannix and Neale 2005). The existence of a collaborative bridge to diverse members also enables MDTs to reduce process losses including the tendency to conform and suppress alternative perspectives in teams (Gruenfeld et al. 1996). All of these benefits help MDTs achieve higher performance levels.

Hypothesis 6 predicts an ordinal interaction between the two training techniques when they are used as a team training intervention. When MDTs train using an analogical encoding technique without collaborative learning, there is no MDT performance improvement due to the increased cognitive load outweighing the deeper understanding achieved by this technique. However, when collaborative learning is employed, the collaboration facilitates an improvement in MDT performance through reducing cognitive load for each member by the sharing of their individual knowledge. It is therefore suggested that combining the two techniques will lead to greater improvement in performance due the reduced cognitive load facilitated by collaboration.

Findings reported in this thesis support Hypothesis 4 and suggest that increasing levels of difficulty affect MDT performance. In this context, difficulty is measured by perceptions of the mental effort necessary for task execution. With regard to Hypothesis 5, the results indicate support for the prediction that MDTs whose members train using the collaborative learning technique will outperform MDTs whose members train without it when generating hypotheses. Results relating to Hypothesis 6 also provide support for the ordinal interaction between the two training techniques.

Hypotheses 7, 8, 9 and 10 examined the effect of team training on performance in hypothesis evaluation and in the final causal judgment. Hypothesis 7 predicts that MDT performance in evaluating hypotheses (i.e., both the inherited and the correct hypothesis) will be better when team members train using analogical encoding compared to when they train without it. Hypothesis 8 predicts that MDT performance in evaluating hypotheses (i.e., both the inherited and the correct hypothesis) will be better when the team members train using collaborative learning than when they train without it due to the additional perspectives brought to the problem. Furthermore, Hypothesis 9 proposes an ordinal interaction such that MDT performance in evaluating the hypotheses (i.e., both the inherited and the correct hypothesis) will be better when they train using a combination of analogical encoding and collaborative learning techniques than when they train with only one or neither of these techniques. Finally, focusing on the final causal judgment, Hypothesis 10 proposes the same ordinal interaction for selecting the correct causal hypothesis.

The findings reported in this thesis provide support for the predictions of Hypothesis 7, i.e., there is significant performance improvement when evaluating hypotheses (i.e., both the inherited and the correct hypothesis) for MDTs trained using the analogical encoding technique. The mechanism enabling this improved performance is the deeper understanding it facilitates. The use of the analogical encoding technique is likely to facilitate counterexplanation by team members (Koonce 1992) as well as their performance of sufficiency checks (Anderson and Koonce 1998), which are important processes when evaluating hypotheses. The predictions of Hypothesis 8 are also supported by the results, i.e., MDTs trained using collaborative learning performed significantly better when evaluating both the inherited hypothesis and the correct hypothesis. This supports the idea that one of the benefits of collaborative learning is the reduction of cognitive load, which allows team members to optimise available team resources (information-processing capacity) for necessary team task demands. These results are also consistent with the view that the social ties that are created between team members becoming familiar with each other enable them to collaborate in the task performance phase (Gruenfeld et al. 1996). The predictions proposed by Hypotheses 9 and 10 are also supported and suggest that the improvements in these stages (i.e., hypothesis evaluation and the final judgment) are possible due to a combination of the benefits from the two training techniques. The combined effects of these training techniques result in team members having a deeper understanding of the principles behind the hypotheses as well as an enhanced opportunity to discuss alternatives, which facilitates more objective evaluation of the hypotheses. MDTs are therefore less biased towards the inherited hypothesis and are more likely to select the correct causal hypothesis.

The third aim of the thesis, addressed by Hypotheses 11 to 25, is to explore the role of cognitive structures as potential mediating variables between training interventions and MDT performance. Previous research suggests that cognitive structures are one of the mediational factors, in addition to team processes, that may intervene and transmit the influence of team inputs to outcomes (Ilgen et al. 2005; Mathieu et al. 2008). Two types of team cognitive structures are investigated in this thesis: team mental models (TMMs) and transactive memory systems (TMSs).

In order to examine the role of TMMs, an investigation was carried out on the effect of training intervention on the development of TMMs in the hypothesis generation stage. It is suggested that the use of analogical encoding will lead to more accurate TMMs (Hypothesis 11a) but will not lead to more similar TMMs (Hypothesis 11b). By using this technique, individuals are instructed in a way that allows them to structure their knowledge in a particular organisation. In this way, accurate individual and team mental models can be developed. However, because each member may have a propensity to develop a particular mental model, they may develop different mental models after receiving particular structures from training via analogical encoding. Similar TMMs are therefore difficult to develop for individuals trained using the analogical encoding technique.

It is suggested that the use of collaborative learning will not lead to more accurate and similar TMMs (Hypotheses 12a and 12b). These predictions are based on the contention that learning collaboratively with other members may disrupt the learning process and thus may not facilitate the development of a similar mental model. A positive effect from the use of the collaborative learning technique can occur when individuals have compatible pre-existing mental models (i.e., in this thesis, team members who have no prior knowledge of auditing). Because TMM accuracy is measured by aggregating individual mental models, this technique has, in general, no effect on the development of accurate TMMs (i.e., due to the effects being cancelled out by the different mental models of the two team members). Furthermore, because the resulting individual mental models differ, TMMs will not be more similar compared to those of MDTs that train without this technique.

Given that the use of analogical encoding leads to the development of more accurate TMMs (Hypothesis 11a) and the use of collaborative learning has no effect on this development (Hypothesis 12a), this leads to the expectation that there will be no interaction effect on TMM accuracy from the use of these two training techniques (Hypothesis 13a). Although the use of collaborative learning has, in general, no effect on the development of similar TMMs as predicted by Hypothesis 12b, an interaction effect is expected such that the use of collaborative learning with analogical encoding will enhance TMM similarity, whereas the use of collaborative learning without analogical encoding will not. Therefore, Hypothesis 13b predicts an interaction between the two training techniques such that MDTs that trained with (without) analogical encoding have less (more) similar hypothesis generation TMMs than MDTs trained using collaborative learning. The findings relating to these hypotheses indicate that the use of these techniques did not affect TMM accuracy and similarity except for the effect of analogical encoding on TMM accuracy.

In examining TMMs as a mediator between training interventions and MDT performance in the hypothesis generation stage, three hypotheses are proposed. Consistent with prior TMM studies, it is predicted that TMM accuracy and similarity will mediate the relationship between training interventions and MDT performance (Hypotheses 14 and 15). It is also predicted that the TMM properties (i.e., accuracy and similarity) will interact with and will be positively related to MDT performance. The findings relating to these hypotheses provide evidence that TMM accuracy and similarity do not mediate the relationships between team training inputs and MDT performance in hypothesis generation.

The results relating to the role of TMMs in the hypothesis generation stage indicate that it is difficult to achieve a high level of TMM similarity in the unique setting investigated in this thesis, in which diverse-background MDT members learn and work together with differing pre-existing knowledge structures and mental models. The different pre-existing individual mental models also make it difficult to develop similar and accurate TMMs. The findings also suggest that although some team members (i.e., accountant members of the MDT) have 'inaccurate' mental models compared to the training referent model (which affected TMM accuracy and similarity), they have a consistently higher ability to generate hypotheses due to their familiarity with the task of using analytical procedures to find errors in financial statements. In an MDT context, recognising the most capable members in a team (i.e., accountant members are better at generating hypotheses) may be a more important mechanism in team functioning than developing more similar and/or accurate TMMs.

In the hypothesis evaluation stage, it is predicted that MDTs that train using analogical encoding will have more accurate and similar hypothesis evaluation TMMs than MDTs that train without analogical encoding (Hypotheses 17a and 17b). Analogical encoding is useful in overcoming the tendency to be more biased in favour of an inherited explanation when evaluating hypotheses. By using this technique, an accurate mental model can be developed that contains a balanced evaluation of hypotheses. In addition, given that TMMs used in evaluating hypotheses are simpler than TMMs used in generating hypotheses, the negative effect of incompatible mental models is less likely to occur when team members learn via training materials. As a result, all individual team members can develop similar accurate mental models. For collaborative learning, it is expected that the use of this technique has no effect on TMM accuracy and has positive effect on TMM similarity (Hypotheses 18a and 18b). These predictions are proposed because this technique does not facilitate schema induction in order to develop accurate mental models that contain a balanced evaluation of hypotheses. However, this technique allows interaction in dialogues between team members and it will lead to a shared understanding or representation of the information. This positive effect on TMM similarity may occur because most of the team members (as individuals in general) have no particular schema regarding hypothesis evaluation for the experimental task in their pre-existing mental models. Based on the argument that the use of analogical encoding is beneficial in improving the development of more accurate TMMs when the two training techniques are combined, it is predicted that TMM accuracy will be highest compared to other conditions (Hypothesis 19a). Furthermore, because both analogical encoding and collaborative learning lead to the development of more similar TMMs, Hypothesis 19b predicts that there will be no interaction effect on TMM similarity from these two training techniques. With respect to the role of TMMs in the hypothesis evaluation stage, consistent with prior TMM studies, it is predicted the TMM accuracy and similarity mediate the relationship between training interventions and MDT performance (Hypotheses 20 and 21). Findings, which relate to whether training interventions affect the development of TMM accuracy and similarity in the hypothesis evaluation stage, indicate that the only significant mediation relationships between the use of analogical encoding and the use of a combination of analogical encoding and collaborative learning are for TMM accuracy. It is found that TMM accuracy mediates the relationship between training interventions and MDT performance. These results suggest that TMMs potentially play a more important role, since TMM accuracy mediates the relationship between training input and MDT performance in evaluating hypotheses. However, this thesis did not find evidence to support a mediating role for TMM similarity. A possible reason for this may be the small number of correct responses by the participants. Alternatively, the measure of TMMs in hypothesis evaluation may not fully capture all elements of the TMMs.

With regard to the second potential mediator, TMSs, the findings that relate to whether training interventions affect the development of TMSs (Hypotheses 22, 23 and 24) and whether TMSs mediate the relationship between training input and MDT performance in generating hypotheses (Hypothesis 25) indicate that training inputs have no impact on the development of TMSs. The findings also show that TMSs do not mediate the relationship between training input and MDT performance in generating hypotheses. A possible reason for these results may be the particular design of this study. Specifically, the training inputs employed in this study may not have impacted on the development of TMSs because these interventions did not provide sufficient opportunity for team members to learn something about each other's expertise as they interacted during task processing when they were trained together. In addition, the results of this study suggest that learning from worked examples does not allow sufficient information for team members to determine the other member's expertise and role. Finally, the results also indicate that learning collaboratively does not appear to have provided diagnostic feedback about the functioning of retrieval and communication activities.

5.3. Contributions and Implications

The results presented in this thesis add to knowledge regarding the effect of training interventions on both individual team members and MDTs in performing a complex task. Prior research has only examined these training mechanisms in isolation and in simple task settings. The study also furthers our knowledge of the effect of these training interventions on team cognitive structures and the role of cognitive structures in the performance of heterogeneous teams such as MDTs. A detailed discussion of the theoretical and practical contributions and implications of this thesis are provided in the following sections.

5.3.1. Theoretical Contributions

The first contribution of this thesis is that it extends prior research on the use of the analogical encoding technique in educational psychology as well as in accounting research. Prior research suggests that the use of the analogical encoding technique is effective in improving task learning in certain situations while not in other situations (Cummins 1992; VanderStoep and Seifert 1994; Gentner et al. 2003; Day et al. 2010). Specifically, the compare-and-contrast activity employed in analogical encoding as an underlying constructive learning activity (Chi 2009) and its ability to facilitate the development of knowledge structures have been used to explain the advantage of this technique. Prior research also suggests that the cognitive load imposed on learners by this technique may make its use ineffective (Renkl 2011). However, to date there has been no empirical study to support this prediction. The findings of this thesis provide evidence about the boundary conditions of the analogical encoding technique. While a single intervention training technique using analogical encoding may have potential limitations in improving individual performance in learning a complex task, this technique is found to lead to higher learning outcomes when used in combination with the collaborative learning technique. The extension to current research in analogical encoding is achieved by simultaneously addressing all three important principles of learning: limited capacity, the deep processing and memory organisation principle (Gentner et al. 2003; Mayer 2008; Chi 2009). This thesis makes an important contribution in this regard because, in prior studies, these principles have been studied in separate lines of research in cognitive and educational psychology and have been investigated in isolation. The importance of considering these principles together may be when individuals learn a complex learning task. This thesis provides evidence that a combination of training techniques may compensate for the limitations of one technique.

The second contribution of this thesis is that its findings extend current research on the effectiveness of the collaborative learning technique. Prior studies have found that the use of this technique can reduce cognitive load for homogeneous learners (i.e., those with similar knowledge and backgrounds) (e.g., Kirschner et al. 2009a; Kirschner, Paas, and Kirschner 2011; Kirschner, Paas, Kirschner, et al. 2011). This thesis provides evidence that this technique also reduces cognitive load for heterogeneous learners (i.e., those who do not have similar knowledge or backgrounds) when learning a complex task. The findings also support the argument that collaborative learning is an interactive learning activity that leads to superior learning outcomes (Chi 2009). This thesis demonstrates that in understanding a complex task involving knowledge from a variety of fields, the use of collaborative learning enables deep processing and strong encoding processes; these enable individuals to achieve better learning outcomes.

In addition, this thesis furthers knowledge about the boundary conditions of the collaborative learning technique by demonstrating that collaboration may inhibit the development of knowledge structures and appropriate memory retrieval. Prior studies report a phenomenon called collaborative inhibition, which means that working collaboratively with a partner to recall information may disrupt his/her recall performance (Cummins 1992; VanderStoep and Seifert 1994; Basden et al. 1997; Barber et al. 2010; Rajaram and Pereira-Pasarin 2010; Rajaram 2011). This thesis extends this research with the finding that collaborative inhibition can occur when each individual team member possesses a different pre-existing knowledge structure (or way of organising information in memory) that may not match or be compatible with the other team member’s knowledge structure, as is the case in a MDT setting. When these individuals learn collaboratively, one team member’s incompatible organisation structure may disrupt the other team member’s organisation structure; therefore, it may impair the encoding process for the knowledge structure supplied in the training material.

The third contribution of this thesis is that its findings extend research literature related to team training by examining team-training interventions that can be applied to MDTs performing a conceptual task. Because of the unique setting investigated in this thesis, in which diverse-background members of MDTs with differing knowledge and mental models learn and work together, the findings reported in this thesis have important contributions to current research. To date, no study has investigated team-training interventions for teams performing a conceptual task or examined team training for MDTs. As shown in this thesis, the instructional objective of team training for these teams is to improve team processes in realising the benefits of MDTs (van Knippenberg et al. 2004; Homan et al. 2007). In particular, this thesis provides evidence on the effectiveness of two training techniques, analogical encoding and collaborative learning, as team-training interventions for the performance of MDTs in an analytical procedures task. The findings suggest the limitations of analogical encoding and the advantages of collaborative learning in the hypothesis generation stage. In the hypothesis evaluation stage, both analogical encoding and collaborative learning have a beneficial effect on MDT performance. Furthermore, in both stages, a greater improvement in MDT performance was possible when a combination of analogical encoding and collaborative learning techniques was employed in team training.

The fourth contribution of this thesis is that the findings extend current research on the role of cognitive structures, TMMs in particular, in team functioning. While prior studies have suggested that team effectiveness can be improved by developing highly accurate and similar TMMs, and that this is more likely to occur when the teams consist of members who have similar or homogeneous characteristics (Resick et al. 2010; Fisher et al. 2012), the findings reported in this thesis provide insights on the development of TMMs in heterogeneous teams. It may be difficult for these teams, whose members have very different characteristics, to develop similar TMMs. However, less similar TMMs may be viewed as both a problem and a potential advantage for MDTs (Williams and O'Reilly 1998; Mannix and Neale 2005). In fact, similar mental models may impair performance through narrowed perspectives that fail to take advantage of the two team members’ diverse knowledge, the very reason for creating the MDT in the first place. In such cases, it may be important that some team members (but not necessarily all members) have highly accurate mental models. Therefore, in the MDT setting, it is possible that the low-similarity, high-accuracy combination for TMMs is more feasible, easier to achieve and therefore likely to lead to more effective processes and performance compared to the low-similarity, low-accuracy TMM combination. This study finds no evidence for the effect of team-training interventions on TMM similarity. TMM similarity did not mediate the relationship between team training and MDT performance. However, this thesis finds evidence that one of the interventions (i.e., a combination of analogical encoding and collaborative learning) is effective in improving TMM accuracy. TMM accuracy also mediates the relationship between team training and MDT performance in hypothesis evaluation. A combination of low-similarity, high-accuracy TMMs is therefore possible and may be needed to improve MDT performance.

The fifth contribution of this thesis is that the findings extend current research on training to improve performance of an analytical procedures task. Only a few prior studies (e.g., Bonner and Walker 1994; Moreno et al. 2007) examine training techniques to improve individual performance in this task. This thesis demonstrates the importance of examining multiple stages of a task rather than considering only single stages. Through this multi-stage approach, this thesis contributes to our understanding of how to improve the performance of an analytical procedures task. In particular, it provides evidence on how to improve performance in two important stages of an analytical procedures task: hypothesis generation and hypothesis evaluation. In hypothesis generation, the findings suggest that a combination of analogical encoding and collaborative learning facilitated the acquisition of knowledge content and the development of appropriate knowledge structures in the mental representations of both individuals and teams. In the hypothesis evaluation stage, MDT performance can be improved by using a combination of these training techniques because they enable MDT members to create an environment that is conducive to elaboration where the exchange of diverse information, ideas, and viewpoints is likely to be realised. This in turn leads team members to be less biased towards individual hypotheses such as the inherited hypothesis and to evaluate hypotheses objectively. In this way, MDTs are more likely to select the correct causal hypothesis.

5.3.2. Practical Contributions and Implications

The findings of this thesis provide significant practical contributions on the use of the training interventions that can be recommended for use in training of multidisciplinary practitioners in audit firms. In addition, the findings provide insights into the development of training materials and learning activities for courses relating to GHG assurance taught in higher education institutions. The practical implications of the findings of this thesis are explained below.

First, it is important that the design of the training takes into account the cognitive load that may be imposed on the learners' cognitive resources. The benefits of a training technique, such as the analogical encoding technique, may not be realised because too many cognitive resources may be needed for this technique. The results also imply that this technique should be accompanied with other methods that are able to reduce or manage cognitive load. As shown by the findings of this thesis, a combination of analogical encoding with collaborative learning is effective in improving the performance of individuals and MDTs.

Second, learning activities should be designed by considering activities that encourage deep processing during learning. Designing appropriate learning activities allows meaningful learning processes to occur (i.e., selecting, organising, integrating and encoding) (Chi 2009). Because interactive activities are shown to be superior for learning compared to other learning activities, the use of collaborative learning as one of the interactive learning activities can be used as a training technique to facilitate deep processing. Furthermore, as indicated by the findings of this thesis, a combination of interactive and constructive activities (i.e., analogical encoding) leads to a better learning performance. This suggests that more benefits can be realised when both constructive and interactive activities are combined.

Third, in order to improve individual and team learning, the objectives of training are not only to facilitate the acquisition of knowledge content but also the development of knowledge structure. In a complex task such as an analytical procedures task, such development is important in order to enable efficient and effective conduct of the task. Analogical encoding is effective in facilitating the development of knowledge structures. However, training material that is accompanied by analogical encoding prompts must be designed to take into account the learners' prior knowledge. As demonstrated by the findings of this thesis, such development is more likely to be facilitated when a learner's pre-existing knowledge structures are compatible with the referent knowledge structure in the training material.

Fourth, team-training interventions should be designed so that team members in the training session are encouraged to create an environment that is conducive to elaboration of task-relevant information. This thesis provides evidence that such an environment can be developed by using training techniques such as collaborative learning. This technique allows teams to enhance process gains and/or reduce process losses. By using this technique, team members are able to contribute to the team by exchanging information and perspectives and correcting each other's errors. The results reported in this thesis suggest that the use of this technique brings beneficial effects through bridging diversity and enhancing elaboration, which in turn helps MDTs to achieve higher performance levels.

Fifth, for heterogeneous teams such as the MDTs examined in this thesis, it is important that training is designed to develop highly accurate TMMs. This property is expected to contribute to improved team decisions even though team members may have different rather than similar pre-existing mental models. Analogical encoding is a potential training technique that can be used to enhance the development of TMM accuracy. By using this technique, individual team members can be instructed in a way that allows them to structure their knowledge in an appropriate manner.

Finally, the findings provide insights on how to train individuals and teams to perform an analytical procedures task. Because of the complex nature of analytical procedures, a combination of training interventions may be necessary and may overcome the limitations of a single technique. Consistent with prior research (Moreno et al., 2007), the results reported in this thesis suggest that a complex analytical procedures task requires a combination of interventions in both the hypothesis generation and hypothesis evaluation stages. Since these stages have different cognitive processes, it is important that training techniques are designed specifically for each stage. Hypothesis generation is a cognitive process that is characterised as a construction process since the individuals must construct explanations for the observed unexpected fluctuations by generating potential causes as hypotheses (Bonner and Pennington 1991). For this stage, training can be designed to improve individual knowledge about the many types of potential hypotheses (i.e., knowledge content) and category (i.e., knowledge structure). The use of a combination of analogical encoding (with problem-category comparison) and collaborative learning can be used as an effective training technique in this stage. In the next stage, hypothesis evaluation, which involves a reduction process (choosing among possibilities), large amounts of information are processed through elaboration to form an evaluation. Training interventions for this stage should be designed to encourage the exchange, discussion and integration of alternative information, different ways of thinking, and different perspectives and interpretations (Nemeth 1986; Nemeth and Kwan 1987; van Knippenberg et al. 2004). The collaborative learning technique is useful in facilitating these processes.

5.4. Limitations

The findings and conclusions of reported in this thesis should be considered in light of its limitations. First, the design of the experiment does not allow the participants to generate hypotheses together as a team, nor to add new hypotheses during their discussions with other members. This design choice was made because it allows the measurement of individual performance in hypothesis generation. However, as a result of this, the design did not enable the development of all possible process gains and losses (e.g., cognitive interstimulation and production blocking). It is not known how these processes might affect team performance.

Second, participants in this research study may not be representative of actual practitioners. The participants are postgraduate students who have a background in either accounting or science; however, they are not real experts in their respective domains. This may call into question the generalisability of the findings to real-life teams. However, as explained in Chapter 3, the participants were selected based on the following requirements: (1) expertise diversity (i.e., the participants have different educational backgrounds) and (2) required competencies (i.e., the participants have attained basic knowledge and skills in their respective domain, which is indicated by their postgraduate status). Therefore, participants in this study were recruited to reflect the minimal requirements of actual practitioners in MDTs. In addition, because the aim of this thesis is to examine the effectiveness of training interventions, using student (i.e., nonprofessional) participants with no experience in GHG assurance engagements enabled the thesis to more clearly assess the effects of the training treatment. On other hand, it is important to note that in an actual setting with actual experts, problems associated with expertise diversity could be even more salient than those in the setting used in the thesis. For example, examining actual experts, O'Dwyer (2011) found that MDTs suffered from the different mindsets of accountant and non-accountant experts when working together on a sustainability assurance task. He showed that non-accountant experts were uncomfortable working with financial auditors because the auditors usually brought the mindsets and habits (i.e., mental models) of financial audit to sustainability assurance. The difference in mental models led to both misunderstanding and a lack of understanding among team members. As a result there was less cooperation and the team was less effective.

Third, this thesis is focused on GHG assurance engagements, which is a more closely-defined and confined subject matter within the overall sustainability assurance area. As noted in Chapter 1, the risk model used for audits of financial statements translates well to the GHG reporting domain. Accountants can bring their mental models of financial audit to this setting by following standard testing procedures. However, as shown by O'Dwyer (2011), this was not the case in the broader context of sustainability assurance. As suggested by O'Dwyer (2011), one reason why non-accountant experts are uncomfortable working in MDTs in this setting is that accountants follow strict standard testing procedures when dealing with non-financial data. This restricts their ability to deal with the nuances of this data. Transferring their mental models created problems in this context. Therefore, caution should be exercised when generalising the findings of this thesis to a broader context.

Fourth, the number of participants and the resulting sample for some tests in this thesis is relatively small. In particular, in the hypothesis evaluation stage, not all of the participants included an inherited hypothesis in their hypothesis sets nor did all participants generate the correct hypothesis. The number of participants with the correct hypothesis evaluation response is even smaller. This may limit the statistical power available to detect effects. This is a common problem faced by a large team-level sample size when each team comprises several individual participants. However, as noted in Chapter 4, the problem is addressed in this thesis by using an appropriate statistical analysis (i.e., using the exact method logistic regression for small samples). Nonetheless, despite the potential loss of power for the tests, the majority of the hypotheses were supported.

Fifth, the training material (i.e., the material used in stage 2a of the experiment) was deliberately designed in a manner that is incompatible with accountants' prior knowledge, which is generally structured according to audit objectives or assertions (Frederick et al. 1994). By using a different knowledge structure, this thesis is able to consider how pre-existing auditing knowledge may affect the development of auditors' GHG knowledge structures. In this way the thesis is able to examine whether the prior knowledge of individual team member affects their cognitive processes during learning and learning outcomes. However, this thesis does not examine whether the development of knowledge structures (and team mental models) would be enhanced if the training material was designed with a structure that is compatible with the pre-existing knowledge structures of the participants. In such cases, participants may not have any difficulty in developing knowledge structures that are compatible with their pre-existing knowledge structure or mental models when they learn a new domain. The extent to which individual and team learning performance is improved by using such a compatible structure is left for future research.

Sixth, in this thesis, elaboration of task-relevant information is not measured using an objective measure. An alternative team process measure using a subjective measure that captures the element of elaboration (Marks et al. 2001; Mathieu et al. 2006) was used, which is comparable with Homan et al. (2008). However, the findings relating to subjective team process (as reported in the additional analysis in Chapter 4, Section 4.2.5.3) suggest that this measure is sensitive to the perceived difficulty of the task and stems from the use of the two training techniques. The findings using this alternative measure provide conflicting results to those reported in Chapter 4, Section 4.2.5.2, that MDTs trained with a combination of two training techniques (Condition 4) exhibited process gains, which implies that using these two techniques improve team process. Therefore an objective measure may be more appropriate to capture the dimension of elaboration as a component of team process. Objective measurement by independent coders in prior organisational psychology research has been obtained through observation from videos or audiotapes of actual team processes (e.g., Jehn and Shah 1997). This thesis did not utilise audio or video recordings. Future research may consider employing these alternative measures of team processes.

A seventh potential limitation lies in the measure used for TMMs in hypothesis evaluation. In this thesis, TMMs in hypothesis evaluation are measured using a qualitative method and determined by reviewing the extent to which team members have the same view or evaluation for each specific hypothesis. After reviewing written documentation for the individual and team decisions during the hypothesis evaluation stage, team responses were classified into a simple categorical measure (Carley 1997). A TMM is deemed accurate if the team members shared the task representation in favour of an alternative (error) hypothesis, and inaccurate if they shared the task representation in favour of the inherited hypothesis (or other explanations characterised as a non-error hypothesis). TMM similarity is measured by coding the similarity of the two team members' hypothesis evaluation task representations. A TMM is similar when both members generate either an inherited or an alternative or error hypothesis in their hypothesis set and not similar when the team members generate dissimilar hypotheses (i.e., one member generates an inherited hypothesis but the other member does not generate an inherited hypothesis). These simple measures may not fully capture the organised knowledge dimension of TMMs. As suggested by the TMM literature, because organised knowledge is central to the definition of TMMs, both content and structure are viewed as integral elements of their measurement (e.g., Langan-Fox et al. 2000; Rentsch et al. 2008; DeChurch and Mesmer-Magnus 2010). Content refers to the knowledge that comprises cognition, whereas structure represents the way concepts are organised in the minds of participants and the pattern of relationships between elements (Mohammed and Dumville 2001; Mohammed et al. 2010). The measure of TMMs in hypothesis evaluation in this study may not fully capture the structural element of TMMs due to the use of a one-dimensional TMM concept.

Eighth, the design used in this thesis may not have provided sufficient opportunity for team members to develop TMSs due to the short duration of the training interventions and the use of worked examples. As suggested by prior studies, development of TMSs requires a substantial period of time (Moreland et al. 1996; Moreland 1999). Future research may explore TMS development using tasks where MDT members have more time to learn about each other.

Ninth, consistent with prior analytical procedures studies (e.g., Libby 1985; Bedard and Biggs 1991; Asare and Wright 1997b, 1997a; Bhattacharjee et al. 1999; Asare and Wright 2003; Green and Trotman 2003), this study limits complexity by instructing participants to assume there is only *one* cause of an observed fluctuation. As suggested by Srivastava et al. (2012), consideration of potential causes is quite complex since the relationship between the hypothesised cause may vary dramatically across different settings. In actual practice, the important characteristics of causal inference tasks in analytical procedures include: (1) that there are typically multiple potential causes for an observed effect; (2) that hypotheses may not be exclusive (i.e., more than one cause may contribute to an observed effect); (3) that the hypothesis set under consideration may not be exhaustive (i.e., the auditor acknowledges that all potential causes may not have been identified); and (4) that causal inference tasks usually entail relying on evidence that is not perfectly diagnostic (Srivastava et al. 2012). Thus, this thesis's results may be less generalizable as the number of causes associated with an unexpected fluctuation increases.

Tenth, the majority of participants in the experiment are international students from Asian countries. Their cultural background could impact the way that participants work as team members. Prior studies indicate that cultural background could affect how individuals trust other people and it is found that collectivist cultures encourage individuals to trust in-groups more than out-group relative to individualist cultures (Triandis 1995; Huff and Kelley 2003).

Individuals from collectivist cultures are prone to in-group bias and relatively ineffective with strangers, commonly use avoidance behaviors, and compete with, manipulate, and exploit out-groups more extensively than individualists (Watkins and Liu 1996; Yamagishi et al. 1998). Given that Asian cultures are categorized as collectivist cultures (Hofstede 1980; Triandis 1995), the results of the experiment in this thesis could be affected in a way that individuals (and MDTs) from collectivist cultures are relatively ineffective compared to individuals (and MDTs) from individualist cultures. Nevertheless, the results of this thesis suggest that a training intervention (i.e., a combination of analogical encoding and collaborative learning) is effective in improving performance of MDT which mostly consists of individuals from collectivist culture. It is reasonable to expect that this intervention would be more effective when used by individuals and MDTs from individualist cultures.

Finally, potential limitations may result from the incentives used for the control condition in this thesis. Participants in the control condition received a $10 retail gift card as their compensation for completing the task. No further compensation was received by the control condition participants. On the other hand, in the training conditions, as the participants completed additional components of the experimental task, there was an opportunity for an additional incentive payment as three further team payments were made (for the three best teams). Although participants in the control condition did not perform the team task (stages 4b team to 4e), there is a possibility that because there were no incentives for these participants, they were not motivated to perform better in the individual task (Stage 4b individual).

5.5. Future Research Directions

The results reported in this thesis provide insights for potential directions for future research. First, the participants were not able to add new hypotheses during their discussions with other team members. As a result, it was not possible to fully capture potential process gains due to cognitive interstimulation. As discussed in Chapter 3, this design was imposed to allow the measurement of individual performance in hypothesis generation. Future research could explore whether even higher beneficial effects are possible if the design includes the estimation of hypotheses (i.e., if it allows the generation of additional hypotheses).

Second, the focus of training is to improve individual and team performance in conducting an analytical procedures task, a task with which an accountant team member who has knowledge in auditing is already familiar. In this setting, the accountant members have a pre-existing mental model, while the scientist members have a blank-slate mental model for this task. To enable an investigation into the effect of incompatible mental models, the training materials used in this thesis are deliberately designed in a structure that is incompatible with the accountants' prior knowledge. In this thesis, the causal hypotheses were organised according to two elements: the direction of misstatement (i.e., overstatement or understatement) and the nature of the potential causes (i.e., energy consumption or emission quantifications). This structure is incompatible with accountants' knowledge structure, which is generally structured according to audit objectives or assertions (Frederick et al. 1994). Future research could explore whether even higher beneficial effects for the training techniques are possible when the training materials are designed in a structure that is compatible with the knowledge structure of all team members.

Third, the use of analogical encoding in this thesis is found to be a very difficult task that imposes a very high cognitive load. As suggested by cognitive load theory, when learners are novice and the skills are complex, extraneous (irrelevant) cognitive load should be kept low and intrinsic cognitive load should be managed in order to free up working memory for learning (Clark et al. 2006). Therefore, it is important to find ways to reduce cognitive load. Research in cognitive load theory provides insights on how to reduce intrinsic load. Intrinsic cognitive load arises from the complexity of the content and associated instructional objectives (Sweller et al. 1998). Although the intrinsic cognitive load of the content cannot be controlled, it can be managed by reducing the amount of content presented at any one time by segmenting and sequencing the content (Clark et al. 2006) (e.g., the content can be segmented into progressively smaller sections). Future research that addresses these structuring methods would be beneficial in order to improve the usefulness of the analogical encoding technique.

Fourth, in order to ensure that the individual team members perform higher quality collaborative learning processes, the collaborative learning technique in this thesis is operationalised with the participants working together to answer questions or prompts that guide learners in discussing a specific aspect of the concepts to be learned. In prior educational psychology studies, such instructional support has been described and analysed more systematically as scaffolding (i.e., a way to support learners as they accomplish tasks that they would not be able to accomplish on their own) (Kollar et al. 2006). This thesis did not examine a second type of scaffolding, that is, scaffolds that provide support related to the interactive processes between the collaborators. These scaffolds structure the interactive processes of collaborative learning and shape collaboration by specifying different roles and associated activities to be carried out by the collaborators. For example, learners are asked to explain the content of a text and to critique contributions of their learning partners at specific points in the learning process. Such scaffolds have been called collaboration scripts in research on computer-supported collaborative learning (Dillenbourg 2002; Rummel and Spada 2005; Weinberger et al. 2005; Fischer et al. 2010). Collaboration scripts have been used to structure both face-to-face (e.g., Palincsar and Brown 1984; O'Donnell and Dansereau 1992) and computer-mediated collaboration (e.g., Dillenbourg 2002; Rummel and Spada 2005; Weinberger et al. 2005). Therefore, future research could look at these scaffoldings and their effects on individual and team performance in the GHG analytical procedures task.

Fifth, the role of TMMs as a mediator between team inputs and MDT performance should be further investigated by using alternative research designs and measures. Designing training materials in a structure that is not in conflict with pre-existing mental models may allow more accurate and similar TMMs to be developed. In addition, using alternative TMM measures may enable future research to capture the dimensions of TMMs more fully in this setting.

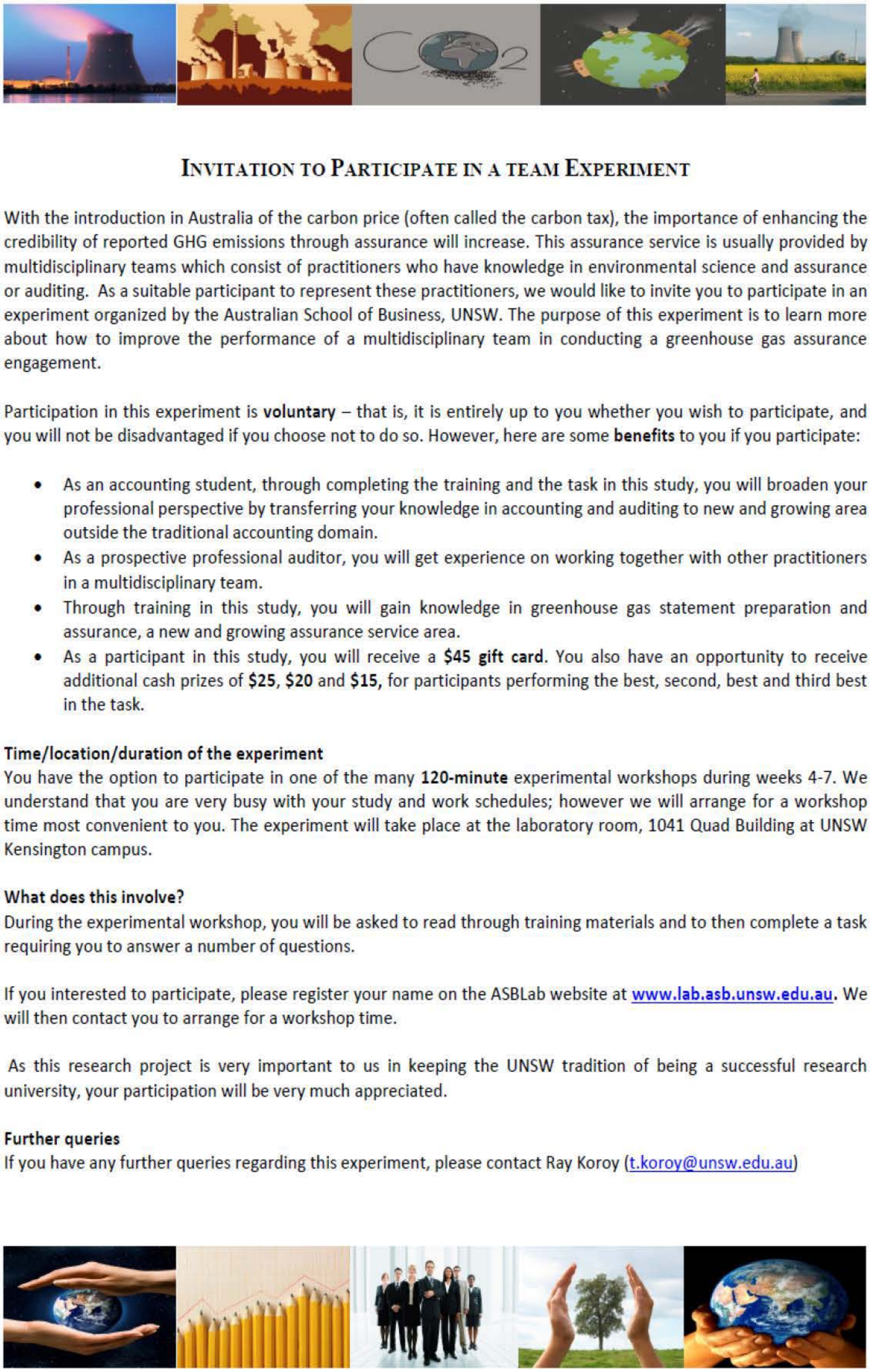
Finally, no support was found in this thesis for the proposed mediation effect of TMSs on the relationship between the training intervention and MDT performance. As discussed in Chapter 4, two factors may explain these results: (1) the short duration of the training interventions may not have provided sufficient opportunity for team members to learn something about each other's expertise during task processing as they trained together; and (2) in this thesis learning from the worked examples may not provide sufficient information about each team member's expertise and roles. Future research could investigate whether the development of TMSs in this setting could be enhanced by providing more time and additional opportunities for team members to learn about each other when learning, with or without worked examples.

APPENDIX 1: INVITATION FLYER

A1.1 Invitation Flyer for Accountant Participants

A1.2 Invitation Flyer for Scientist/Engineer Participants

A1.1 Invitation Flyer for Accountant Participants



INVITATION TO PARTICIPATE IN A TEAM EXPERIMENT

With the introduction in Australia of the carbon price (often called the carbon tax), the importance of enhancing the credibility of reported GHG emissions through assurance will increase. This assurance service is usually provided by multidisciplinary teams which consist of practitioners who have knowledge in environmental science and assurance or auditing. As a suitable participant to represent these practitioners, we would like to invite you to participate in an experiment organized by the Australian School of Business, UNSW. The purpose of this experiment is to learn more about how to improve the performance of a multidisciplinary team in conducting a greenhouse gas assurance engagement.

Participation in this experiment is **voluntary** – that is, it is entirely up to you whether you wish to participate, and you will not be disadvantaged if you choose not to do so. However, here are some **benefits** to you if you participate:

- As an accounting student, through completing the training and the task in this study, you will broaden your professional perspective by transferring your knowledge in accounting and auditing to new and growing area outside the traditional accounting domain.
- As a prospective professional auditor, you will get experience on working together with other practitioners in a multidisciplinary team.
- Through training in this study, you will gain knowledge in greenhouse gas statement preparation and assurance, a new and growing assurance service area.
- As a participant in this study, you will receive a **$45 gift card**. You also have an opportunity to receive additional cash prizes of **$25**, **$20** and **$15,** for participants performing the best, second, best and third best in the task.

Time/location/duration of the experiment

You have the option to participate in one of the many **120-minute** experimental workshops during weeks 4-7. We understand that you are very busy with your study and work schedules; however we will arrange for a workshop time most convenient to you. The experiment will take place at the laboratory room, 1041 Quad Building at UNSW Kensington campus.

What does this involve?

During the experimental workshop, you will be asked to read through training materials and to then complete a task requiring you to answer a number of questions.

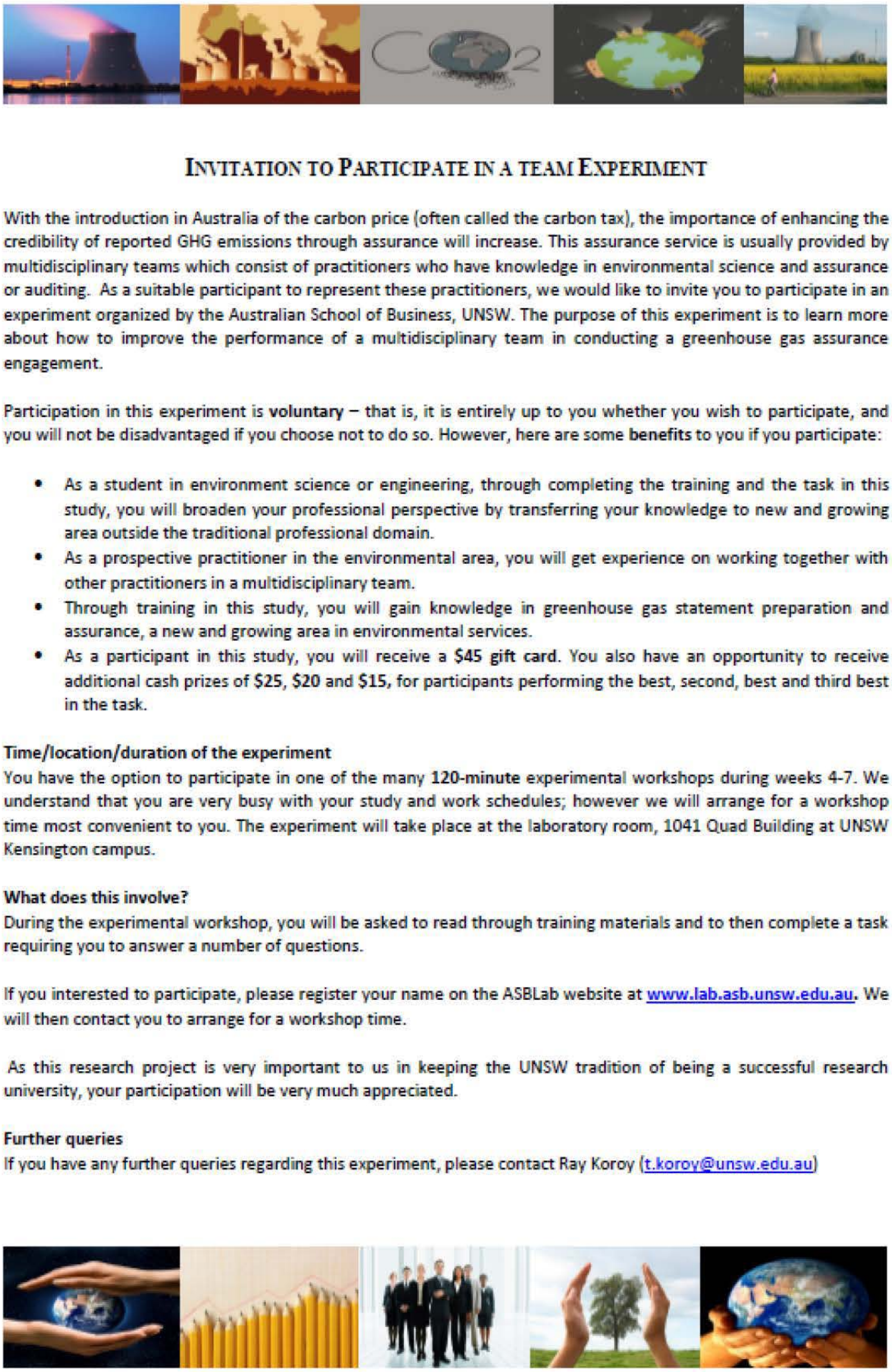
If you interested to participate, please register your name on the ASBLab website at www.lab.asb.unsw.edu.au**.** We will then contact you to arrange for a workshop time.

As this research project is very important to us in keeping the UNSW tradition of being a successful research university, your participation will be very much appreciated.

Further queries

If you have any further queries regarding this experiment, please contact Ray Koroy (t.koroy@unsw.edu.au)

A1.2 Invitation Flyer for Scientist/Engineer Participants



INVITATION TO PARTICIPATE IN A TEAM EXPERIMENT

With the introduction in Australia of the carbon price (often called the carbon tax), the importance of enhancing the credibility of reported GHG emissions through assurance will increase. This assurance service is usually provided by multidisciplinary teams which consist of practitioners who have knowledge in environmental science and assurance or auditing. As a suitable participant to represent these practitioners, we would like to invite you to participate in an experiment organized by the Australian School of Business, UNSW. The purpose of this experiment is to learn more about how to improve the performance of a multidisciplinary team in conducting a greenhouse gas assurance engagement.

Participation in this experiment is **voluntary** – that is, it is entirely up to you whether you wish to participate, and you will not be disadvantaged if you choose not to do so. However, here are some **benefits** to you if you participate:

- As a student in environment science or engineering, through completing the training and the task in this study, you will broaden your professional perspective by transferring your knowledge to new and growing area outside the traditional professional domain.
- As a prospective practitioner in the environmental area, you will get experience on working together with other practitioners in a multidisciplinary team.
- Through training in this study, you will gain knowledge in greenhouse gas statement preparation and assurance, a new and growing area in environmental services.
- As a participant in this study, you will receive a **$45 gift card**. You also have an opportunity to receive additional cash prizes of **$25**, **$20** and **$15**, for participants performing the best, second, best and third best in the task.

Time/location/duration of the experiment

You have the option to participate in one of the many **120-minute** experimental workshops during weeks 4-7. We understand that you are very busy with your study and work schedules; however we will arrange for a workshop time most convenient to you. The experiment will take place at the laboratory room, 1041 Quad Building at UNSW Kensington campus.

What does this involve?

During the experimental workshop, you will be asked to read through training materials and to then complete a task requiring you to answer a number of questions.

If you interested to participate, please register your name on the ASBLab website at www.lab.asb.unsw.edu.au. We will then contact you to arrange for a workshop time.

As this research project is very important to us in keeping the UNSW tradition of being a successful research university, your participation will be very much appreciated.

Further queries

If you have any further queries regarding this experiment, please contact Ray Koroy (t.koroy@unsw.edu.au)

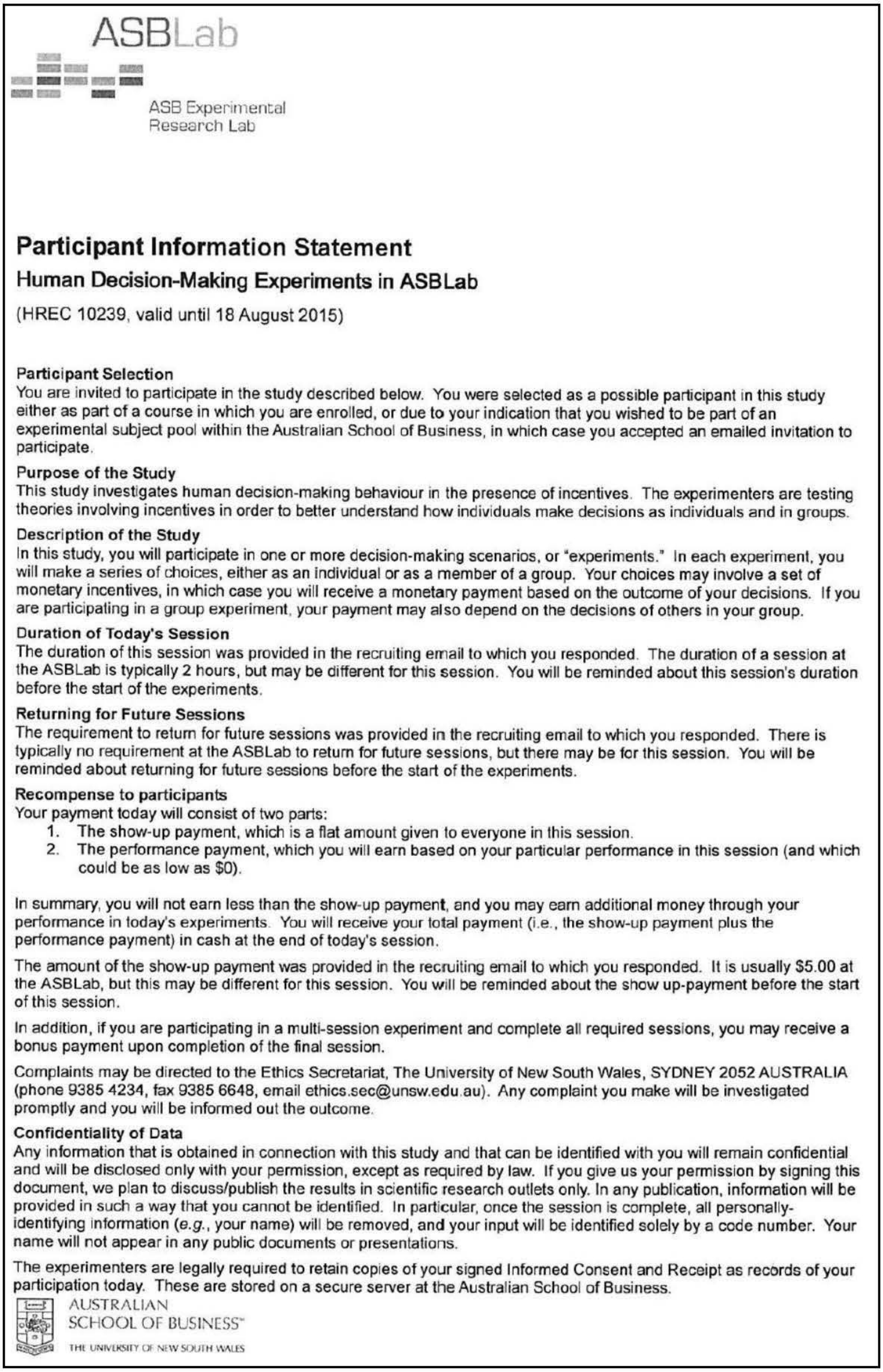
APPENDIX 2: FORMS

A2.1 Participant Information Statement

A2.2 Informed Consent

A2.3 Receipt Form

A.2.1 Participant Information Statement



ASBLab

ASB Experimental
Research Lab

Participant Information Statement

Human Decision-Making Experiments in ASBLab

(HREC 10239, valid until 18 August 2015)

Participant Selection
You are invited to participate in the study described below. You were selected as a possible participant in this study either as part of a course in which you are enrolled, or due to your indication that you wished to be part of an experimental subject pool within the Australian School of Business, in which case you accepted an emailed invitation to participate.

Purpose of the Study
This study investigates human decision-making behaviour in the presence of incentives. The experimenters are testing theories involving incentives in order to better understand how individuals make decisions as individuals and in groups.

Description of the Study
In this study, you will participate in one or more decision-making scenarios, or "experiments." In each experiment, you will make a series of choices, either as an individual or as a member of a group. Your choices may involve a set of monetary incentives, in which case you will receive a monetary payment based on the outcome of your decisions. If you are participating in a group experiment, your payment may also depend on the decisions of others in your group.

Duration of Today's Session
The duration of this session was provided in the recruiting email to which you responded. The duration of a session at the ASBLab is typically 2 hours, but may be different for this session. You will be reminded about this session's duration before the start of the experiments.

Returning for Future Sessions
The requirement to return for future sessions was provided in the recruiting email to which you responded. There is typically no requirement at the ASBLab to return for future sessions, but there may be for this session. You will be reminded about returning for future sessions before the start of the experiments.

Recompense to participants
Your payment today will consist of two parts:

1. The show-up payment, which is a flat amount given to everyone in this session.
2. The performance payment, which you will earn based on your particular performance in this session (and which could be as low as $0).

In summary, you will not earn less than the show-up payment, and you may earn additional money through your performance in today's experiments. You will receive your total payment (i.e., the show-up payment plus the performance payment) in cash at the end of today's session.

The amount of the show-up payment was provided in the recruiting email to which you responded. It is usually $5.00 at the ASBLab, but this may be different for this session. You will be reminded about the show up-payment before the start of this session.

In addition, if you are participating in a multi-session experiment and complete all required sessions, you may receive a bonus payment upon completion of the final session.

Complaints may be directed to the Ethics Secretariat, The University of New South Wales, SYDNEY 2052 AUSTRALIA (phone 9385 4234, fax 9385 6648, email ethics.sec@unsw.edu.au). Any complaint you make will be investigated promptly and you will be informed out the outcome.

Confidentiality of Data
Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission, except as required by law. If you give us your permission by signing this document, we plan to discuss/publish the results in scientific research outlets only. In any publication, information will be provided in such a way that you cannot be identified. In particular, once the session is complete, all personally-identifying information (*e.g.*, your name) will be removed, and your input will be identified solely by a code number. Your name will not appear in any public documents or presentations.

The experimenters are legally required to retain copies of your signed Informed Consent and Receipt as records of your participation today. These are stored on a secure server at the Australian School of Business.

AUSTRALIAN
SCHOOL OF BUSINESS™
THE UNIVERSITY OF NEW SOUTH WALES

ASBLab

ASB Experimental
Research Lab

Risks
There are no anticipated risks attending your participation in this study.

Benefits
There are no anticipated benefits attending your participation in this study.

Your consent
Your decision whether or not to participate will not prejudice your future relations with the University of New South Wales, the Australian School of Business, or the experimenters. If you decide to participate, you are free to withdraw your consent and to discontinue participation at any time without prejudice. If you wish to withdraw during this session, please raise your hand. An experimenter will come to your station, and you can then quietly inform him or her of your intention to withdraw.

You can keep the show-up payment if you decide to withdraw. However, you will not be paid the performance payment unless you complete the entire session. In addition, if you are participating in a multi-session experiment, you will not be paid the multi-session bonus.

If you have any questions, please feel free to ask us. If you have any additional questions later, either the ASB Lab Director (listed below) or the Chief Investigator listed on the Consent Form will be happy to answer them.

You will be given a copy of this form to keep.

Participation Restrictions
If you meet any of the following criteria, you are not eligible to participate in today's session:

- You are under 18 years of age.
- You are in a position of authority over or authority under one of the experimenters in this session (*e.g.*, an employer or an employee of one of the experimenters).

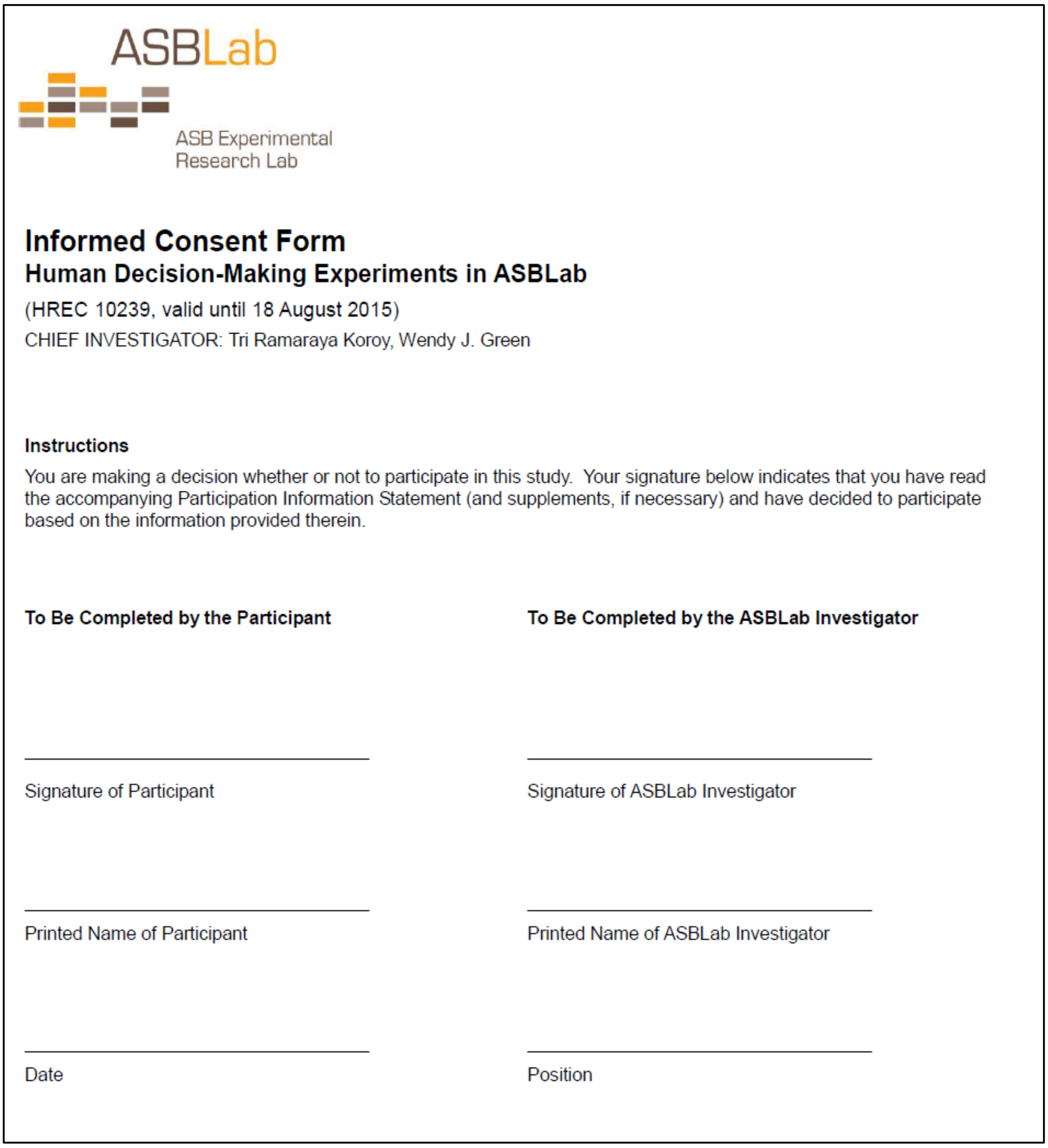
If any of these apply to you, please inform an experimenter before this session begins.

ASBLab Contact
Questions about the purpose or methodology of the study should be directed to the ASBLab Director:

Dr Mathew Chylinski
Australian School of Business
University of New South Wales
UNSW Sydney NSW 2052 AUSTRALIA
Email: m.chylinski@unsw.edu.au

AUSTRALIAN
SCHOOL OF BUSINESS
THE UNIVERSITY OF NEW SOUTH WALES

A2.2 Informed Consent Form



ASBLab
ASB Experimental
Research Lab

Informed Consent Form

Human Decision-Making Experiments in ASBLab

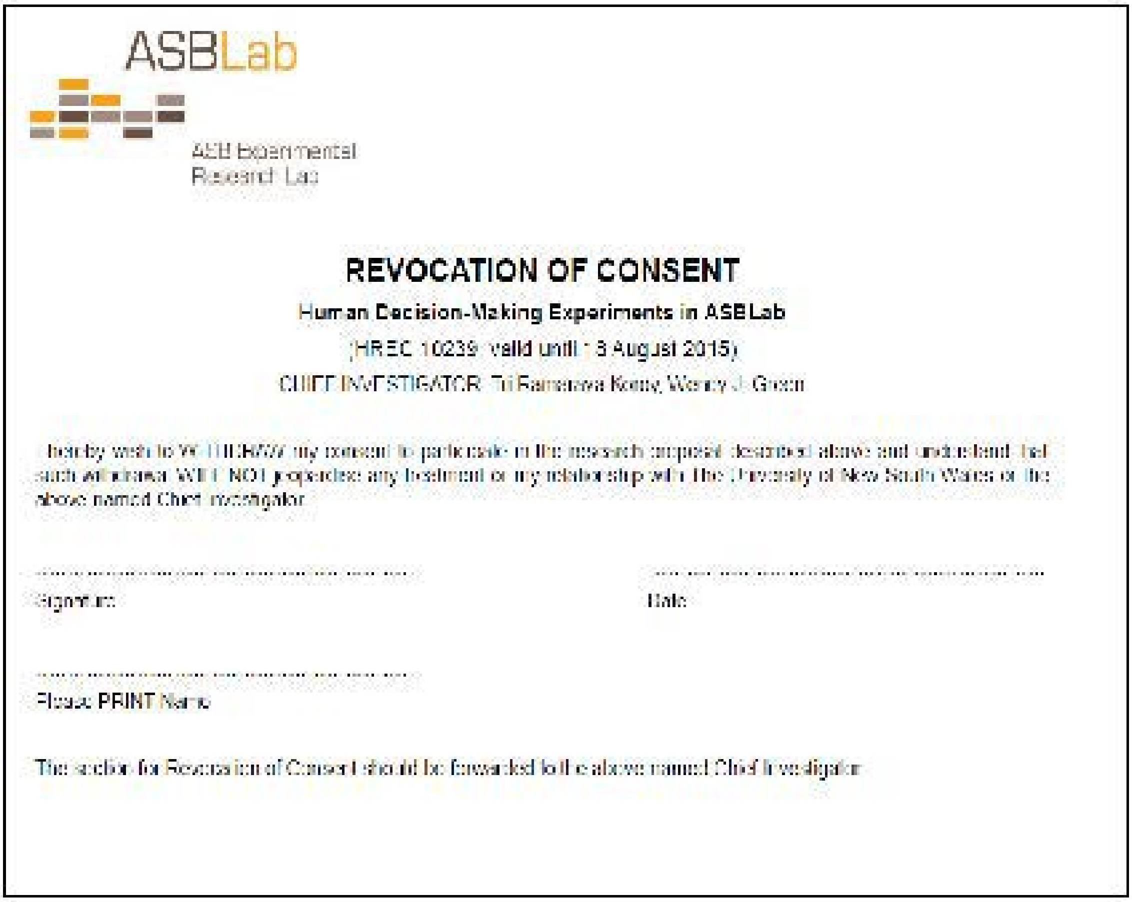
(HREC 10239, valid until 18 August 2015)

CHIEF INVESTIGATOR: Tri Ramaraya Koroy, Wendy J. Green

Instructions

You are making a decision whether or not to participate in this study. Your signature below indicates that you have read the accompanying Participation Information Statement (and supplements, if necessary) and have decided to participate based on the information provided therein.

To Be Completed by the Participant	To Be Completed by the ASBLab Investigator
Signature of Participant	Signature of ASBLab Investigator
Printed Name of Participant	Printed Name of ASBLab Investigator
Date	Position



ASBLab

ASB Experimental
Research Lab

REVOCATION OF CONSENT

Human Decision-Making Experiments in ASBLab

(HREC 10239 valid until 13 August 2015)

CHIEF INVESTIGATOR: Dr Ramasava Kenny, Wendy J. Green

I hereby wish to WITHDRAW my consent to participate in the research proposal described above and understand that such withdrawal WILL NOT jeopardise any treatment or my relationship with The University of New South Wales or the above named Chief Investigator.

……………………………………………… ………………………………………………

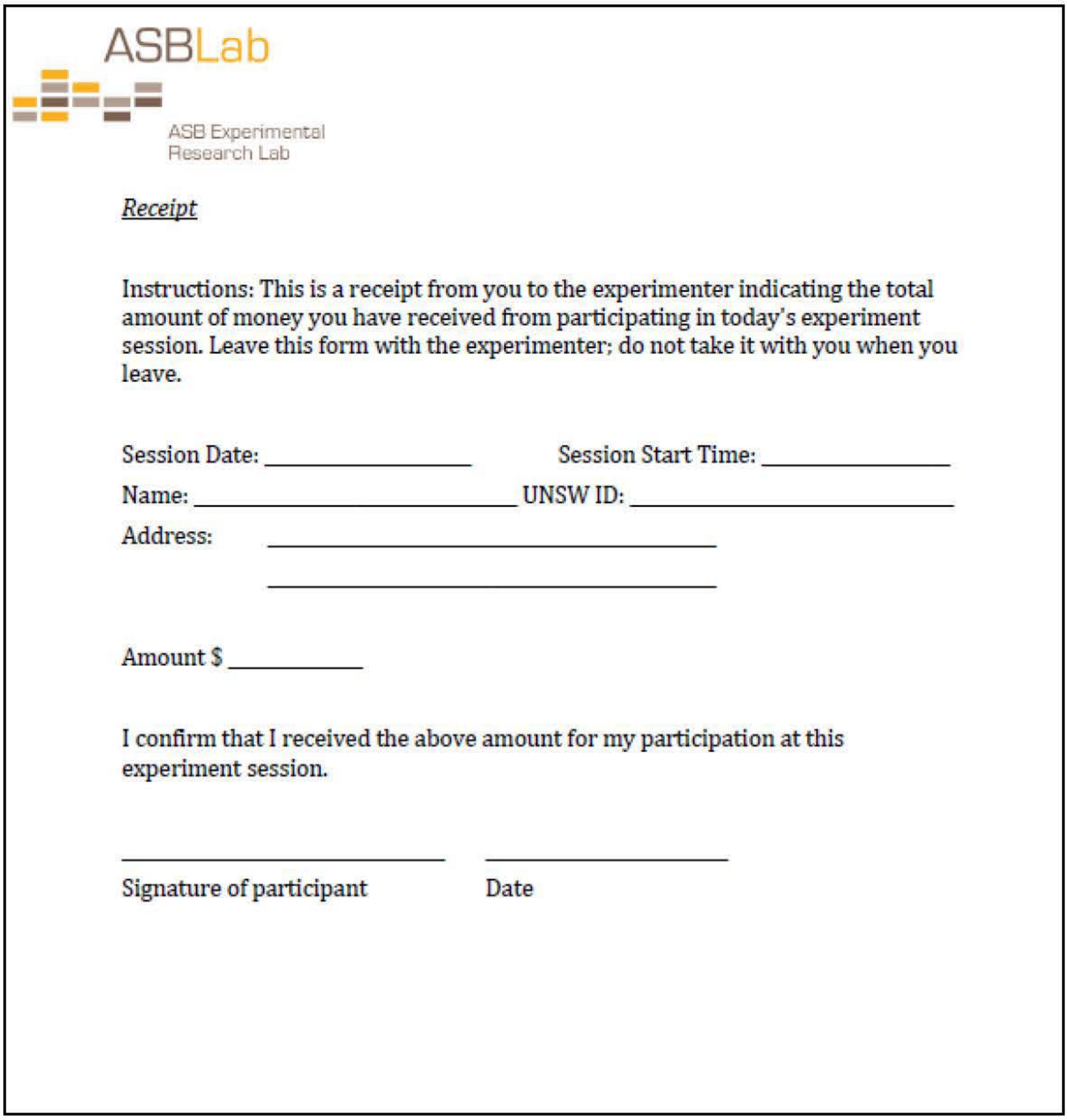
Signature Date

………………………………………………

Please PRINT Name

The section for Revocation of Consent should be forwarded to the above named Chief Investigator.

A2.3 Receipt Form



ASBLab

ASB Experimental
Research Lab

Receipt

Instructions: This is a receipt from you to the experimenter indicating the total amount of money you have received from participating in today's experiment session. Leave this form with the experimenter; do not take it with you when you leave.

Session Date: ________________ Session Start Time: ______________

Name: _________________________ UNSW ID: _________________________

Address: __________________________________
____

Amount $ __________

I confirm that I received the above amount for my participation at this experiment session.

_________________________ ___________________

Signature of participant Date

APPENDIX 3: VERBAL INSTRUCTION DURING EXPERIMENT

A.3.1 Verbal Instruction during Experiment – Non Collaborative Conditions

A.3.2 Verbal Instruction during Experiment – Collaborative Conditions

A.3.3 Verbal Instruction during Experiment – No Training Condition

A.3.1 Verbal Instruction during Experiment – Non Collaborative Conditions

Thank you for coming and participating in this study. Your participation in this experiment is really appreciated.

Before we begin, please read the Participant Information Sheet and please sign the Informed Consent Form and also the Receipt. Please recall that you will receive $45 for participating in this study and you also have an opportunity to receive additional cash prizes for participants performing the best, second best and third best in the task.

This study asks you to assume that you are a member of multidisciplinary team. In this team, because the nature and expertise required is complex and diverse, so team members from different backgrounds are needed. In order to contribute to the team, each member should have sufficient knowledge in conducting the task. To form a multidisciplinary team in this study, half of you have background in accounting and the other half of you have background in science or engineering.

Your goal in in this study is to learn about specific knowledge that is needed in order to perform a task. The knowledge needed is for a greenhouse gas (GHG) assurance engagement and the task is an analytical procedures task.

In the first part of training you are asked to learn the basic knowledge involved in GHG statement preparation. This part of training will take 10 minutes. In the second part, you are asked to learn from two case studies providing examples of analytical procedures, an important task in GHG assurance. This second part will take 40 minutes. After completing the two training phases, you will be asked to perform a card sorting task and answer a short question which will take 24 minutes. Next you work with another team member from a different background to form a multidisciplinary GHG assurance engagement team to complete an analytical procedures task. It will take about 50 minutes. The last task is to fill a demographic questionnaire. Total time will take a maximum of 120 minutes or 2 hours.

On your desk, there are a series of envelopes containing the training materials. Please only open the appropriate envelope when instructed to do so. Please open Envelope 1. You have 10 minutes to learn this part. You can begin now…

1 minutes warning bell

10 minutes

Training Part 1 is finished. Please answer the question in the last page of the training material. Now, please open Part 2 Training in Envelope 2. You have 10 minutes to learn this part. You can begin now…

1 minutes warning bell

10 minutes

Please stop reading…

Now, please open the third envelope which contains questions that need to be answered. Please write down your answer on space provided. You have 30 minutes to answer. You can use training material Part 2 to answer the questions.

5 minutes warning bell

30 minutes

This part of the session is finished now.

Please answer the question in the last page of your answer sheets.

Next, please open envelope 4A. Please read the instruction and complete the card sorting task. After you have finished sorting the cards, please use paper clips provided to clip each pile and bind all piles together with a rubber band. You have 8 minutes to complete the card sorting task in envelope 4A. Please do not use the training materials to complete this task.

1 minutes warning bell

8 minutes

Card sorting task 4A is finished now

Please open envelope 4B. Please read the instruction and complete the card sorting task. After you have finished sorting the cards, please use a paper clip provided to clip each pile and bind all piles together with a rubber band. You have 8 minutes each to complete the card sorting task in envelope 4B.

1 minutes warning bell

8 minutes

Card sorting task 4B is finished now

Please open envelope 5 which contains a problem that needs to be answered. This question is not related to the training material, so do not use training materials to answer the question. You have 4 minutes to answer this short problem.

4 minutes

Please stop writing now.

The next task is to perform a team task. You will work together with another team member. Your other team member is the participant who sits next to you. Both of you have same number (for example Number 018, but with a different letter. One of you is A, and the other is B. Please introduce yourself with other team member.

Please login to computer using user name and password on the card provided. Please follow the instructions in computer program. In some part of task, you will be asked to join with other team members to discuss and complete the task. You have up to 50 minutes to perform this task.

You will read some background material on your computer screen. Envelope 6 contains a hard copy of this background information if you wish to refer to this during completion of task. Please do not click to go backwards on screen at any time as this may cause a computer problem.

5 minutes warning bell

40 minutes

When this team task is finished, we just need you to open envelope 7 and complete the demographic questions.

Thank you so much for your participation. Please bring your signed payment receipt to me. I will give your $45 payment.

FINISH

A.3.2 Verbal Instruction during Experiment – Collaborative Conditions

Thank you for coming and participating in this study. Your participation in this experiment is really appreciated.

Before we begin, please read the Participant Information Sheet and please sign the Informed Consent Form and also the Receipt. Please recall that you will receive $45 for participating in this study and you also have an opportunity to receive additional cash prizes for participants performing the best, second best and third best in the task.

This study asks you to assume that you are a member of multidisciplinary team. In this team, because the nature and expertise required is complex and diverse, so team members from different backgrounds are needed. In order to contribute to the team, each member should have sufficient knowledge in conducting the task. To form a multidisciplinary team in this study, half of you have background in accounting and the other half of you have background in science or engineering.

Your goal in in this study is to learn about specific knowledge that is needed in order to perform a task. The knowledge needed is for a greenhouse gas (GHG) assurance engagement and the task is an analytical procedures task.

In the first part of training you are asked to learn the basic knowledge involved in GHG statement preparation. This part of training will take 10 minutes. In the second part, you are asked to learn from two case studies providing examples of analytical procedures, an important task in GHG assurance. This second part will take 40 minutes. After completing the two training phases, you will be asked to perform a card sorting task and answer a short question which will take 24 minutes. Next you work with another team member from a different background to form a multidisciplinary GHG assurance engagement team to complete an analytical procedures task. It will take about 50 minutes. The last task is to fill a demographic questionnaire. Total time will take a maximum of 120 minutes or 2 hours.

On your desk, there are a series of envelopes containing the training materials. Please only open the appropriate envelope when instructed to do so. Please open Envelope 1. You have 10 minutes to learn this part. You can begin now…

1 minutes warning bell

10 minutes

Training Part 1 is finished. Please answer the question in the last page of the training material. Now, please open Part 2 Training in Envelope 2. You have 10 minutes to learn this part. You can begin now…

1 minutes warning bell

10 minutes

Please stop reading [*and now please join with your other team member to learn more about the cases by collaborating together. Your other team member is the participant who sits next to you. Both of you have same number (for example Number 076, but with a different letter. One of you is A, and the other is B. Please introduce yourself with other team member.*]

Now, please open the third envelope which contains questions that need to be [*discussed together and*] answered [*as team*]. [*When you discuss with your other team member, please share your relevant knowledge (e.g. knowledge in auditing or knowledge in environmental sciences) in order to understand and solve the problems.*] Please write down your *team's* answer on space provided. You have 30 minutes *to discuss and* answer. You can use training material Part 2 to answer the questions.

5 minutes warning bell

30 minutes

This part of the session is finished now.

Please return to your desk to answer the question in the separate paper in Envelope 3.

Next, please open envelope 4A. Please read the instruction and complete the card sorting task. After you have finished sorting the cards, please use paper clips provided to clip each pile and bind all piles together with a rubber band. You have 8 minutes to complete the card sorting task in envelope 4A.

1 minutes warning bell

8 minutes

Card sorting task 4A is finished now

Please open envelope 4B. Please read the instruction and complete the card sorting task. After you have finished sorting the cards, please use a paper clip provided to clip each pile and bind all piles together with a rubber band. You have 8 minutes each to complete the card sorting task in envelope 4B.

1 minutes warning bell

8 minutes

Card sorting task 4B is finished now

Please open envelope 5 which contains a problem that needs to be answered. This question is not related to the training material, so do not use training materials to answer the question. You have 4 minutes to answer this short problem.

4 minutes

Please stop writing now.

The next task is to perform a team task. Please login to computer using user name and password on the card provided. Please follow the instructions in computer program. In some part of task, you will be asked to join with other team members to discuss and complete the task. You have up to 50 minutes to perform this task.

You will read some background material on your computer screen. Envelope 6 contains a hard copy of this background information if you wish to refer to this during completion of task. Please do not click to go backwards on screen at any time as this may cause a computer problem.

5 minutes warning bell

40 minutes

When this team task is finished, we just need you to open envelope 7 and complete the demographic questions.

Thank you so much for your participation. Please bring your signed payment receipt to me. I will give your $45 payment.

FINISH

A3.3 Verbal Instruction during Experiment – No Training Condition

Thank you for coming and participating in this study. Your participation in this experiment is really appreciated.

Before we begin, please sign the Receipt. Please recall that you will receive $10 for participating in this study.

This study asks you to assume that you are a member of multidisciplinary team. In this team, because the nature and expertise required is complex and diverse, so team members from different backgrounds are needed. In order to contribute to the team, each member should have sufficient knowledge in conducting the task. To form a multidisciplinary team in this study, half of you have background in accounting and the other half of you have background in science or engineering.

Your goal in in this study is to learn about specific knowledge that is needed in order to perform a task. The knowledge needed is for a greenhouse gas (GHG) assurance engagement and the task is an analytical procedures task.

In the training phase you are asked to learn the basic knowledge involved in GHG statement preparation and analytical procedures. This part of training will take 10 minutes. After completing the training phases, you will be asked to answer a short question which will take 5 minutes. Next you will be asked to fill a demographic questionnaire. The last task is you will perform a card sorting task. It will take about 8 minutes. Total time will take a maximum of 25 minutes.

On your desk, there are a series of envelopes containing the training materials. Please only open the appropriate envelope when instructed to do so. Please open Envelope 1. You have 10 minutes to learn this part. You can begin now…

1 minutes warning bell

10 minutes

Training Phase is finished. Please answer the question in the last page of the Part 1 training material and put the training material back into the envelope.

Now, please open Envelope 2. You have 5 minutes to answer the question. You can begin now…

1 minutes warning bell

5 minutes

Please stop writing now and put your answer back into the envelope.

Now, please open the third envelope which contains demographic questions that need to be answered. Please write down your answer on space provided. You have 2 minutes to answer.

2 minutes

Next, please open envelope 4. Please read the instruction and complete the card sorting task. After you have finished sorting the cards, please use paper clips provided to clip each pile and bind all piles together with a rubber band. You have 8 minutes to complete the card sorting task in envelope 4. Please do not use the training materials to complete this task.

1 minutes warning bell

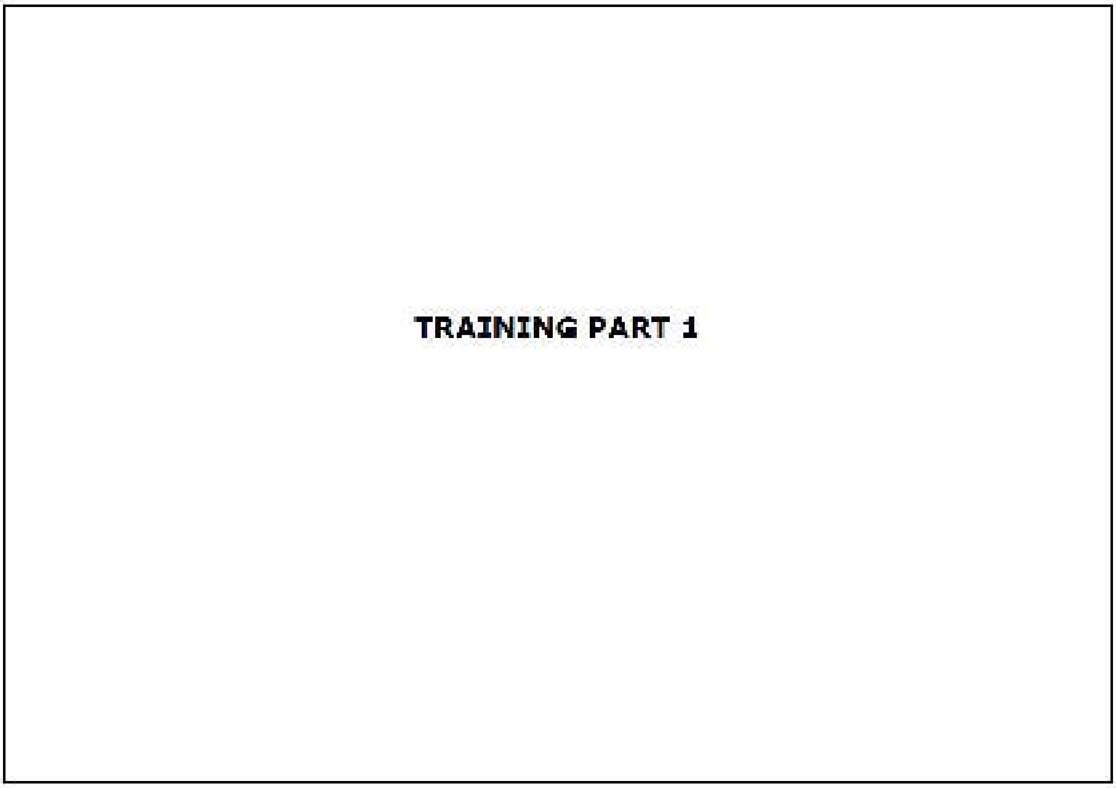
8 minutes

Card sorting task is finished now and the experimental session end now.

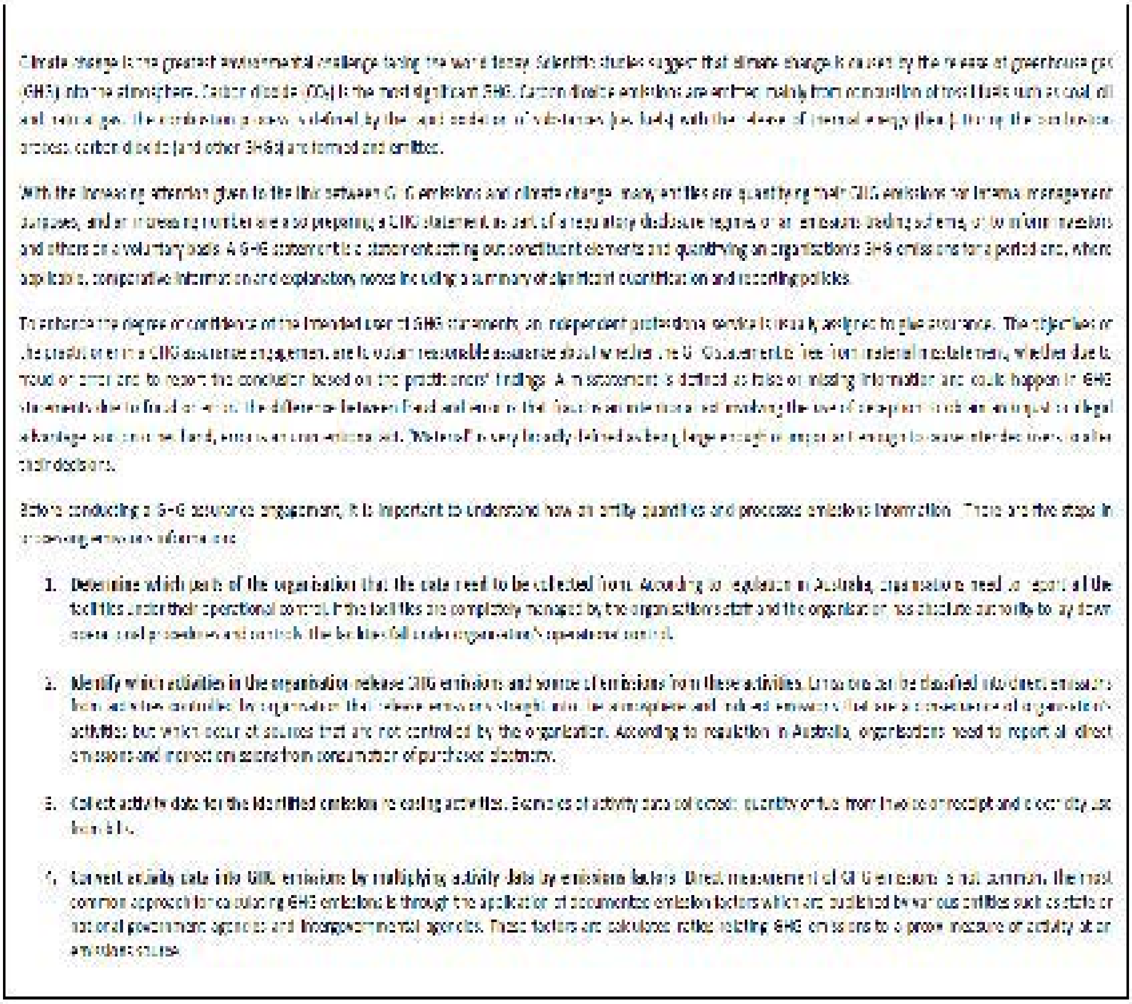
Thank you so much for your participation. Please take your $10 payment.

FINISH

APPENDIX 4: TRAINING MATERIAL – STAGE 1



TRAINING PART 1



Climate change is the greatest environmental challenge facing the world today. Scientific studies suggest that climate change is caused by the release of greenhouse gas (GHG) into the atmosphere. Carbon dioxide (CO_2) is the most significant GHG. Carbon dioxide emissions are emitted mainly from combustion of fossil fuels such as coal, oil and natural gas. The combustion process is defined by the rapid oxidation of substances (i.e. fuels) with the release of thermal energy (heat). During the combustion process, carbon dioxide (and other GHGs) are formed and emitted.

With the increasing attention given to the link between GHG emissions and climate change, many entities are quantifying their GHG emissions for internal management purposes, and an increasing number are also preparing a GHG statement as part of a regulatory disclosure regime or an emissions trading scheme, or to inform investors and others on a voluntary basis. A GHG statement is a statement setting out constituent elements and quantifying an organisation's GHG emissions for a period and, where applicable, comparative information and explanatory notes including a summary of significant quantification and reporting policies.

To enhance the degree of confidence of the intended user of GHG statements, an independent professional service is usually assigned to give assurance. The objectives of the practitioner in a GHG assurance engagement are to obtain reasonable assurance about whether the GHG statement is free from material misstatement, whether due to fraud or error and to report the conclusion based on the practitioners' findings. A misstatement is defined as false or missing information and could happen in GHG statements due to fraud or error. The difference between fraud and error is that fraud is an intentional act involving the use of deception to obtain an unjust or illegal advantage. On the other hand, error is an unintentional act. 'Material' is very broadly defined as being large enough or important enough to cause intended users to alter their decisions.

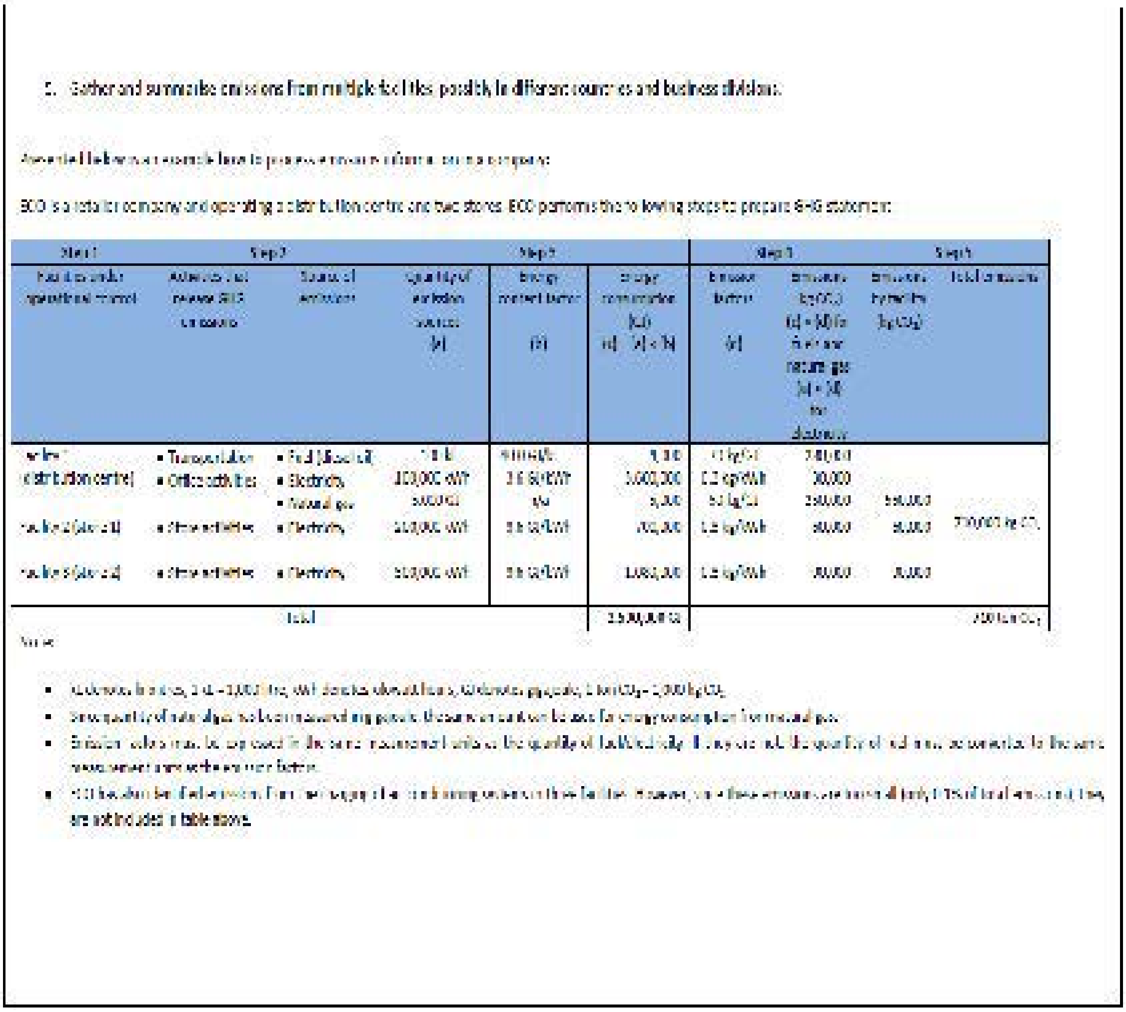
Before conducting a GHG assurance engagement, it is important to understand how an entity quantifies and processes emissions information. There are five steps in processing emissions information:

1. **Determine which parts of the organisation that the data need to be collected from.** According to regulation in Australia, organisations need to report all the facilities under their operational control. If the facilities are completely managed by the organisation's staff and the organisation has absolute authority to lay down operational procedures and controls, the facilities fall under organisation's operational control.

2. **Identify which activities in the organisation release GHG emissions and source of emissions from these activities.** Emissions can be classified into direct emissions from activities controlled by organisation that release emissions straight into the atmosphere and indirect emissions that are a consequence of organisation's activities but which occur at sources that are not controlled by the organization. According to regulation in Australia, organisations need to report all direct emissions and indirect emissions from consumption of purchased electricity.

3. **Collect activity data for the identified emission reporting activities.** Examples of activity data collected: quantity of fuel from invoice or receipt and electricity use from bills.

4. **Convert activity data into GHG emissions by multiplying activity data by emissions factors.** Direct measurement of GHG emissions is not common, the most common approach for calculating GHG emissions is through the application of documented emission factors which are published by various entities such as state or national government agencies and intergovernmental agencies. These factors are calculated ratios relating GHG emissions to a proxy measure of activity at an emissions source.



5. Gather and summarize emissions from multiple facilities, possibly in different countries and business divisions.

[illegible]

[illegible]

Step 1	Step 2			Step 3		Step 4		Step 5	
Facilities under operational control	Activities that release GHG emissions	Source of emissions	Quantity of emission sources (a)	Energy content factor (b)	Energy consumption (GJ) (c) = (a) × (b)	Emission factor (d)	Emissions kgCO2 (e) = (c) × (d) for fuel and natural gas (a) × (d) for electricity	Emissions by facilities (kgCO2)	Total emissions
Facility 1 (distribution centre)	• Transportation • Office activities	• Fuel (diesel oil) • Electricity • Natural gas	[illegible] [illegible] [illegible]	[illegible] [illegible] n/a	[illegible] [illegible] [illegible]	[illegible] [illegible] [illegible]	[illegible] [illegible] [illegible]	[illegible]	
Facility 2 (store 1)	• Store activities	• Electricity	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Facility 3 (store 2)	• Store activities	• Electricity	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Total					[illegible]				[illegible]

Notes:

- [illegible]
- [illegible]
- [illegible]
- [illegible] are not included in table above.

APPENDIX 5: TRAINING MATERIAL – STAGE 2

A.5.1 Introduction to Analytical Procedures Task

A.5.2 Case A: Description and Questions

A.5.3 Case A: Solutions to the Questions

A.5.4 Case B: Description and Questions

A.5.5 Case B: Solutions to the Questions

A.5.1 Introduction to Analytical Procedures Task

TRAINING PART 2 – ANALYTICAL PROCEDURES TASK IN A GHG ASSURANCE ENGAGEMENT

In this study you are asked to learn **analytical procedures**, one type of procedure which is important in GHG assurance engagements. The utilisation of analytical procedures is important, due to the fixed nature of the physical or chemical relationship between particular emissions and other measurable phenomena.

Analytical procedures consist of evaluations of information made by a study of plausible relationships between various data sets (i.e. greenhouse gas emissions and units of production). They also encompass the investigation of identified fluctuations and relationships that are inconsistent with other relevant information, established expectations, or deviate significantly from predicted amounts. As one of the purposes of the assurance engagement plan is an efficient and effective assurance engagement, analytical procedures are often used as one of the key means of testing the reported data.

Performing analytical procedures can be done in the following steps:

STEP 1: Develop the expectation of emissions and energy consumption.

STEP 2: Define the significant difference between the expected and the reported amounts.

STEP 3: Compare the expected and the reported amounts and compute the differences.

STEP 4: If the differences are significant, investigate the differences by generating the potential causes of the differences or fluctuations.

STEP 5: Test the potential causes by gathering information through performing specific assurance tests.

STEP 6: Evaluate the potential causes based on result of assurance tests.

STEP 7: Select the most likely cause of differences.

STEP 8: Take action based on this finding, i.e. propose an adjustment to reported emissions and energy consumption.

In a moment, you will be reading examples of an analytical procedures task in a GHG assurance engagement, particularly from Step 3 until Step 7. Please pay close attention, as you will be asked questions afterwards.

A.5.2 Case A: Description and Questions

CASE A

A GHG assurance engagement team consisting of Kenneth (an auditor) and Samantha (an environmental scientist) are assigned to perform analytical procedures on the reported GHG statement of **ABC Properties (ABC)**, a facility manager of commercial office buildings. The emissions from commercial building operators, such as ABC, arise primarily from energy use, particularly electricity consumption and fuel used for heating.

To gain the necessary assurance, the team is performing analytical procedures over the reported GHG emissions. The following are analytical procedures steps the team performed. The first step in this task, developing the expectation of total emissions, has already been conducted using the projections developed by the team's assurance firm. The projections were developed by a highly reliable software package and are based on results of the calculation of the current activity data and relevant emission factors, last year's data and industry trends. The projection also includes the calculation of energy consumption by ABC.

The next step in this task is to compare this expectation with reported amounts. Presented below are two items from the actual reported GHG statement of ABC and its expected amounts. The numbers in the first column were from ABC's current year's unassured GHG statement, while the numbers in second column are from the projected GHG statement. The third and fourth columns are the differences between reported and expected amounts.

	Reported	Expected	Differences	Differences (percentage)
Energy consumption (GJ)	900,000	1,000,000	100,000	**-10%**
Total emissions (ton CO_2)	370	400	30	**-10%**

The assurance team members have agreed that the differences found from this comparison will be considered material if they exceed a 4% difference. Based on discussions among team members, the team has determined that the above fluctuations are considered to be unexpected and material. The team task is to determine the ***single*** most likely cause that led to the observed fluctuations in items presented above.

In order to gather information on the above fluctuations, the team approached ABC's management who provides the team with an explanation that ABC has initiated an energy efficiency program. As a result, energy consumption and emissions decrease and are lower than expected.

QUESTIONS TO CONSIDER IN COMPLETING THE ANALYTICAL PROCEDURES CASE A:

a) How does the team perform the comparison and generate the appropriate potential causes that led the observed fluctuations?

b) Presented below are the provided items of information related to assurance tests and the result of tests that can be used by the team to test the potential causes. Based on this information, how does the team evaluate the potential causes and select the most likely cause?

Assurance test performed	Result of test
Review and test the organisation's method for determining facilities and emission sources under its operational control	ABC has appropriately determined facilities under its operational control.
Compare reported energy consumption to summary in financial reports and agree to source documents.	Energy consumption was recorded properly.
Review and test the organisation's method for measuring and calculating energy consumption.	ABC has accurately measured and calculated energy consumption.
By type of energy and facility, compare the energy included in the emission calculations to reported energy consumption.	The emissions were calculated and recorded properly based on correct number of energy consumed by ABC's facilities and divisions.
Review and test the appropriateness of the use of emission factors in emission calculations.	The emission factors used were correct.
Review and test the processing steps in calculating and aggregating emissions.	The emissions were calculated accurately.
Review and test the correctness of unit measurement to emission calculations.	The emissions were calculated using correct unit measurement.
Review the organisations' energy efficiency and/or emissions reduction programs.	The program successfully reduces energy consumption and emissions by 10%. The analysis is based on sound calculation and valid data.

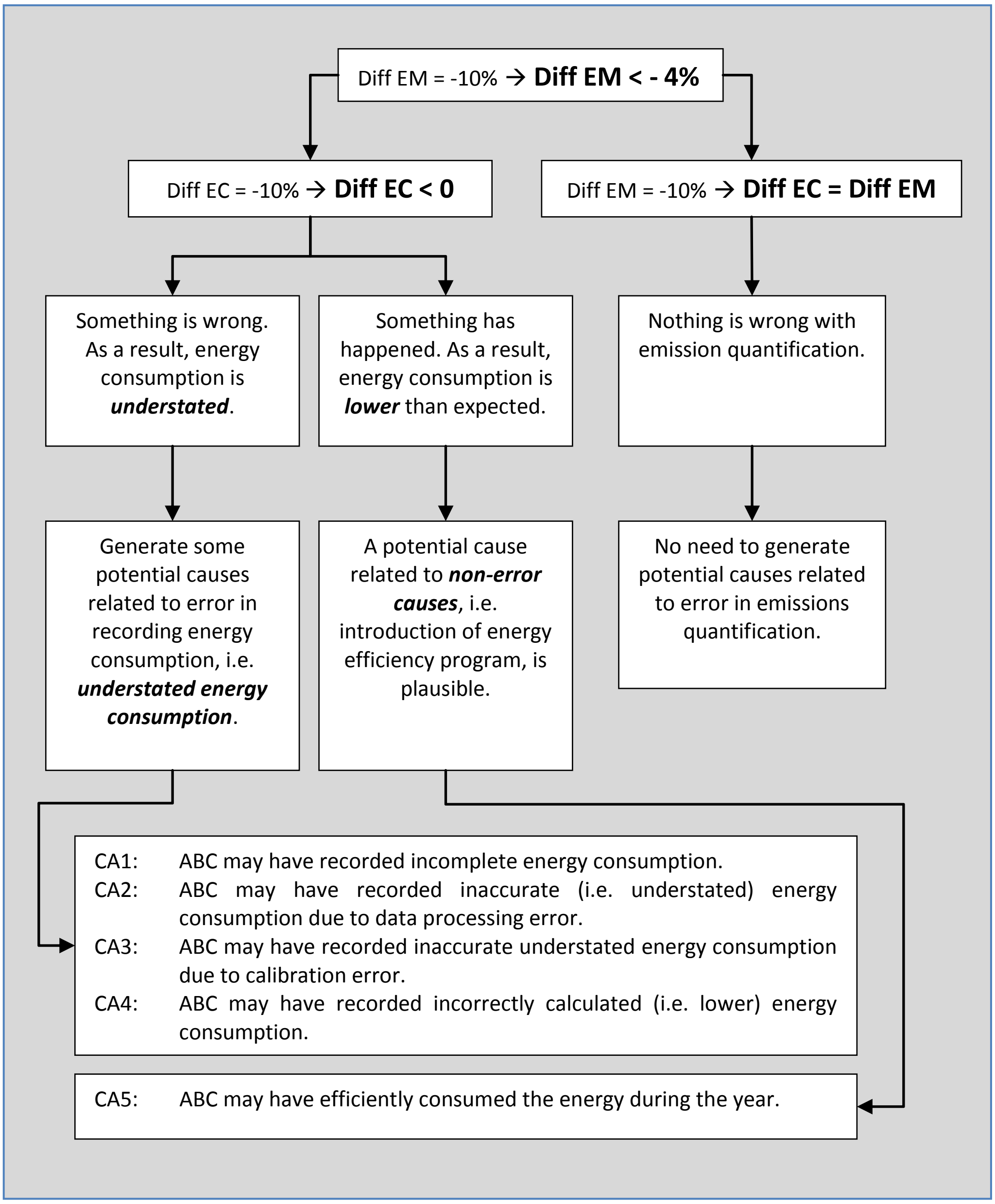
A.5.3 Case A: Solutions to the Questions

SOLUTION TO THE QUESTIONS NOTED FOR CASE A:

Presented below are the diagrams relating to their performance of the analytical procedures task.

Note: The team denotes ***Diff EC*** for difference between reported and expected energy consumption, ***Diff EM*** for the difference between expected and reported emissions.

a) How does the team perform the comparison and generate the appropriate potential causes that led the observed fluctuations?



Something is wrong. As a result, energy consumption is ***understated***.

Something has happened. As a result, energy consumption is ***lower*** than expected.

Nothing is wrong with emission quantification.

Generate some potential causes related to error in recording energy consumption, i.e. ***understated energy consumption***.

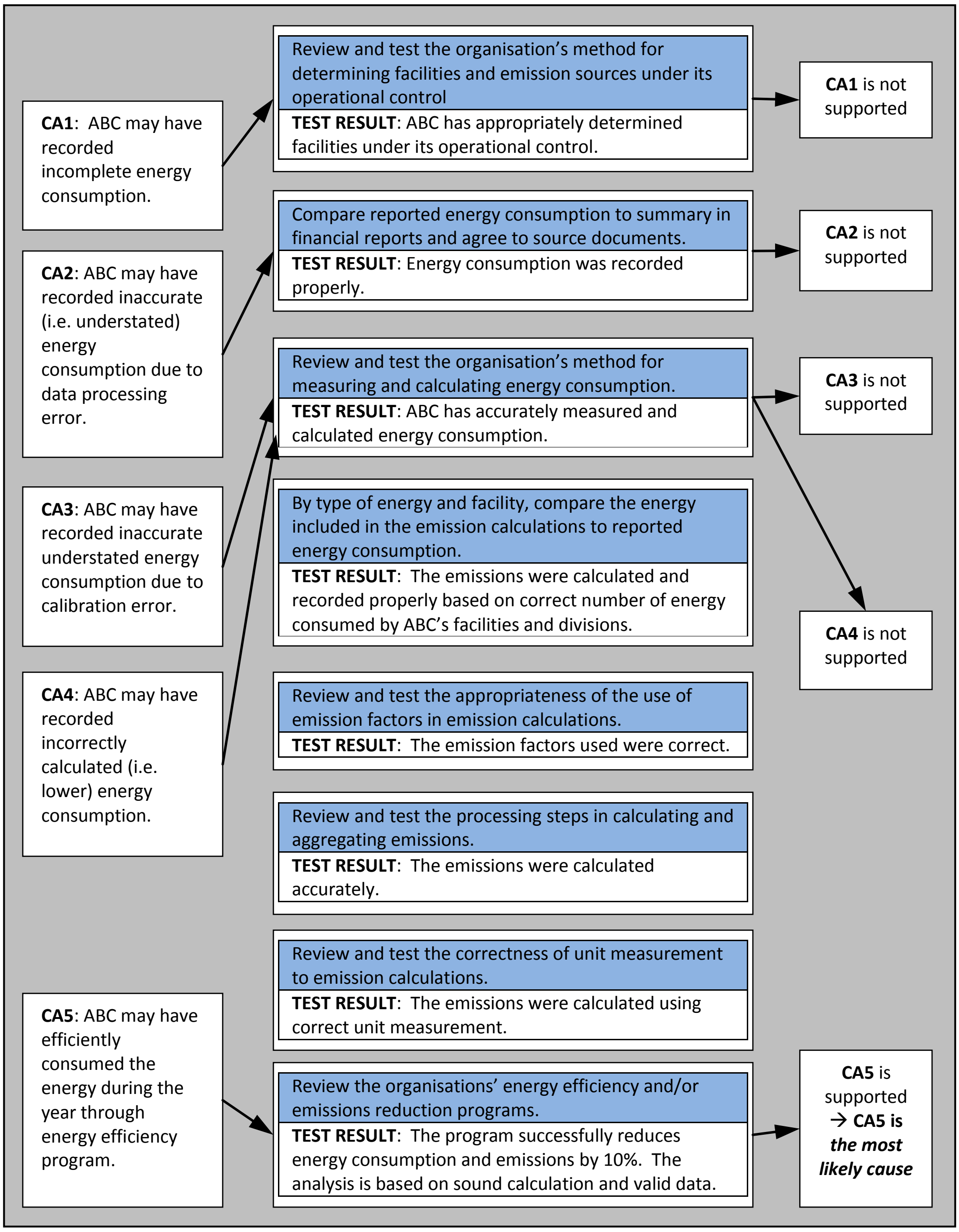
A potential cause related to ***non-error causes***, i.e. introduction of energy efficiency program, is plausible.

No need to generate potential causes related to error in emissions quantification.

CA1: ABC may have recorded incomplete energy consumption.
CA2: ABC may have recorded inaccurate (i.e. understated) energy consumption due to data processing error.
CA3: ABC may have recorded inaccurate understated energy consumption due to calibration error.
CA4: ABC may have recorded incorrectly calculated (i.e. lower) energy consumption.

CA5: ABC may have efficiently consumed the energy during the year.

b) How does the team evaluate the potential causes and select the most likely cause?



CA1: ABC may have recorded incomplete energy consumption.

CA2: ABC may have recorded inaccurate (i.e. understated) energy consumption due to data processing error.

CA3: ABC may have recorded inaccurate understated energy consumption due to calibration error.

CA4: ABC may have recorded incorrectly calculated (i.e. lower) energy consumption.

CA5: ABC may have efficiently consumed the energy during the year through energy efficiency program.

Review and test the organisation's method for determining facilities and emission sources under its operational control

TEST RESULT: ABC has appropriately determined facilities under its operational control.

Compare reported energy consumption to summary in financial reports and agree to source documents.

TEST RESULT: Energy consumption was recorded properly.

Review and test the organisation's method for measuring and calculating energy consumption.

TEST RESULT: ABC has accurately measured and calculated energy consumption.

By type of energy and facility, compare the energy included in the emission calculations to reported energy consumption.

TEST RESULT: The emissions were calculated and recorded properly based on correct number of energy consumed by ABC's facilities and divisions.

Review and test the appropriateness of the use of emission factors in emission calculations.

TEST RESULT: The emission factors used were correct.

Review and test the processing steps in calculating and aggregating emissions.

TEST RESULT: The emissions were calculated accurately.

Review and test the correctness of unit measurement to emission calculations.

TEST RESULT: The emissions were calculated using correct unit measurement.

Review the organisations' energy efficiency and/or emissions reduction programs.

TEST RESULT: The program successfully reduces energy consumption and emissions by 10%. The analysis is based on sound calculation and valid data.

CA1 is not supported

CA2 is not supported

CA3 is not supported

CA4 is not supported

CA5 is supported → **CA5** is ***the most likely cause***

A.5.4 Case B: Description and Questions

CASE B

Alicia (an auditor) and Nathan (an environmental scientist) are members of a GHG assurance engagement team for **DE Food Company (DEF)**, a supplier of food to supermarkets. The main product is bread. The production of bread involves the use of gas and electricity, with the majority of energy consumed in the baking process.

The team is performing analytical procedures on the reported GHG emissions in order to gain necessary assurance. The procedure begins with developing the expectation of total emissions. This has already been conducted using the projections developed by the team's assurance firm. The projections were developed by a highly reliable software package and are based on results of the calculation of the current activity data and relevant emission factors, last year data and industry trends. The projections also include the calculation of energy consumption by DEF.

The next step in this task is to compare this expectation with reported amounts. Presented below are two items from the actual reported GHG statement of DEF and its expected amounts. The numbers in the first column were from DEF's current year's unassured GHG statement, while the numbers in second column are from the projected GHG statement. The third and fourth columns are the differences between reported and expected amounts.

	Reported	Expected	Differences	Differences (percentage)
Energy consumption (GJ)	1,000,000	1,000,000	0	**0%**
Total emissions (ton CO_2)	520	400	120	**30%**

The assurance team members have agreed that the differences found from this comparison will be considered material if they exceed a 4% difference. Based on discussions among team members, the team has determined that the above fluctuations are considered to be unexpected and material. The team task is to determine the ***single*** most likely cause that led to the observed fluctuations in items presented above.

In order to gather information on the above fluctuations, the team approached a DEF's management and he has provided the team with an explanation that there were an increase consumption of higher emission fuels, such as diesel oil, in one of its facilities. As a result, the current year's emissions are higher than expected.

QUESTIONS TO CONSIDER IN COMPLETING THE ANALYTICAL PROCEDURES CASE B:

a) How does the team perform the comparison and generate the appropriate potential causes that led the observed fluctuations?

b) Presented below are the provided items of information related to assurance tests and the result of tests that can be used by the team to test the potential causes. Based on this information, how does the team evaluate the potential causes and select the most likely cause?

Assurance test performed	Result of test
Review and test the organisation's method for determining facilities and emission sources under its operational control	DEF has appropriately determined facilities under its operational control.
Compare reported energy consumption to summary in financial reports and agree to source documents.	Energy consumption was recorded properly.
Review and test the organisation's method for measuring and calculating energy consumption.	DEF has accurately measured and calculated energy consumption.
By type of energy and facility, compare the energy included in the emission calculations to reported energy consumption.	The emissions were calculated and recorded properly based on correct amount of energy consumed by DEF's facilities and divisions.
Review and test the appropriateness of the use of emission factors in emission calculations.	The emission factor used to calculate electricity consumption in a facility was 0.5 (0.2 higher than 0.3, the correct emission factor).
Review and test the processing steps in calculating and aggregating emissions.	The emissions were calculated accurately.
Review and test the correctness of unit measurement to emission calculations.	The emissions were calculated using correct unit measurement.
Review the organisations' energy efficiency and/or emissions reduction programs.	The consumption of diesel oil is increased by 1%, however because of this shift; the emissions were only increased by 0.5%.

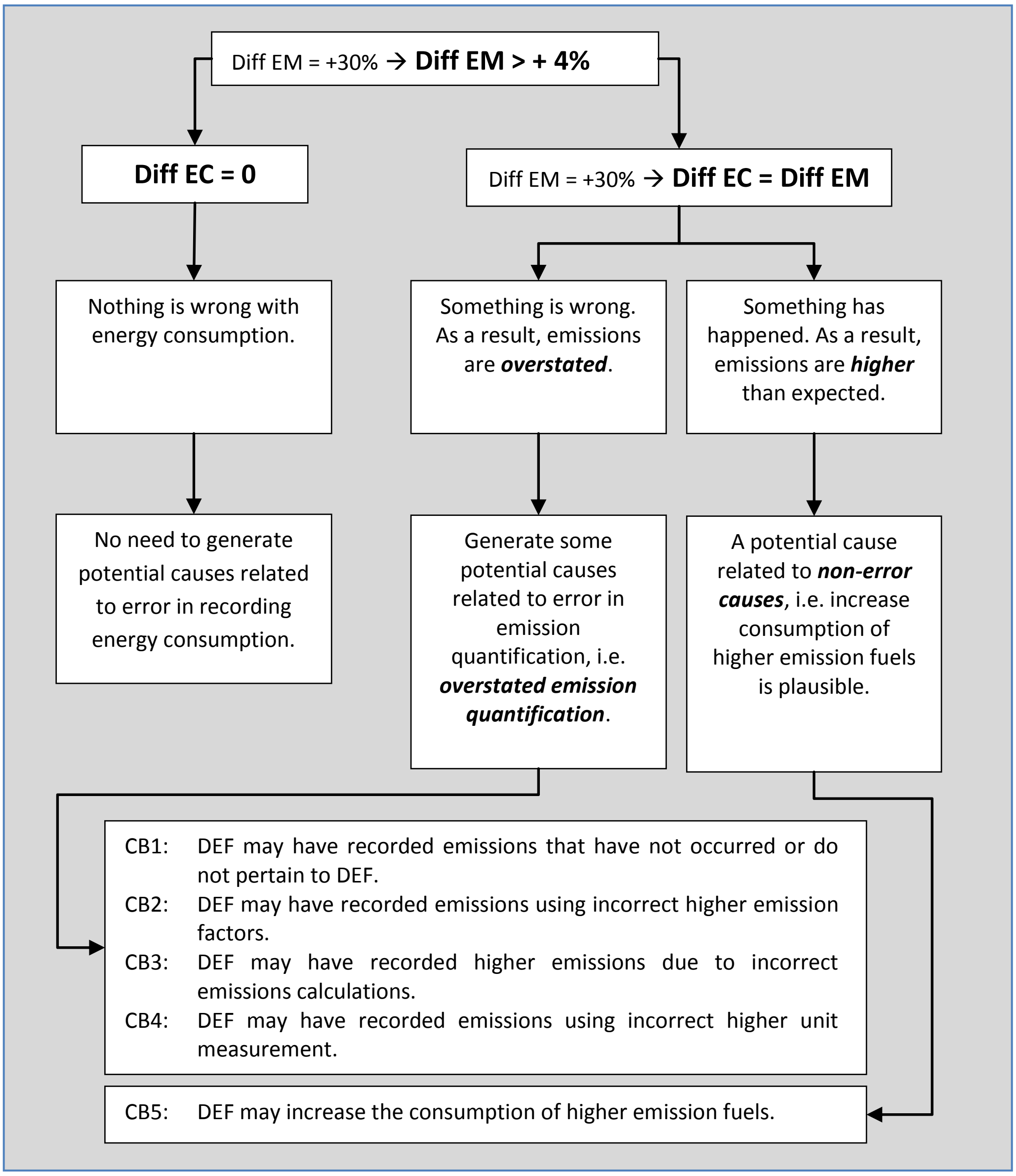
A.5.5 Case B: Solutions to the Questions

SOLUTION TO THE QUESTIONS NOTED FOR CASE B:

Presented below are the diagrams relating to their performance of the analytical procedures task.

Note: The team denotes ***Diff EC*** for difference between reported and expected energy consumption, ***Diff EM*** for the difference between expected and reported emissions.

a) How does the team perform the comparison and generate the appropriate potential causes that led the observed fluctuations?



Nothing is wrong with energy consumption.

No need to generate potential causes related to error in recording energy consumption.

Something is wrong. As a result, emissions are ***overstated***.

Generate some potential causes related to error in emission quantification, i.e. ***overstated emission quantification***.

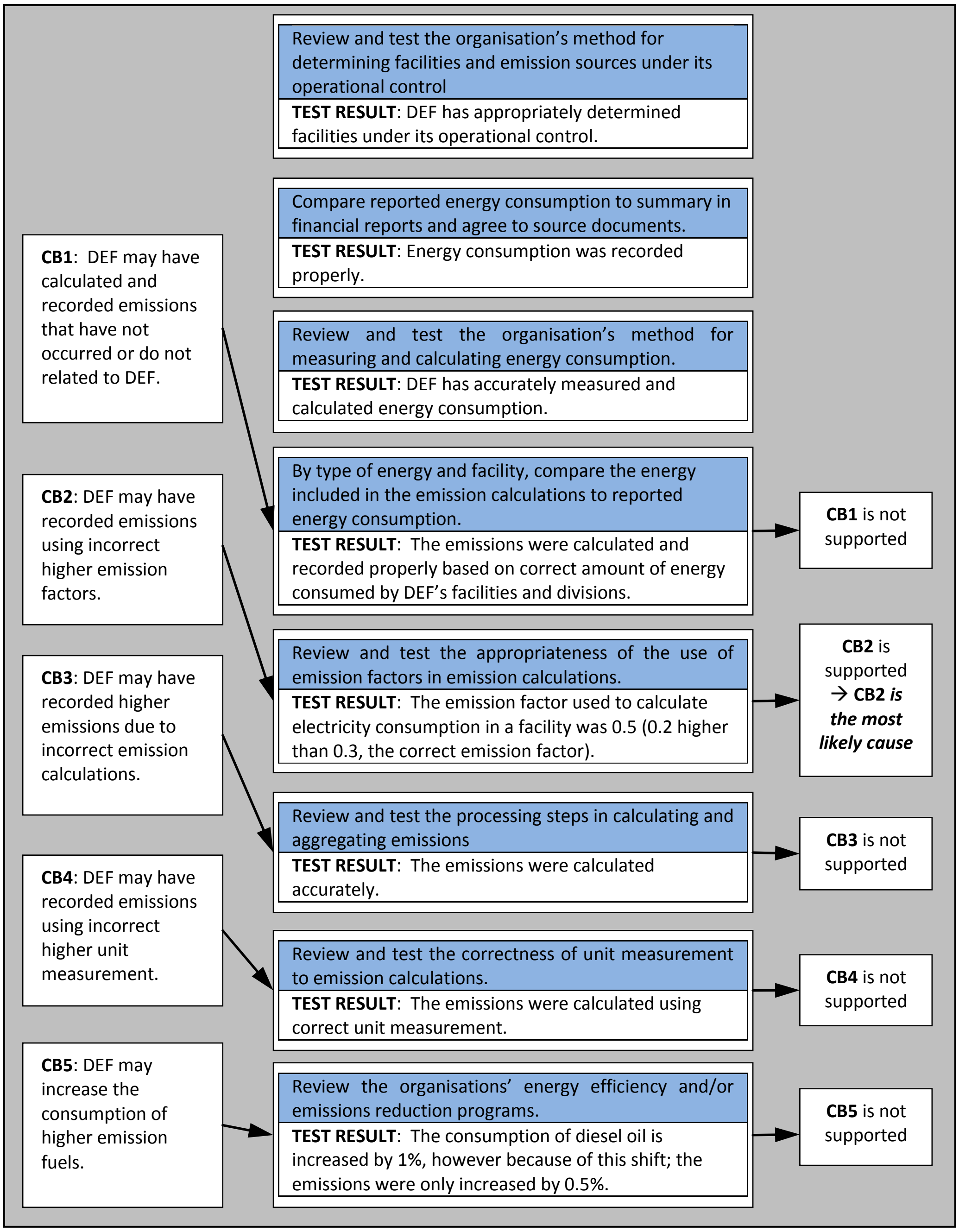
Something has happened. As a result, emissions are ***higher*** than expected.

A potential cause related to ***non-error causes***, i.e. increase consumption of higher emission fuels is plausible.

CB1: DEF may have recorded emissions that have not occurred or do not pertain to DEF.
CB2: DEF may have recorded emissions using incorrect higher emission factors.
CB3: DEF may have recorded higher emissions due to incorrect emissions calculations.
CB4: DEF may have recorded emissions using incorrect higher unit measurement.

CB5: DEF may increase the consumption of higher emission fuels.

b) How does the team evaluate the potential causes and select the most likely cause?



Review and test the organisation’s method for determining facilities and emission sources under its operational control

TEST RESULT: DEF has appropriately determined facilities under its operational control.

Compare reported energy consumption to summary in financial reports and agree to source documents.

TEST RESULT: Energy consumption was recorded properly.

Review and test the organisation’s method for measuring and calculating energy consumption.

TEST RESULT: DEF has accurately measured and calculated energy consumption.

CB1: DEF may have calculated and recorded emissions that have not occurred or do not related to DEF.

By type of energy and facility, compare the energy included in the emission calculations to reported energy consumption.

TEST RESULT: The emissions were calculated and recorded properly based on correct amount of energy consumed by DEF’s facilities and divisions.

CB1 is not supported

CB2: DEF may have recorded emissions using incorrect higher emission factors.

Review and test the appropriateness of the use of emission factors in emission calculations.

TEST RESULT: The emission factor used to calculate electricity consumption in a facility was 0.5 (0.2 higher than 0.3, the correct emission factor).

CB2 is supported → ***CB2 is the most likely cause***

CB3: DEF may have recorded higher emissions due to incorrect emission calculations.

Review and test the processing steps in calculating and aggregating emissions

TEST RESULT: The emissions were calculated accurately.

CB3 is not supported

CB4: DEF may have recorded emissions using incorrect higher unit measurement.

Review and test the correctness of unit measurement to emission calculations.

TEST RESULT: The emissions were calculated using correct unit measurement.

CB4 is not supported

CB5: DEF may increase the consumption of higher emission fuels.

Review the organisations’ energy efficiency and/or emissions reduction programs.

TEST RESULT: The consumption of diesel oil is increased by 1%, however because of this shift; the emissions were only increased by 0.5%.

CB5 is not supported

APPENDIX 6: TRAINING MANIPULATION

A.6.1 No Analogical Encoding Training Conditions (Condition 1 and Condition 3)

A.6.2 Analogical Encoding Training Conditions (Condition 2 and Condition 4)

A.6.1 No Analogical Encoding Training Condition (Condition 1 and Condition 3)

QUESTIONS TO BE ANSWERED BY TEAM MEMBERS

Based on solutions to **Case A**, please answer the following questions:

[FOR COLLABORATIVE LEARNING CONDITION – CONDITION 3]
Note: Remember when you discuss with other team member, please share your relevant knowledge (e.g. knowledge in auditing or knowledge in environmental sciences) in order to understand and solve the problems).

1. Describe how the team in Case A makes comparison between expected and reported amounts and think about the possible reasons that cause the fluctuations.

2. Describe how the team in Case A generates the potential causes that led to the observed fluctuations.

3. Describe why the team in **Case A** generates these five potential causes.

4. Describe how the team in **Case A** evaluates the potential causes based on the results of assurance test and select the most likely cause.

QUESTIONS TO BE ANSWERED BY TEAM MEMBERS

Based on solutions to **Case B**, please answer the following questions:

1. Describe how the team in **Case B** makes comparison between expected and reported amounts and think about the possible reasons that cause the fluctuations.

2. Describe how the team in **Case B** generates the potential causes that led to the observed fluctuations.

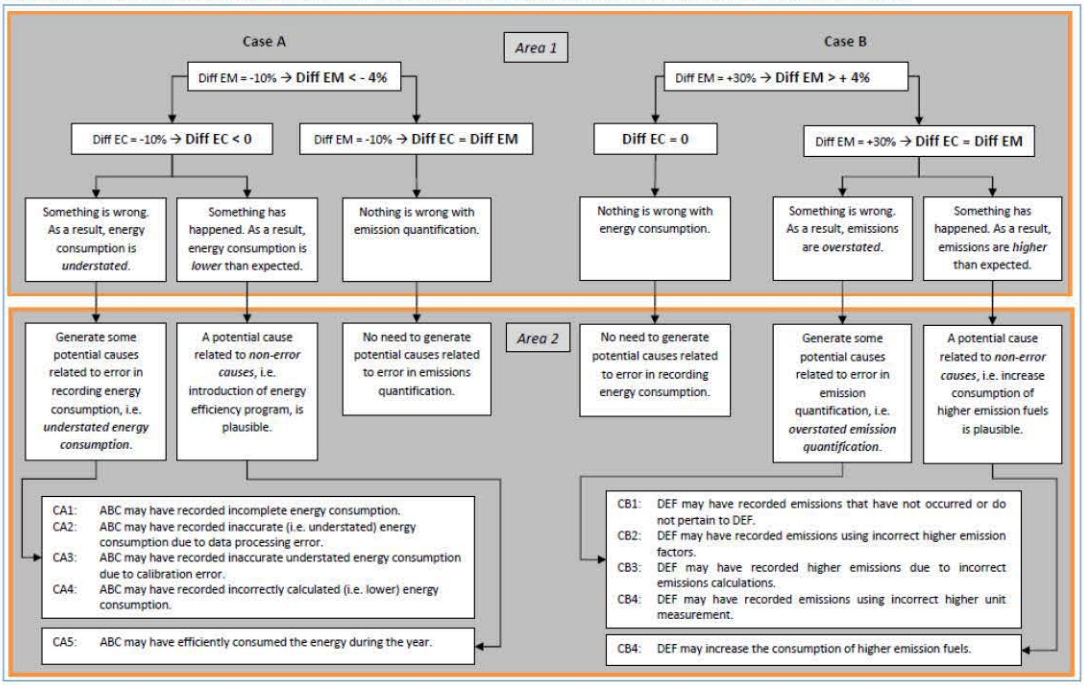
3. Describe why the team in **Case B** generates these five potential causes.

4. Describe how the team in **Case B** evaluates the potential causes based on the results of assurance test and select the most likely cause.

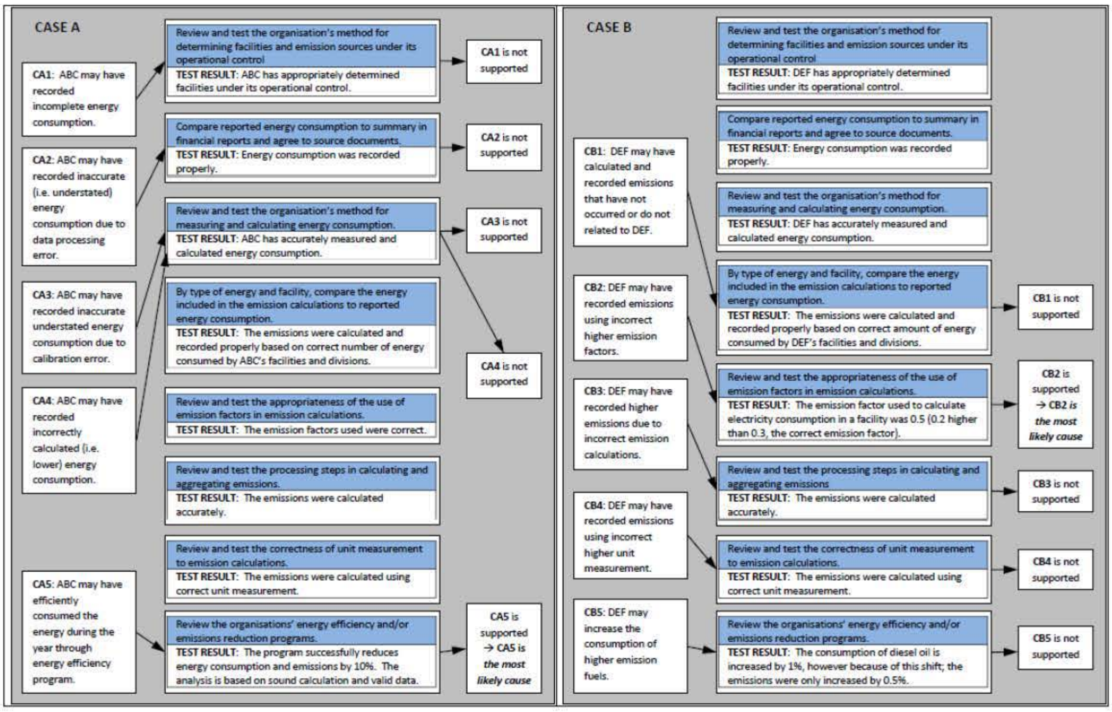
A.6.2 Analogical Encoding Training Conditions (Condition 2 and Condition 4)

COMPARISON OF SOLUTIONS

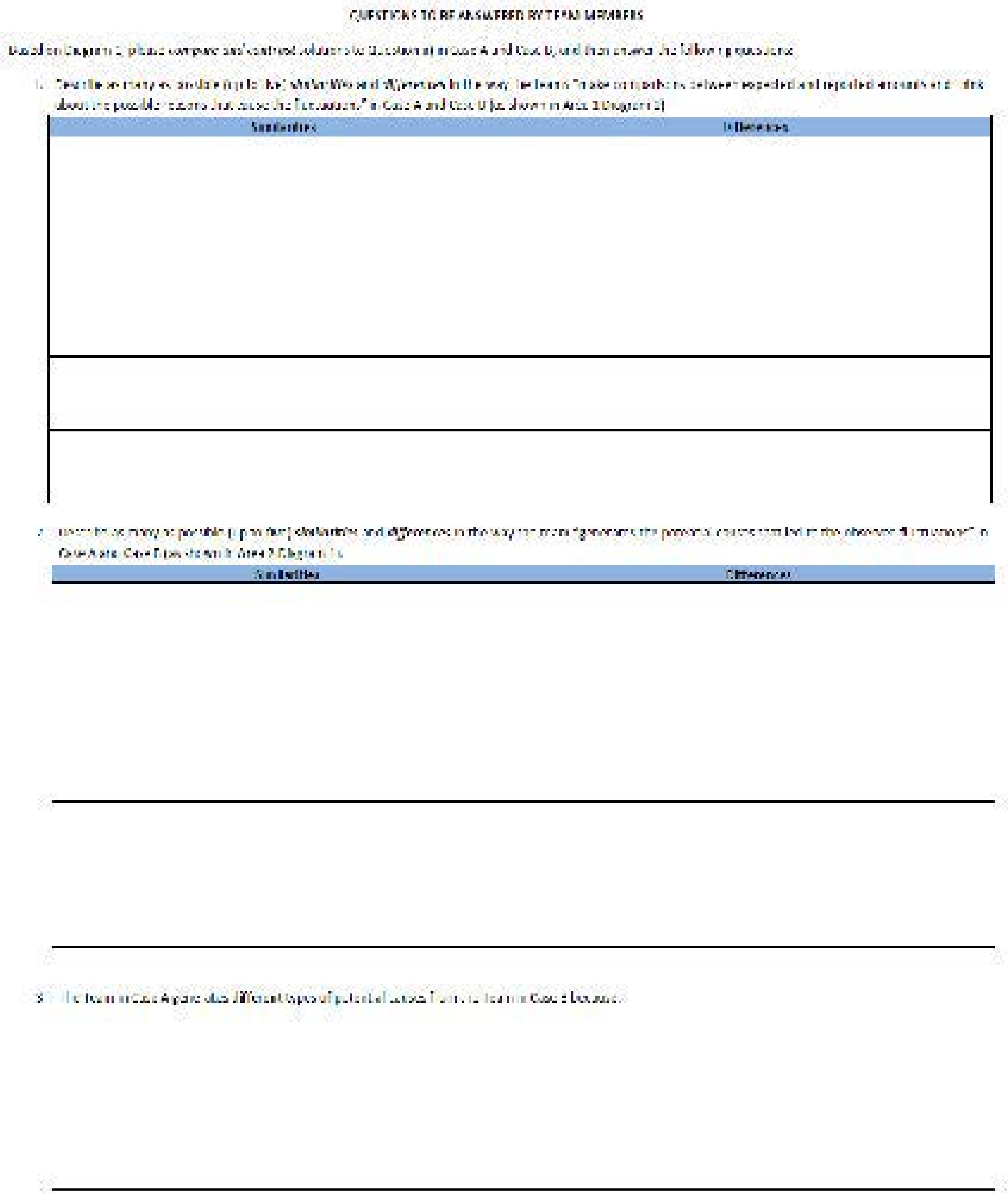
a. **Diagram 1** - How does the team perform the comparison and generate the appropriate potential causes that led to the observed fluctuations?



b. **Diagram 2** - How does the team evaluate the potential causes based on results of assurance tests and select the most likely cause?



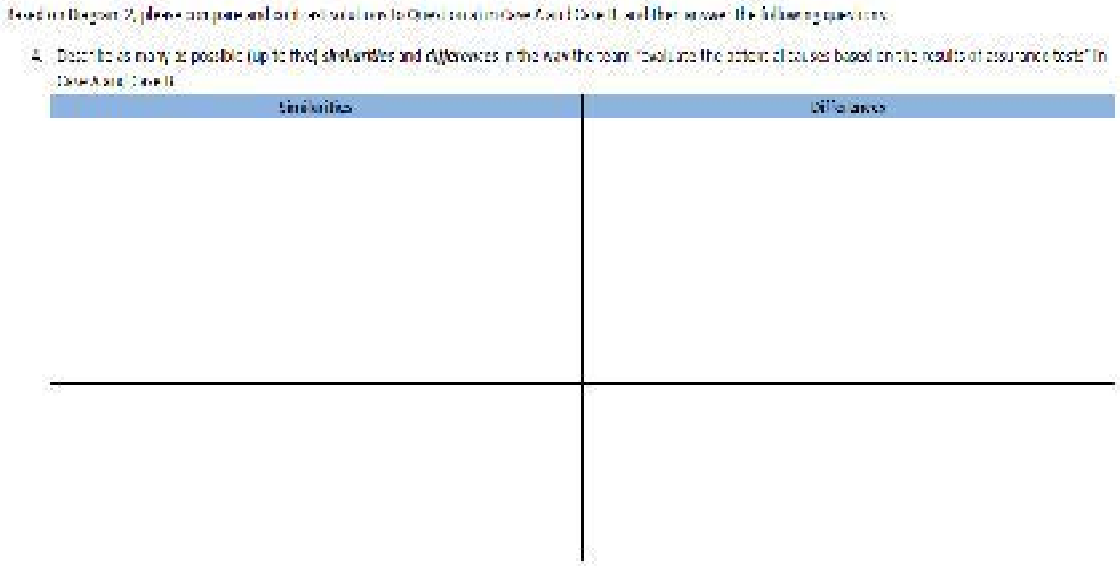
[FOR COLLABORATIVE LEARNING CONDITION – CONDITION 3]
Note: Remember when you discuss with other team member, please share your relevant knowledge (e.g. knowledge in auditing or knowledge in environmental sciences) in order to understand and solve the problems).



QUESTIONS TO BE ANSWERED BY TEAM MEMBERS

Similarities	Differences

Similarities	Differences



Based on Report 2, please compare and contrast solutions to [illegible] in Case A and Case B, and then answer the following questions.

A. Describe as many as possible (up to five) *similarities* and *differences* in the way the team "evaluate the options of causes based on the results of assurance tests" in Case A and Case B.

Similarities	Differences

APPENDIX 7: COGNITIVE LOAD MEASURE

Thank you for completing Phase 2 Training. We are now going to ask you a question about the training you just completed.

1. Please rate how difficult you found this training material?

Extremely Easy			**Undecided**			**Extremely Difficult**
1	**2**	**3**	**4**	**5**	**6**	**7**

APPENDIX 8: INSTRUCTION FOR KNOWLEDGE STRUCTURE AND TEAM MENTAL MODEL MEASUREMENT

Presented below is set of cards representing some potential causes that can explain the fluctuations between expected and reported amounts of energy consumption and/or emissions.

Take these cards and put them into piles representing categories that make sense to you. You may make as many or as few categories as you like. When they are sorted, write a name on the card on the top of each pile for that category. The name can be as long and descriptive as you like, we just want to get a sense of why you consider those cards to be a group - the name does not have to be perfect.

After you have finished sorting the cards, please use a paper clip provided to clip each pile and bind all piles together with a rubber band. You have 8 minutes to complete this card sorting task.

APPENDIX 9: INSTRUCTION FOR TRANSACTIVE MEMORY SYSTEMS MEASUREMENT

Presented below is set of cards representing the tasks related to working as a team in performing an analytical procedures task. Take these cards and put them into piles representing one of these categories:

- Tasks that you believe that both accounting experts and environmental scientists/engineers would do together
- Tasks that you believe that both accounting experts and environmental scientists/engineers would do individually and separately
- Tasks that you believe that only accounting experts would do individually (i.e. environmental scientists/engineers would not do this task)
- Tasks that you believe that only environmental science/engineers would do individually (i.e. accounting experts would not do this task)

After you have finished sorting the cards, please use a paper clip provided to clip each pile and bind all piles together with a rubber band. You have 8 minutes to complete this card sorting task.

APPENDIX 10: DISTRACTOR TASK

Short Question

Please give your answer to the following question:

Assume that you just got your television set back from the repair shop and it cost you $125 to have it repaired. Now it is beginning to do the same thing that you paid to get fixed. What would you do?

Please write down your answer in the provided space below:

APPENDIX 11: TEST PHASE – COMPUTER SCREENS

APPENDIX 11: TEST PHASE – COMPUTER SCREENS (Continued)

APPENDIX 11: TEST PHASE – COMPUTER SCREENS (Continued)

A.11.5 Final Judgment: Stage 4e

A.11.5.1 Selection of the Most Likely Hypothesis

A.11.5.2 Completing the Task

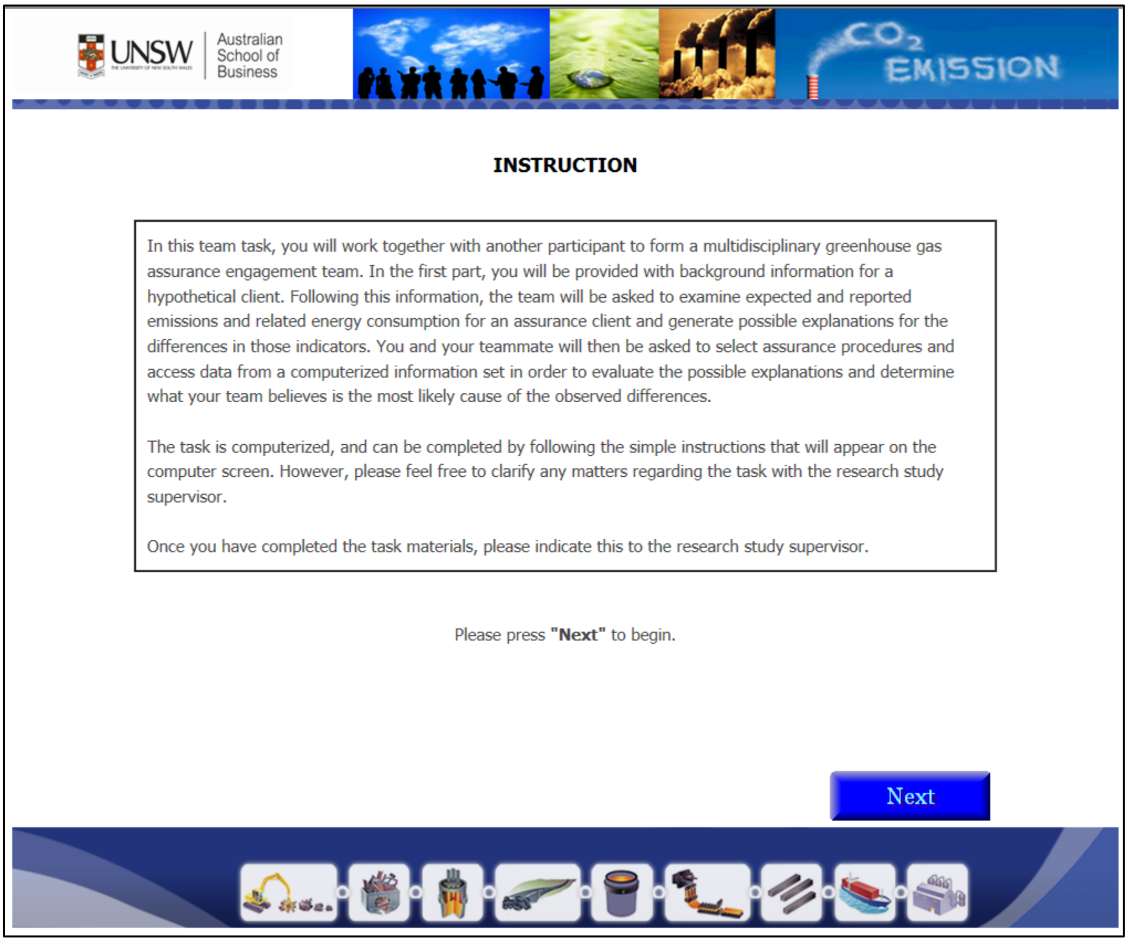
A.11.5.3 Completing the Task for Team Member A

A.11.5.4 Completing the Task for Team Member B

A.11.1 Background Information and Problem Representation: Stage 4a

A.11.1.1 Opening Screen

A.11.1.2 Instruction Screen



INSTRUCTION

In this team task, you will work together with another participant to form a multidisciplinary greenhouse gas assurance engagement team. In the first part, you will be provided with background information for a hypothetical client. Following this information, the team will be asked to examine expected and reported emissions and related energy consumption for an assurance client and generate possible explanations for the differences in those indicators. You and your teammate will then be asked to select assurance procedures and access data from a computerized information set in order to evaluate the possible explanations and determine what your team believes is the most likely cause of the observed differences.

The task is computerized, and can be completed by following the simple instructions that will appear on the computer screen. However, please feel free to clarify any matters regarding the task with the research study supervisor.

Once you have completed the task materials, please indicate this to the research study supervisor.

Please press **"Next"** to begin.

A.11.1.3 Background Information

BACKGROUND INFORMATION

Client Information:

Remington Steel Company (Remsco) manufactures steel sections for use in the construction industry. The company's operation consists of the following sequential steps (**see also Figure 1**): melting scrap steel (and some iron) in an electric arc furnace, adjusting the steel chemistry to exact specifications in a ladle furnace and then casting into basic billets. The billets are then transferred to a hot rolling mill where they are rolled through a series of mill stands to obtain the correct length and cross section as required by the customer orders.

Remsco has four manufacturing plants (Plant A, B, C and D).

Electric Arc Furnace

An electric arc furnace (EAF) is used to produce new steel from scrap metal. This method is lower cost than the traditional blast furnace method of making steel and it conserves raw materials like iron ore, coke and fluxes. The EAF is a large circular steel-lined shell which is filled with a refractory material. Power is supplied to the furnace through the **electrodes**. The electrodes are placed in the furnace and when the power is applied it produces an arc of electricity from the electrode to the scrap steel. The energy from the arch raises the temperature to 1600°C, melting the scrap. The EAF process also uses oxygen, hydrogen, nitrogen and fluxes to control the temperature, to remove small amounts of impurity and prevent oxidation from the air. After about 80 minutes, the molten steel is tapped into a ladle and transferred to the **ladle furnace**.

The main source of scrap steel is from cars, but washing machines, fridges, bicycles and steel from demolished buildings can also be recycled using the EAF.

Casting

The liquid steel is then cast into steel billets which are then ready to be used in the rolling mills.

Rolling

Rolling is the main method to shape steel into different products after it has been cast. At the rolling mills at Remsco, the steel billets are re-heated in a furnace to about 1200°C. The re-heated billet is then drawn from the furnace and passed through a series of mill stands to form the desired end products.

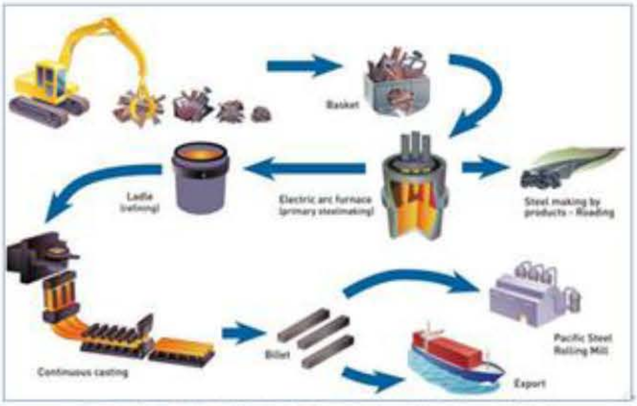
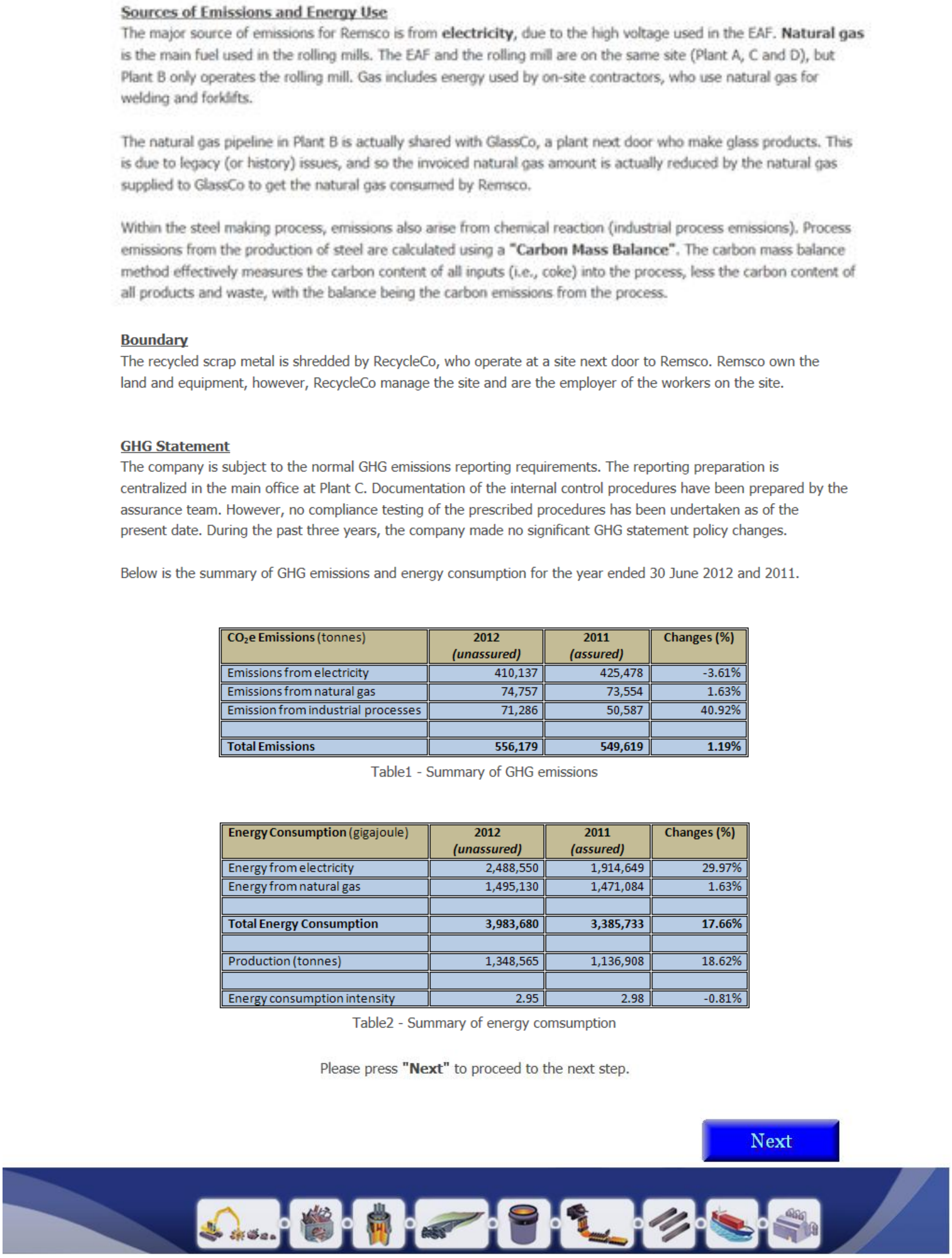


Figure 1: EAF steel making process (Source: www.pacificsteel.co.nz/process)



Sources of Emissions and Energy Use

The major source of emissions for Remsco is from **electricity**, due to the high voltage used in the EAF. **Natural gas** is the main fuel used in the rolling mills. The EAF and the rolling mill are on the same site (Plant A, C and D), but Plant B only operates the rolling mill. Gas includes energy used by on-site contractors, who use natural gas for welding and forklifts.

The natural gas pipeline in Plant B is actually shared with GlassCo, a plant next door who make glass products. This is due to legacy (or history) issues, and so the invoiced natural gas amount is actually reduced by the natural gas supplied to GlassCo to get the natural gas consumed by Remsco.

Within the steel making process, emissions also arise from chemical reaction (industrial process emissions). Process emissions from the production of steel are calculated using a **"Carbon Mass Balance"**. The carbon mass balance method effectively measures the carbon content of all inputs (i.e., coke) into the process, less the carbon content of all products and waste, with the balance being the carbon emissions from the process.

Boundary

The recycled scrap metal is shredded by RecycleCo, who operate at a site next door to Remsco. Remsco own the land and equipment, however, RecycleCo manage the site and are the employer of the workers on the site.

GHG Statement

The company is subject to the normal GHG emissions reporting requirements. The reporting preparation is centralized in the main office at Plant C. Documentation of the internal control procedures have been prepared by the assurance team. However, no compliance testing of the prescribed procedures has been undertaken as of the present date. During the past three years, the company made no significant GHG statement policy changes.

Below is the summary of GHG emissions and energy consumption for the year ended 30 June 2012 and 2011.

CO_2e Emissions (tonnes)	**2012** *(unassured)*	**2011** *(assured)*	**Changes (%)**
Emissions from electricity	410,137	425,478	-3.61%
Emissions from natural gas	74,757	73,554	1.63%
Emission from industrial processes	71,286	50,587	40.92%
Total Emissions	**556,179**	**549,619**	**1.19%**

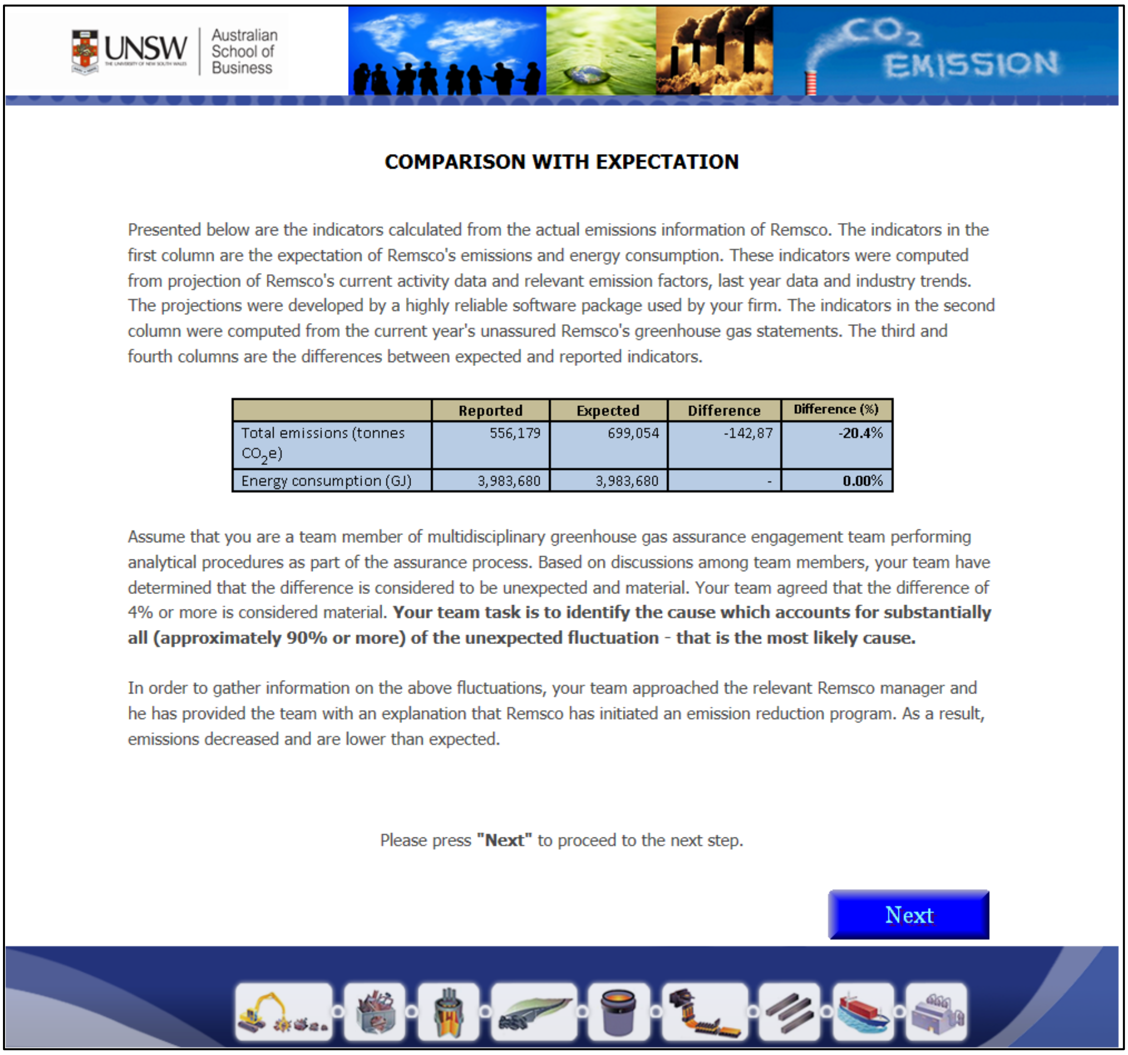
Table1 - Summary of GHG emissions

Energy Consumption (gigajoule)	**2012** *(unassured)*	**2011** *(assured)*	**Changes (%)**
Energy from electricity	2,488,550	1,914,649	29.97%
Energy from natural gas	1,495,130	1,471,084	1.63%
Total Energy Consumption	**3,983,680**	**3,385,733**	**17.66%**
Production (tonnes)	1,348,565	1,136,908	18.62%
Energy consumption intensity	2.95	2.98	-0.81%

Table2 - Summary of energy comsumption

Please press **"Next"** to proceed to the next step.

A.11.1.4 Comparison with Expectation



COMPARISON WITH EXPECTATION

Presented below are the indicators calculated from the actual emissions information of Remsco. The indicators in the first column are the expectation of Remsco's emissions and energy consumption. These indicators were computed from projection of Remsco's current activity data and relevant emission factors, last year data and industry trends. The projections were developed by a highly reliable software package used by your firm. The indicators in the second column were computed from the current year's unassured Remsco's greenhouse gas statements. The third and fourth columns are the differences between expected and reported indicators.

	Reported	Expected	Difference	Difference (%)
Total emissions (tonnes CO_2e)	556,179	699,054	-142,87	**-20.4**%
Energy consumption (GJ)	3,983,680	3,983,680	-	**0.00**%

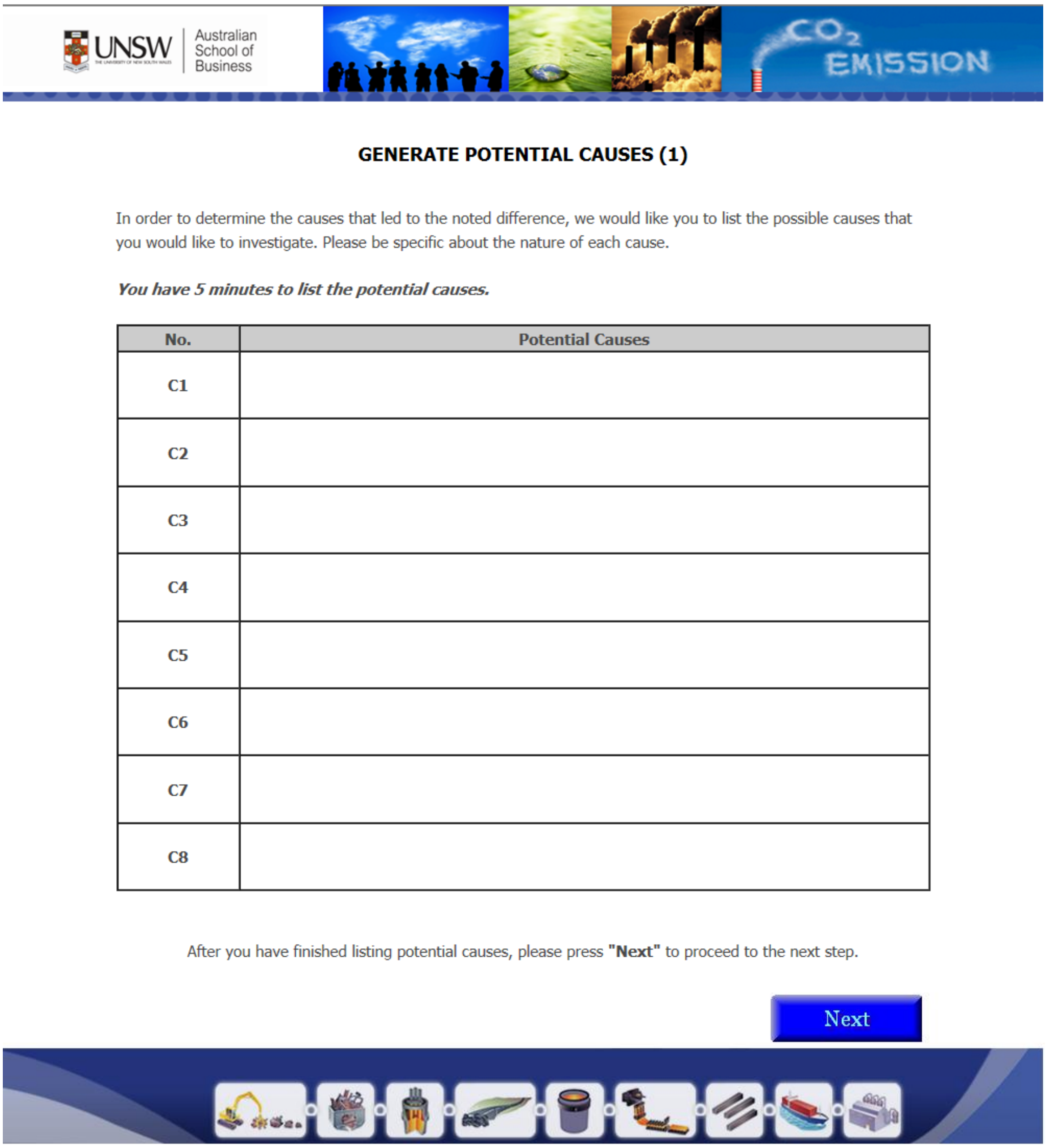
Assume that you are a team member of multidisciplinary greenhouse gas assurance engagement team performing analytical procedures as part of the assurance process. Based on discussions among team members, your team have determined that the difference is considered to be unexpected and material. Your team agreed that the difference of 4% or more is considered material. **Your team task is to identify the cause which accounts for substantially all (approximately 90% or more) of the unexpected fluctuation - that is the most likely cause.**

In order to gather information on the above fluctuations, your team approached the relevant Remsco manager and he has provided the team with an explanation that Remsco has initiated an emission reduction program. As a result, emissions decreased and are lower than expected.

Please press **"Next"** to proceed to the next step.

A.11.2 Hypothesis Generation: Stage 4b

A.11.2.1 Individual Hypothesis Generation



GENERATE POTENTIAL CAUSES (1)

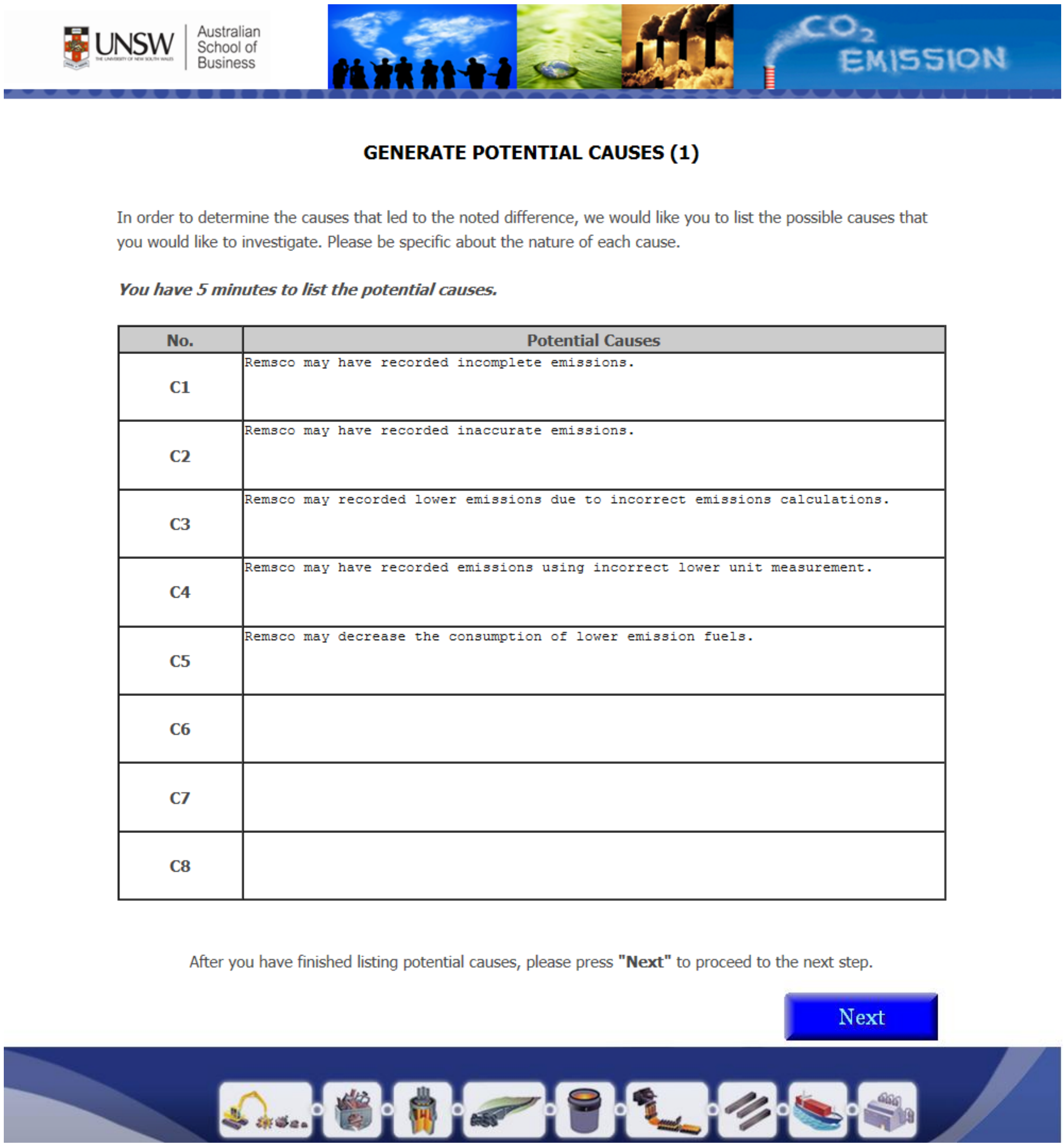
In order to determine the causes that led to the noted difference, we would like you to list the possible causes that you would like to investigate. Please be specific about the nature of each cause.

You have 5 minutes to list the potential causes.

No.	Potential Causes
C1	
C2	
C3	
C4	
C5	
C6	
C7	
C8	

After you have finished listing potential causes, please press **"Next"** to proceed to the next step.

A.11.2.2 Individual Hypothesis Generation: Accountant Member of Team (Member A)



GENERATE POTENTIAL CAUSES (1)

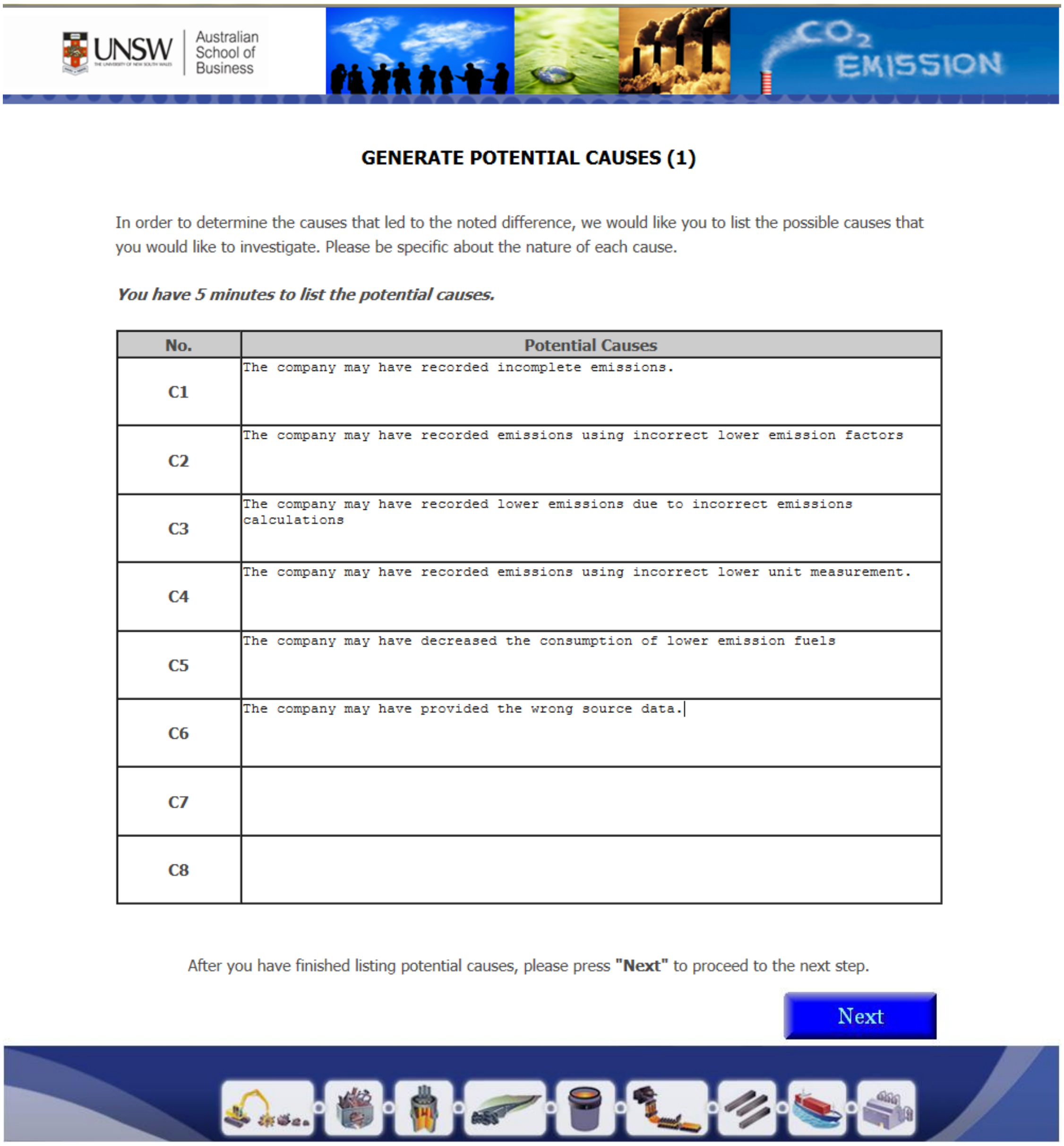
In order to determine the causes that led to the noted difference, we would like you to list the possible causes that you would like to investigate. Please be specific about the nature of each cause.

You have 5 minutes to list the potential causes.

No.	Potential Causes
C1	Remsco may have recorded incomplete emissions.
C2	Remsco may have recorded inaccurate emissions.
C3	Remsco may recorded lower emissions due to incorrect emissions calculations.
C4	Remsco may have recorded emissions using incorrect lower unit measurement.
C5	Remsco may decrease the consumption of lower emission fuels.
C6	
C7	
C8	

After you have finished listing potential causes, please press **"Next"** to proceed to the next step.

A.11.2.3 Individual Hypothesis Generation: Scientist/Engineer Member of Team (Member B)



GENERATE POTENTIAL CAUSES (1)

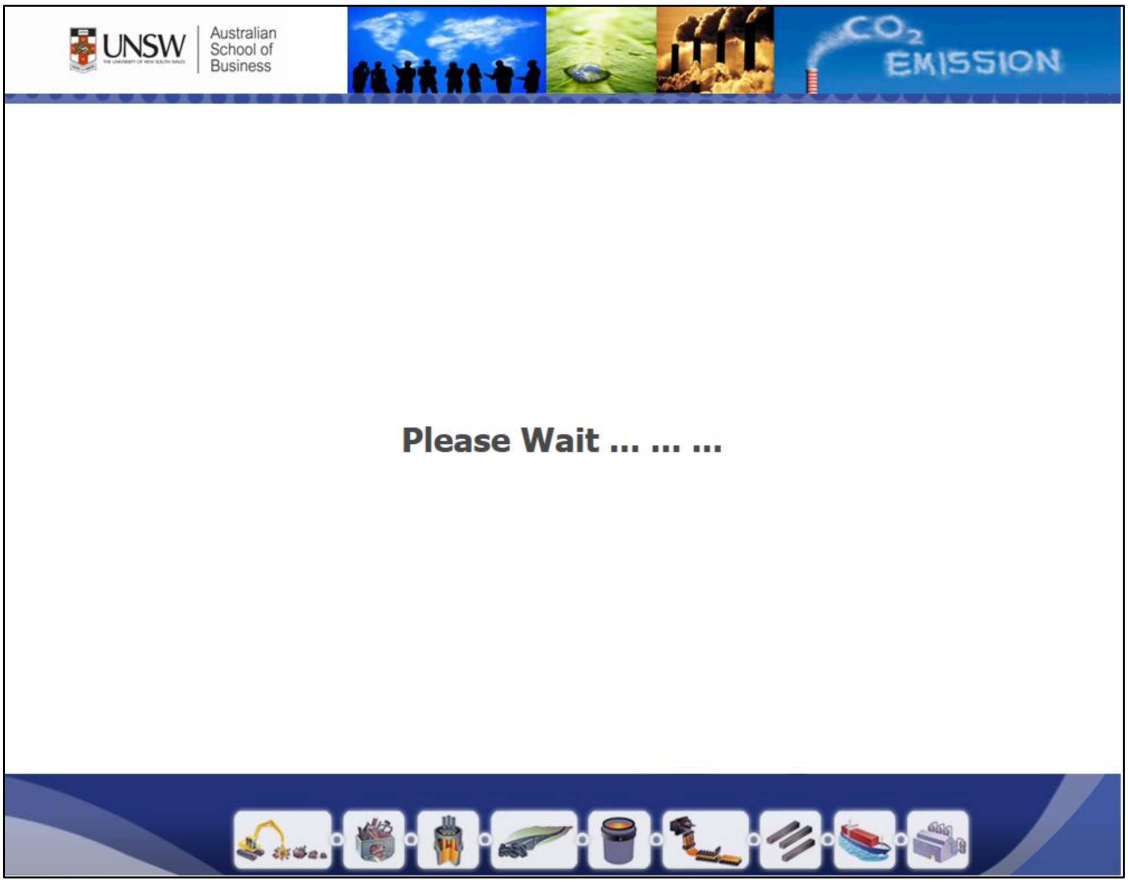
In order to determine the causes that led to the noted difference, we would like you to list the possible causes that you would like to investigate. Please be specific about the nature of each cause.

You have 5 minutes to list the potential causes.

No.	Potential Causes
C1	The company may have recorded incomplete emissions.
C2	The company may have recorded emissions using incorrect lower emission factors
C3	The company may have recorded lower emissions due to incorrect emissions calculations
C4	The company may have recorded emissions using incorrect lower unit measurement.
C5	The company may have decreased the consumption of lower emission fuels
C6	The company may have provided the wrong source data.
C7	
C8	

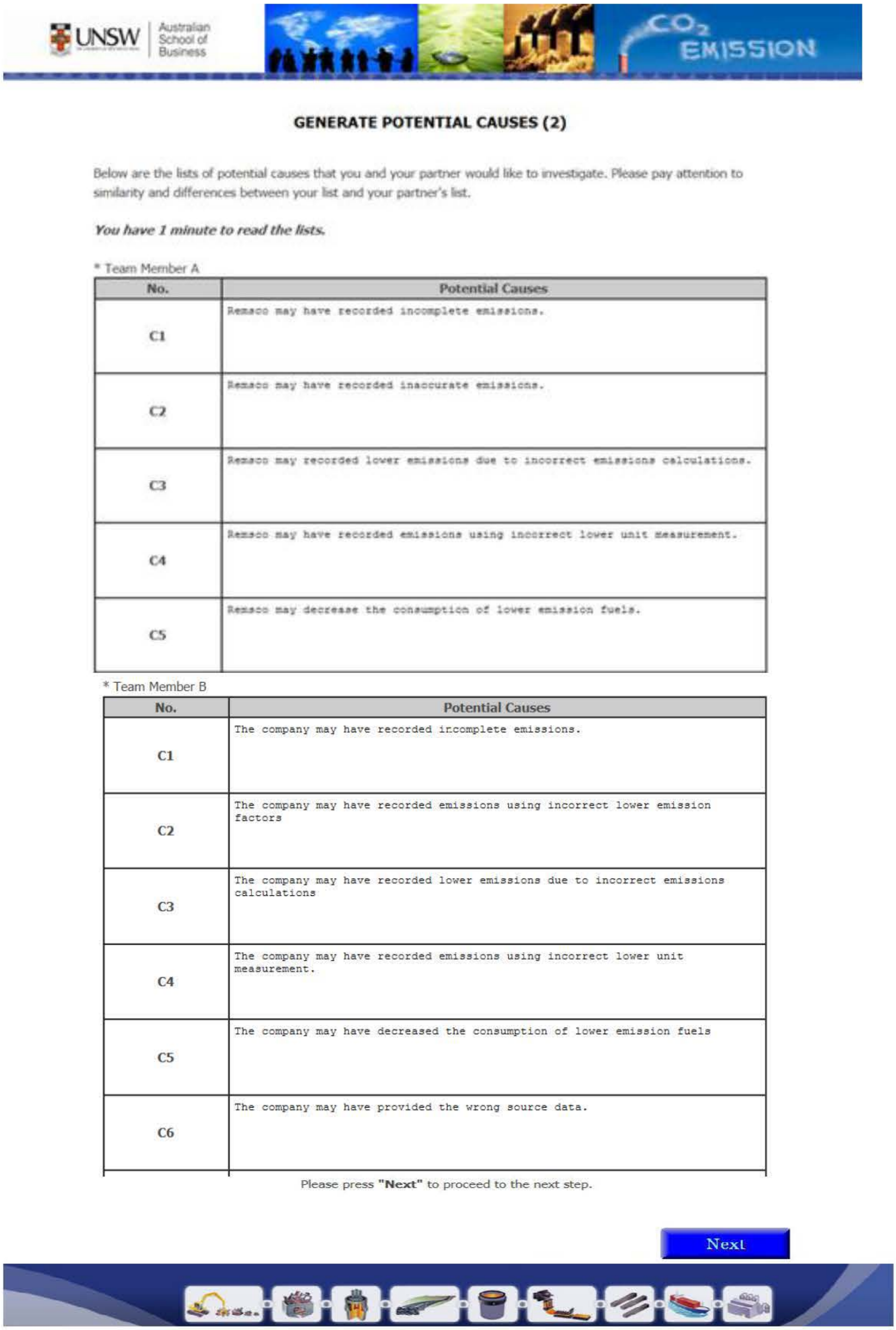
After you have finished listing potential causes, please press **"Next"** to proceed to the next step.

A.11.2.4 Individual Hypothesis Generation: Instruction to Wait for Other Member to Complete His or Her Hypothesis Generation



Please Wait … … …

A.11.2.5 Team Hypothesis Generation: List of Hypotheses



GENERATE POTENTIAL CAUSES (2)

Below are the lists of potential causes that you and your partner would like to investigate. Please pay attention to similarity and differences between your list and your partner's list.

You have 1 minute to read the lists.

* Team Member A

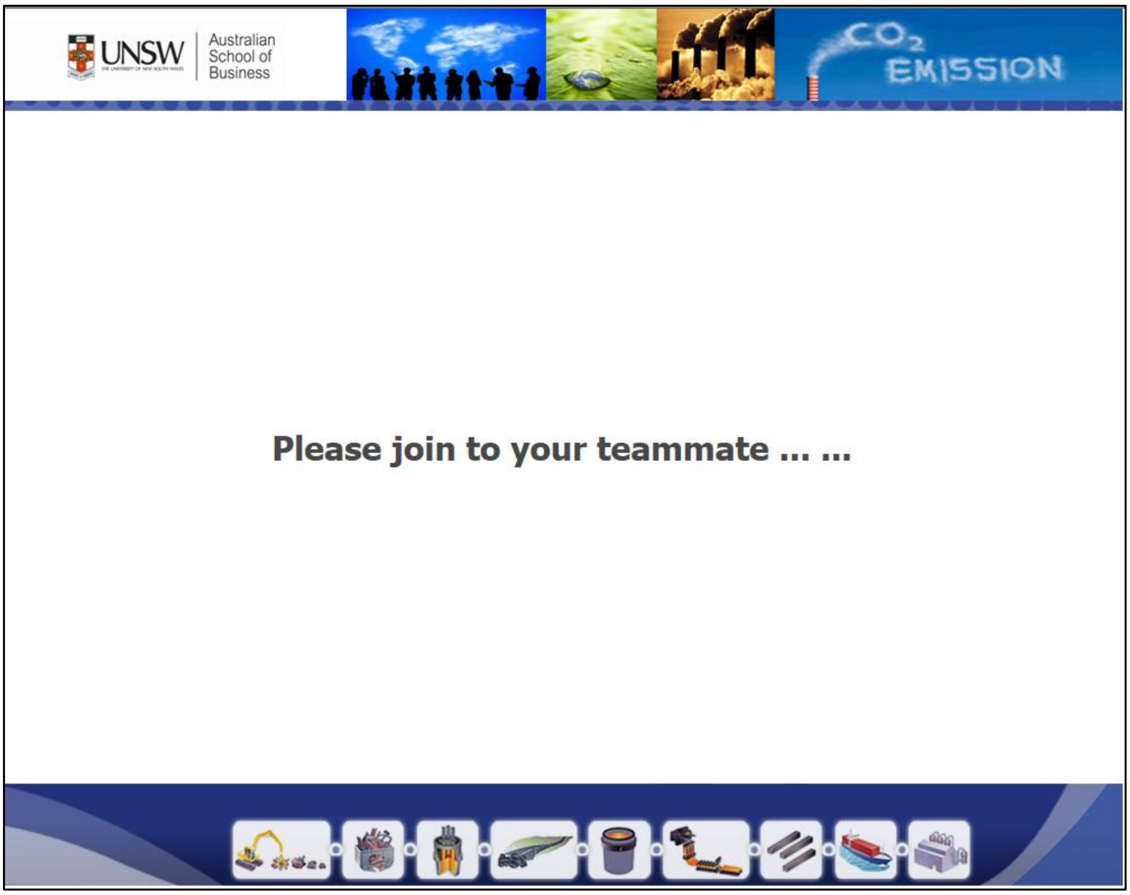
No.	Potential Causes
C1	Remsco may have recorded incomplete emissions.
C2	Remsco may have recorded inaccurate emissions.
C3	Remsco may recorded lower emissions due to incorrect emissions calculations.
C4	Remsco may have recorded emissions using incorrect lower unit measurement.
C5	Remsco may decrease the consumption of lower emission fuels.

* Team Member B

No.	Potential Causes
C1	The company may have recorded incomplete emissions.
C2	The company may have recorded emissions using incorrect lower emission factors
C3	The company may have recorded lower emissions due to incorrect emissions calculations
C4	The company may have recorded emissions using incorrect lower unit measurement.
C5	The company may have decreased the consumption of lower emission fuels
C6	The company may have provided the wrong source data.

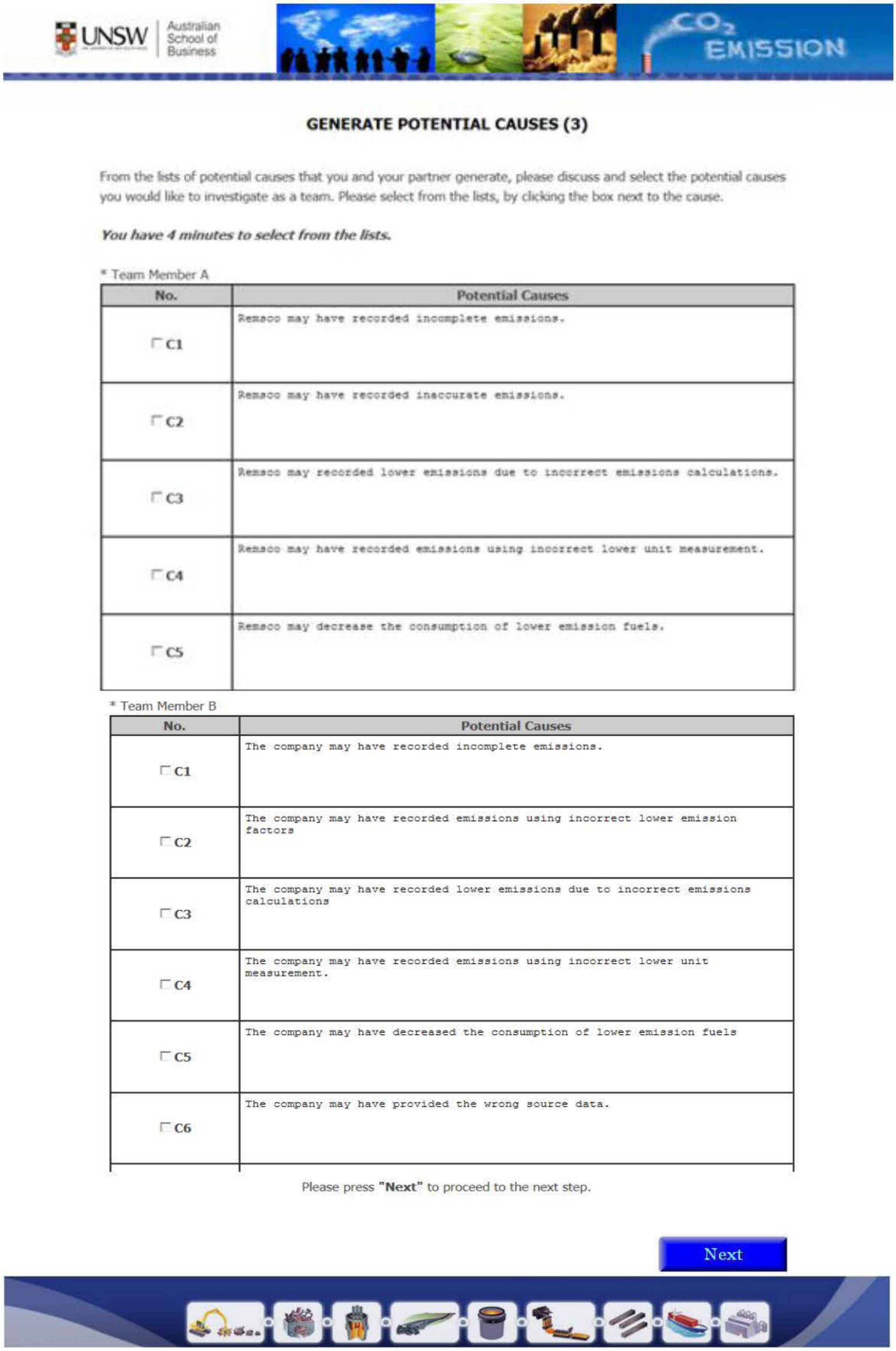
Please press **"Next"** to proceed to the next step.

A.11.2.6 Team Hypothesis Generation: Instruction for Team Member to Join Other Member to Generate Hypotheses Together as a Team



Please join to your teammate … …

A.11.2.7 Team Hypothesis Generation: Select Hypotheses to be Included in Team's Hypothesis Set



GENERATE POTENTIAL CAUSES (3)

From the lists of potential causes that you and your partner generate, please discuss and select the potential causes you would like to investigate as a team. Please select from the lists, by clicking the box next to the cause.

You have 4 minutes to select from the lists.

* Team Member A

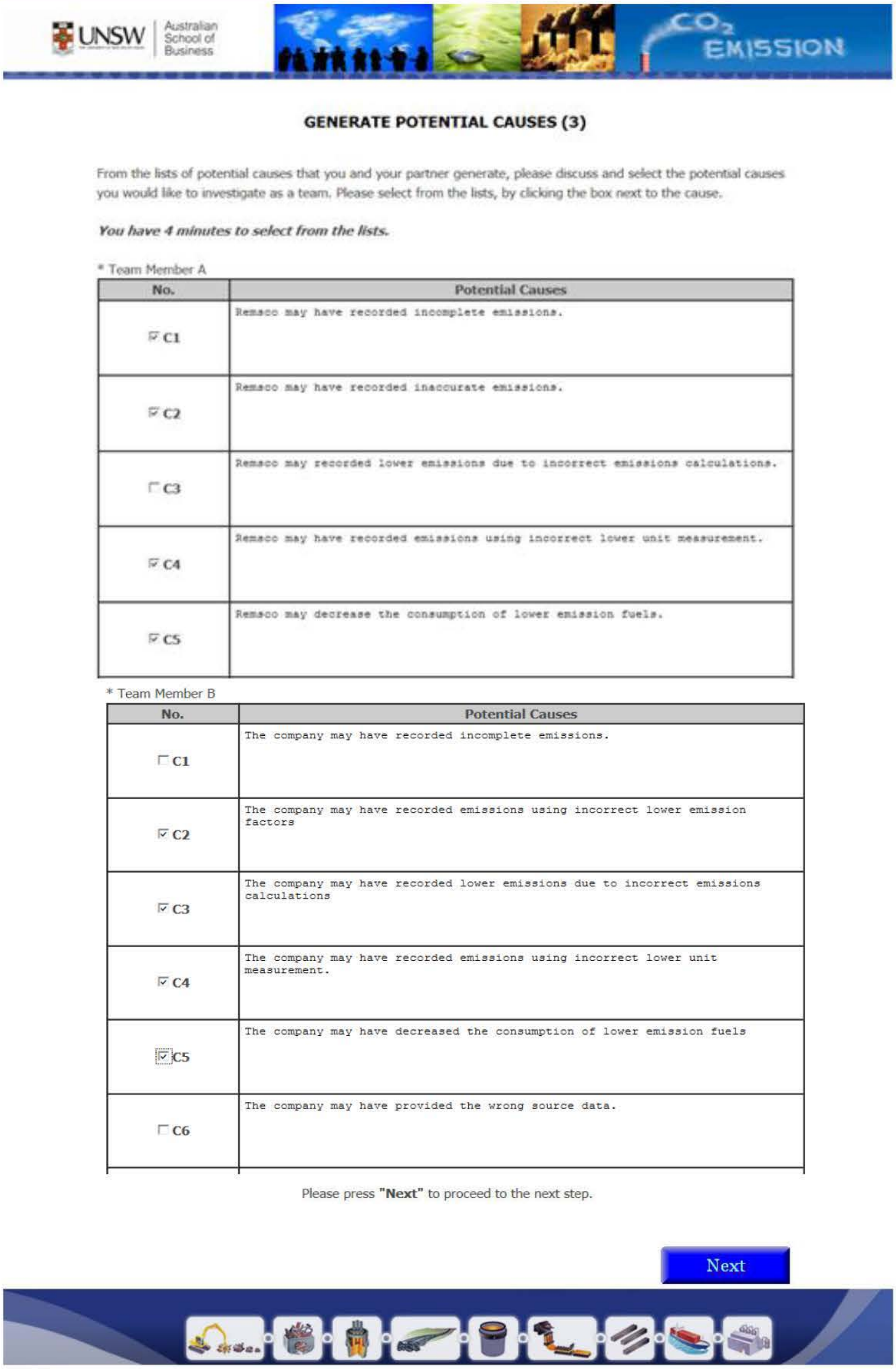
No.	Potential Causes
☐ C1	Remsco may have recorded incomplete emissions.
☐ C2	Remsco may have recorded inaccurate emissions.
☐ C3	Remsco may recorded lower emissions due to incorrect emissions calculations.
☐ C4	Remsco may have recorded emissions using incorrect lower unit measurement.
☐ C5	Remsco may decrease the consumption of lower emission fuels.

* Team Member B

No.	Potential Causes
☐ C1	The company may have recorded incomplete emissions.
☐ C2	The company may have recorded emissions using incorrect lower emission factors
☐ C3	The company may have recorded lower emissions due to incorrect emissions calculations
☐ C4	The company may have recorded emissions using incorrect lower unit measurement.
☐ C5	The company may have decreased the consumption of lower emission fuels
☐ C6	The company may have provided the wrong source data.

Please press **"Next"** to proceed to the next step.

A.11.2.8 Team Hypothesis Generation: Team's Hypothesis Set



GENERATE POTENTIAL CAUSES (3)

From the lists of potential causes that you and your partner generate, please discuss and select the potential causes you would like to investigate as a team. Please select from the lists, by clicking the box next to the cause.

You have 4 minutes to select from the lists.

* Team Member A

No.	Potential Causes
☑ C1	Remsco may have recorded incomplete emissions.
☑ C2	Remsco may have recorded inaccurate emissions.
☐ C3	Remsco may recorded lower emissions due to incorrect emissions calculations.
☑ C4	Remsco may have recorded emissions using incorrect lower unit measurement.
☑ C5	Remsco may decrease the consumption of lower emission fuels.

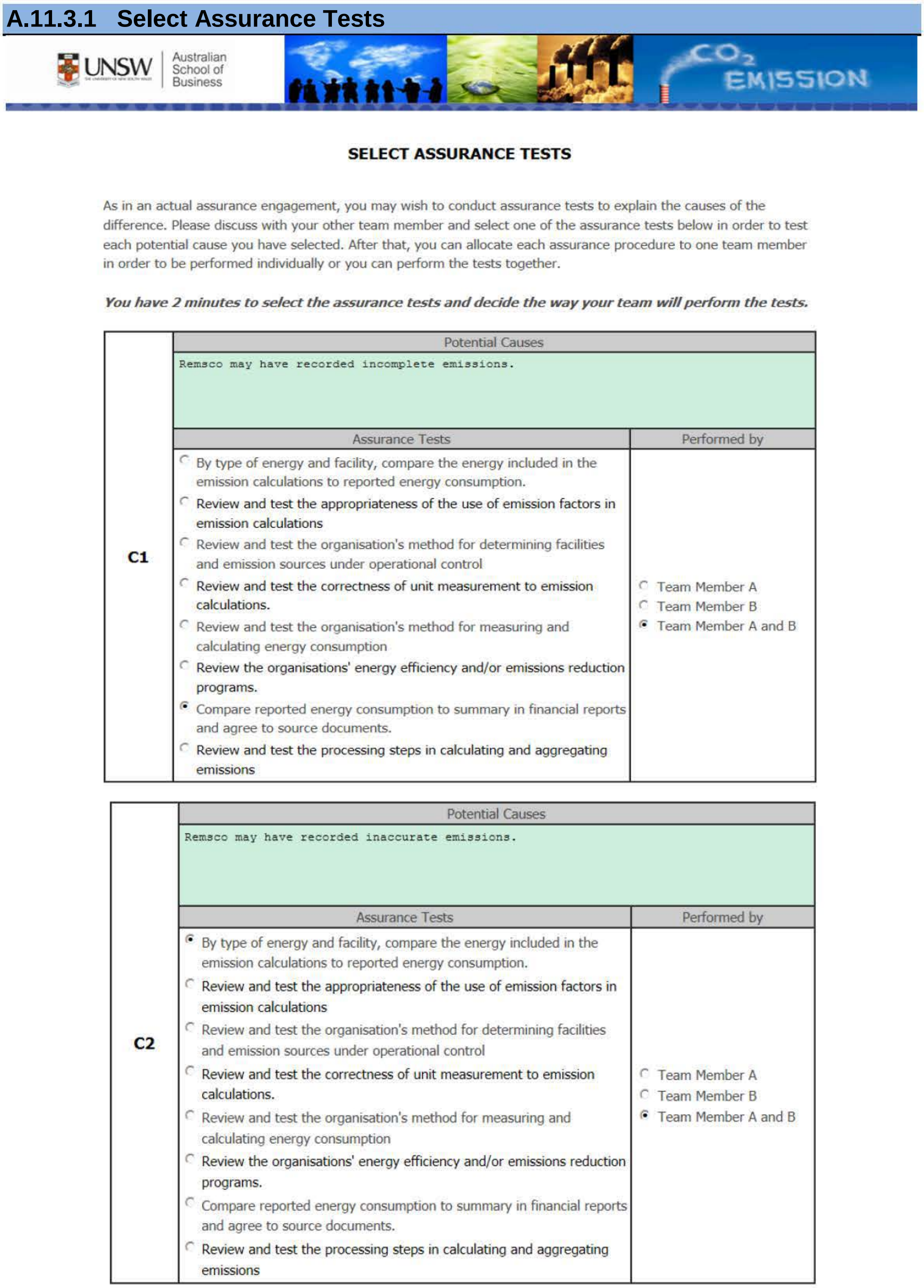
* Team Member B

No.	Potential Causes
☐ C1	The company may have recorded incomplete emissions.
☑ C2	The company may have recorded emissions using incorrect lower emission factors
☑ C3	The company may have recorded lower emissions due to incorrect emissions calculations
☑ C4	The company may have recorded emissions using incorrect lower unit measurement.
☑ C5	The company may have decreased the consumption of lower emission fuels
☐ C6	The company may have provided the wrong source data.

Please press **"Next"** to proceed to the next step.

A.11.3 Hypothesis Testing: Stage 4c

A.11.3.1 Select Assurance Tests



SELECT ASSURANCE TESTS

As in an actual assurance engagement, you may wish to conduct assurance tests to explain the causes of the difference. Please discuss with your other team member and select one of the assurance tests below in order to test each potential cause you have selected. After that, you can allocate each assurance procedure to one team member in order to be performed individually or you can perform the tests together.

You have 2 minutes to select the assurance tests and decide the way your team will perform the tests.

C1

Potential Causes

`Remsco may have recorded incomplete emissions.`

Assurance Tests	Performed by
○ By type of energy and facility, compare the energy included in the emission calculations to reported energy consumption. ○ Review and test the appropriateness of the use of emission factors in emission calculations ○ Review and test the organisation's method for determining facilities and emission sources under operational control ○ Review and test the correctness of unit measurement to emission calculations. ○ Review and test the organisation's method for measuring and calculating energy consumption ○ Review the organisations' energy efficiency and/or emissions reduction programs. ● Compare reported energy consumption to summary in financial reports and agree to source documents. ○ Review and test the processing steps in calculating and aggregating emissions	○ Team Member A ○ Team Member B ● Team Member A and B

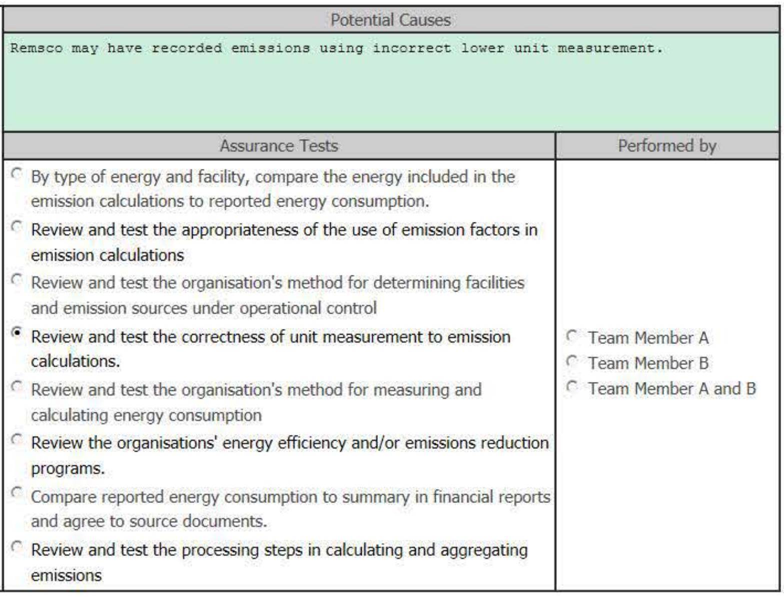
C2

Potential Causes

`Remsco may have recorded inaccurate emissions.`

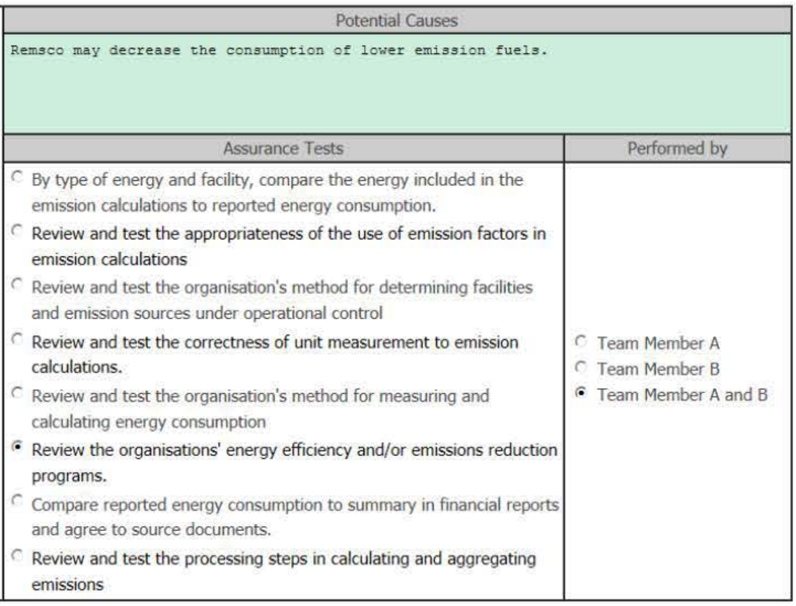
Assurance Tests	Performed by
● By type of energy and facility, compare the energy included in the emission calculations to reported energy consumption. ○ Review and test the appropriateness of the use of emission factors in emission calculations ○ Review and test the organisation's method for determining facilities and emission sources under operational control ○ Review and test the correctness of unit measurement to emission calculations. ○ Review and test the organisation's method for measuring and calculating energy consumption ○ Review the organisations' energy efficiency and/or emissions reduction programs. ○ Compare reported energy consumption to summary in financial reports and agree to source documents. ○ Review and test the processing steps in calculating and aggregating emissions	○ Team Member A ○ Team Member B ● Team Member A and B

C3

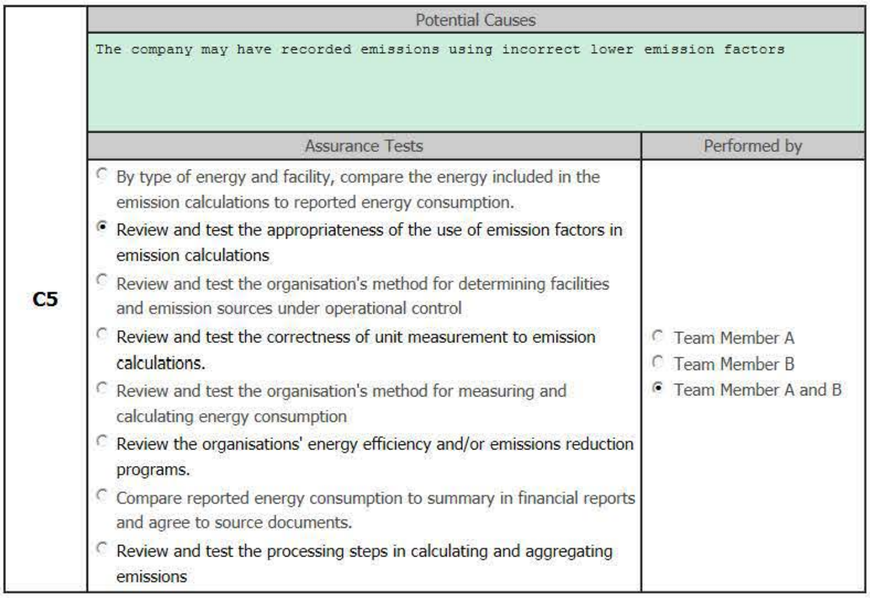


Potential Causes	
`Remsco may have recorded emissions using incorrect lower unit measurement.`	
Assurance Tests	**Performed by**
○ By type of energy and facility, compare the energy included in the emission calculations to reported energy consumption. ○ Review and test the appropriateness of the use of emission factors in emission calculations ○ Review and test the organisation's method for determining facilities and emission sources under operational control ● Review and test the correctness of unit measurement to emission calculations. ○ Review and test the organisation's method for measuring and calculating energy consumption ○ Review the organisations' energy efficiency and/or emissions reduction programs. ○ Compare reported energy consumption to summary in financial reports and agree to source documents. ○ Review and test the processing steps in calculating and aggregating emissions	○ Team Member A ○ Team Member B ○ Team Member A and B

C4



Potential Causes	
`Remsco may decrease the consumption of lower emission fuels.`	
Assurance Tests	**Performed by**
○ By type of energy and facility, compare the energy included in the emission calculations to reported energy consumption. ○ Review and test the appropriateness of the use of emission factors in emission calculations ○ Review and test the organisation's method for determining facilities and emission sources under operational control ○ Review and test the correctness of unit measurement to emission calculations. ○ Review and test the organisation's method for measuring and calculating energy consumption ● Review the organisations' energy efficiency and/or emissions reduction programs. ○ Compare reported energy consumption to summary in financial reports and agree to source documents. ○ Review and test the processing steps in calculating and aggregating emissions	○ Team Member A ○ Team Member B ● Team Member A and B

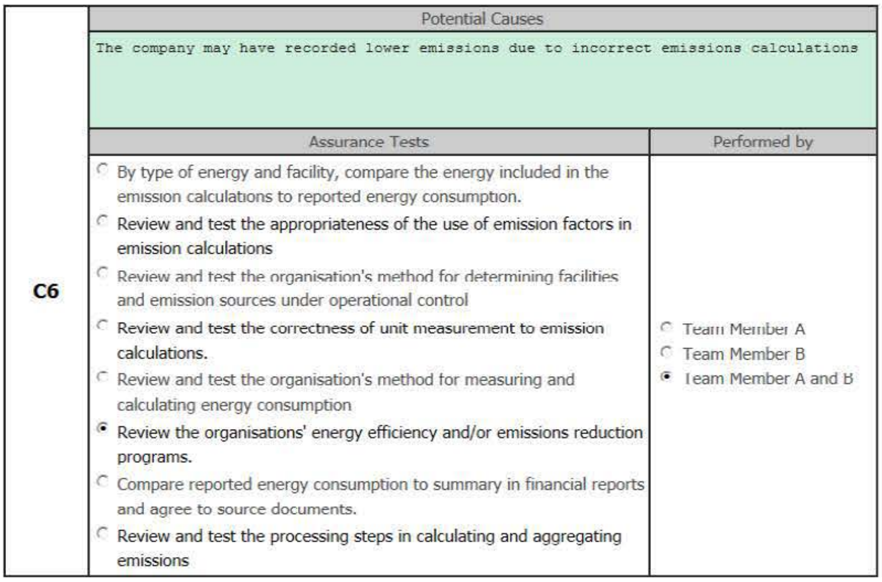


C5

Potential Causes

The company may have recorded emissions using incorrect lower emission factors

Assurance Tests	Performed by
○ By type of energy and facility, compare the energy included in the emission calculations to reported energy consumption. ● Review and test the appropriateness of the use of emission factors in emission calculations ○ Review and test the organisation's method for determining facilities and emission sources under operational control ○ Review and test the correctness of unit measurement to emission calculations. ○ Review and test the organisation's method for measuring and calculating energy consumption ○ Review the organisations' energy efficiency and/or emissions reduction programs. ○ Compare reported energy consumption to summary in financial reports and agree to source documents. ○ Review and test the processing steps in calculating and aggregating emissions	○ Team Member A ○ Team Member B ● Team Member A and B

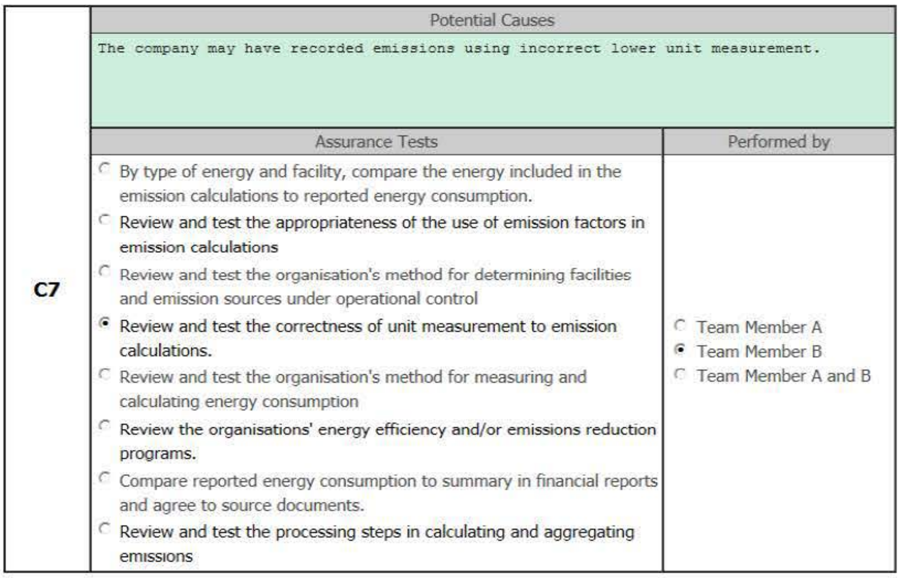


C6

Potential Causes

The company may have recorded lower emissions due to incorrect emissions calculations

Assurance Tests	Performed by
○ By type of energy and facility, compare the energy included in the emission calculations to reported energy consumption. ○ Review and test the appropriateness of the use of emission factors in emission calculations ○ Review and test the organisation's method for determining facilities and emission sources under operational control ○ Review and test the correctness of unit measurement to emission calculations. ○ Review and test the organisation's method for measuring and calculating energy consumption ● Review the organisations' energy efficiency and/or emissions reduction programs. ○ Compare reported energy consumption to summary in financial reports and agree to source documents. ○ Review and test the processing steps in calculating and aggregating emissions	○ Team Member A ○ Team Member B ● Team Member A and B

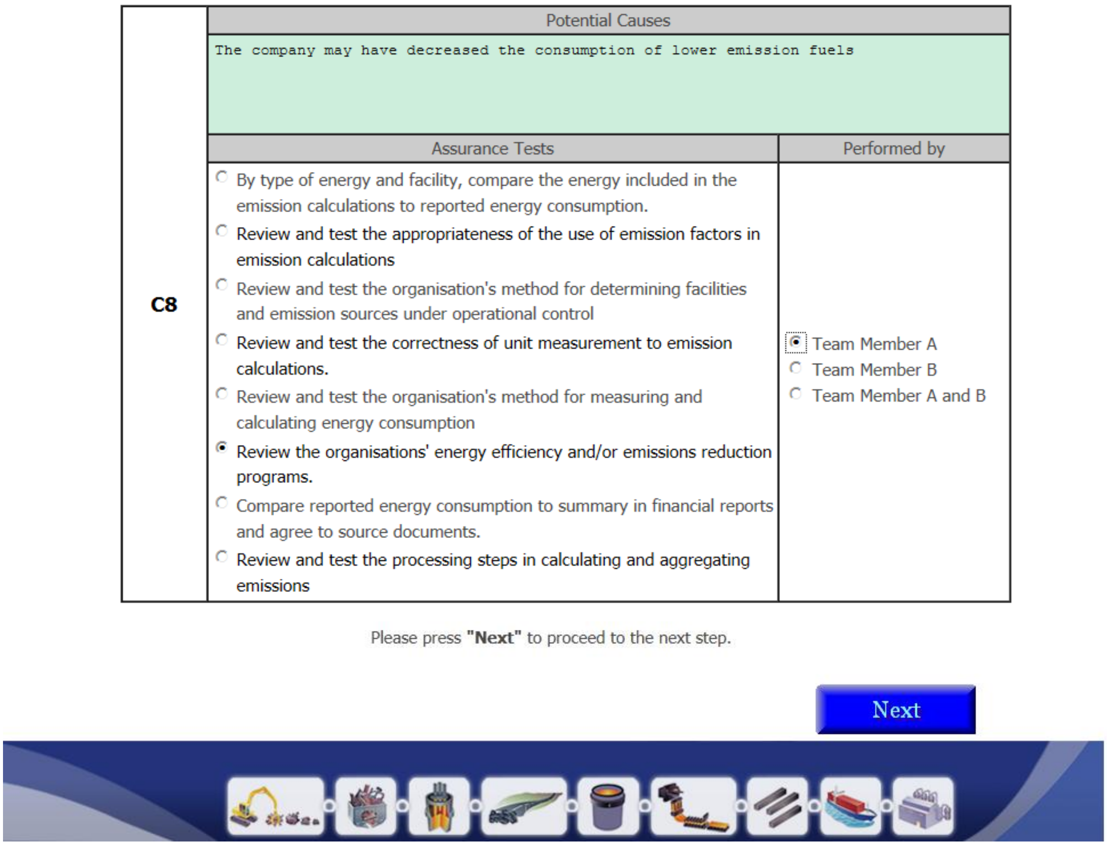


C7

Potential Causes

The company may have recorded emissions using incorrect lower unit measurement.

Assurance Tests	Performed by
○ By type of energy and facility, compare the energy included in the emission calculations to reported energy consumption. ○ Review and test the appropriateness of the use of emission factors in emission calculations ○ Review and test the organisation's method for determining facilities and emission sources under operational control ● Review and test the correctness of unit measurement to emission calculations. ○ Review and test the organisation's method for measuring and calculating energy consumption ○ Review the organisations' energy efficiency and/or emissions reduction programs. ○ Compare reported energy consumption to summary in financial reports and agree to source documents. ○ Review and test the processing steps in calculating and aggregating emissions	○ Team Member A ● Team Member B ○ Team Member A and B



C8

Potential Causes

`The company may have decreased the consumption of lower emission fuels`

Assurance Tests

○ By type of energy and facility, compare the energy included in the emission calculations to reported energy consumption.

○ Review and test the appropriateness of the use of emission factors in emission calculations

○ Review and test the organisation's method for determining facilities and emission sources under operational control

○ Review and test the correctness of unit measurement to emission calculations.

○ Review and test the organisation's method for measuring and calculating energy consumption

● Review the organisations' energy efficiency and/or emissions reduction programs.

○ Compare reported energy consumption to summary in financial reports and agree to source documents.

○ Review and test the processing steps in calculating and aggregating emissions

Performed by

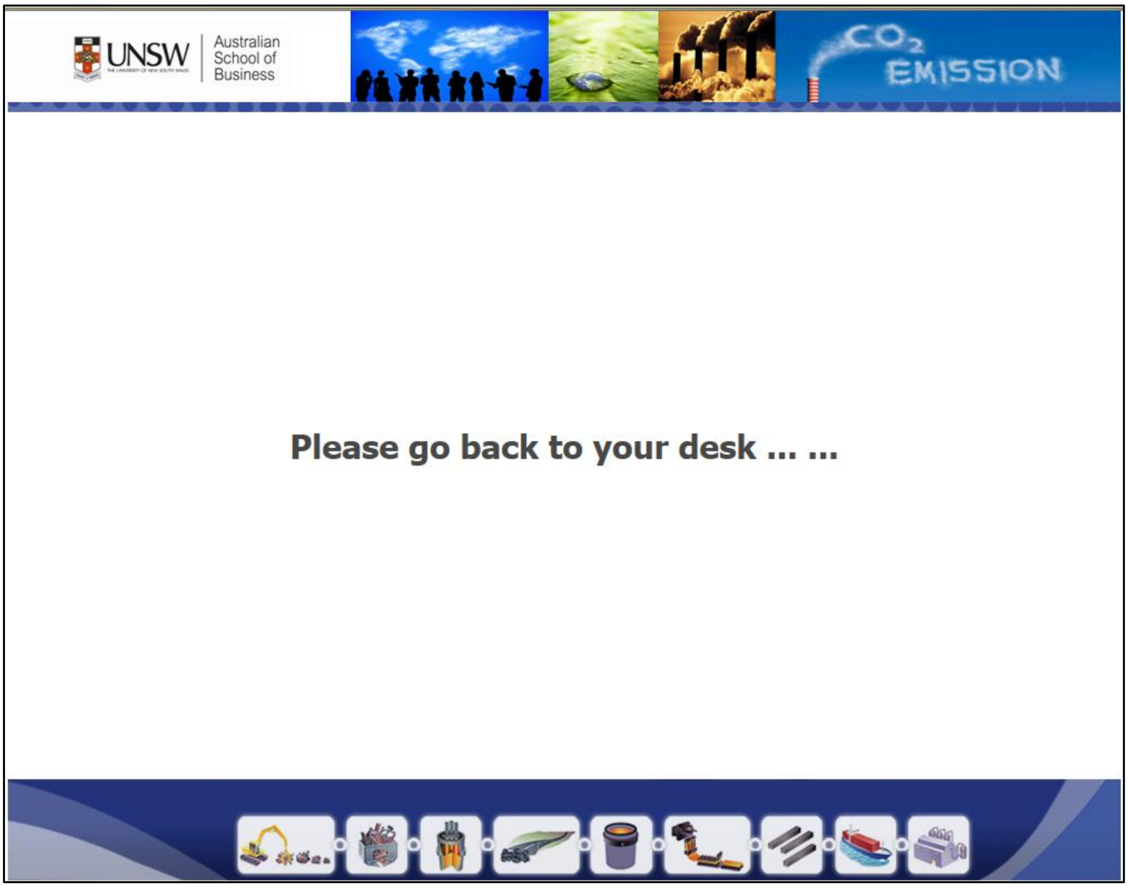
● Team Member A

○ Team Member B

○ Team Member A and B

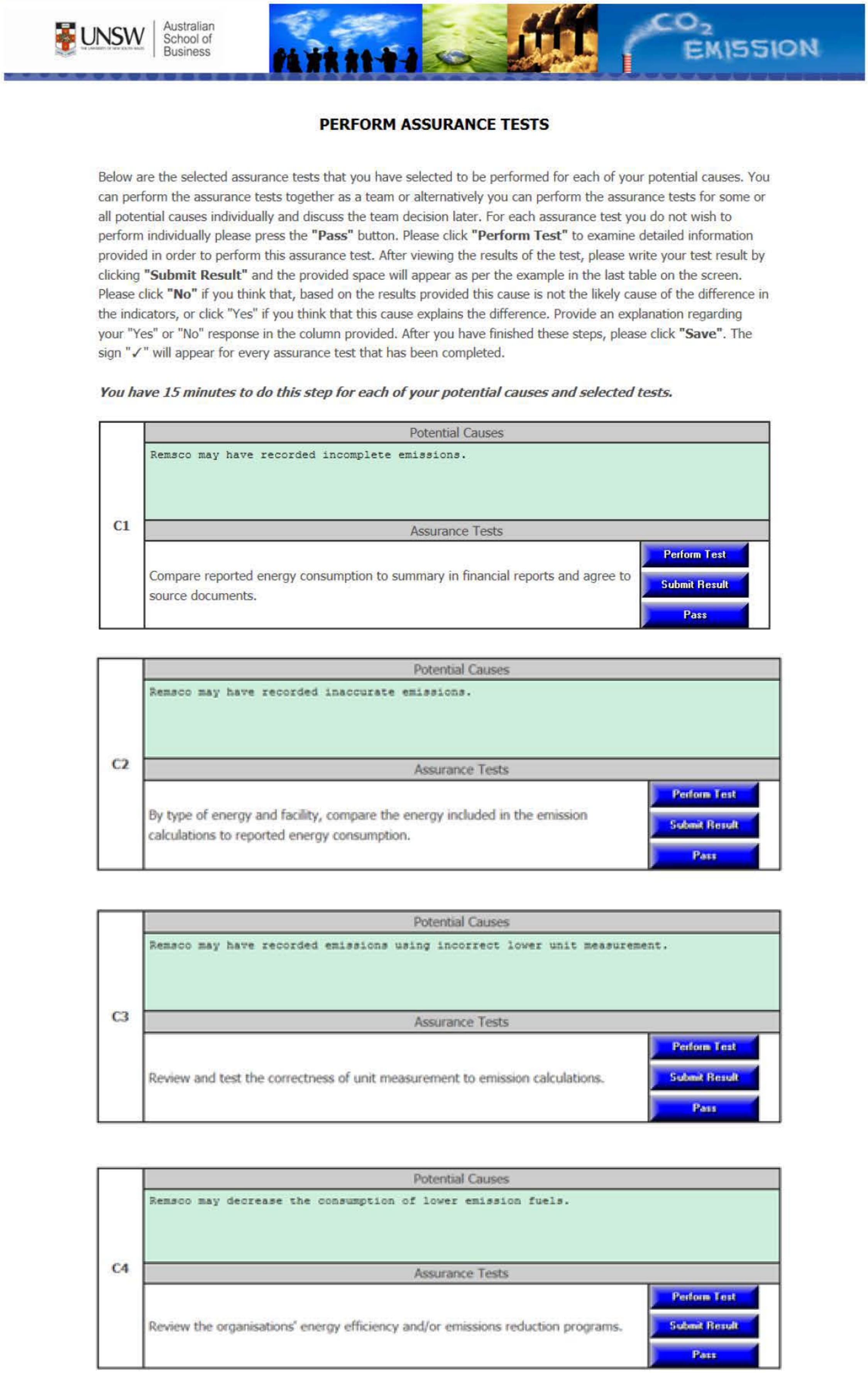
Please press **"Next"** to proceed to the next step.

A.11.3.2 Instruction to Perform Testing Individually



Please go back to your desk … …

A.11.3.3 Instruction for Accountant Member of Team (Member A)



PERFORM ASSURANCE TESTS

Below are the selected assurance tests that you have selected to be performed for each of your potential causes. You can perform the assurance tests together as a team or alternatively you can perform the assurance tests for some or all potential causes individually and discuss the team decision later. For each assurance test you do not wish to perform individually please press the **"Pass"** button. Please click **"Perform Test"** to examine detailed information provided in order to perform this assurance test. After viewing the results of the test, please write your test result by clicking **"Submit Result"** and the provided space will appear as per the example in the last table on the screen. Please click **"No"** if you think that, based on the results provided this cause is not the likely cause of the difference in the indicators, or click "Yes" if you think that this cause explains the difference. Provide an explanation regarding your "Yes" or "No" response in the column provided. After you have finished these steps, please click **"Save"**. The sign "✓" will appear for every assurance test that has been completed.

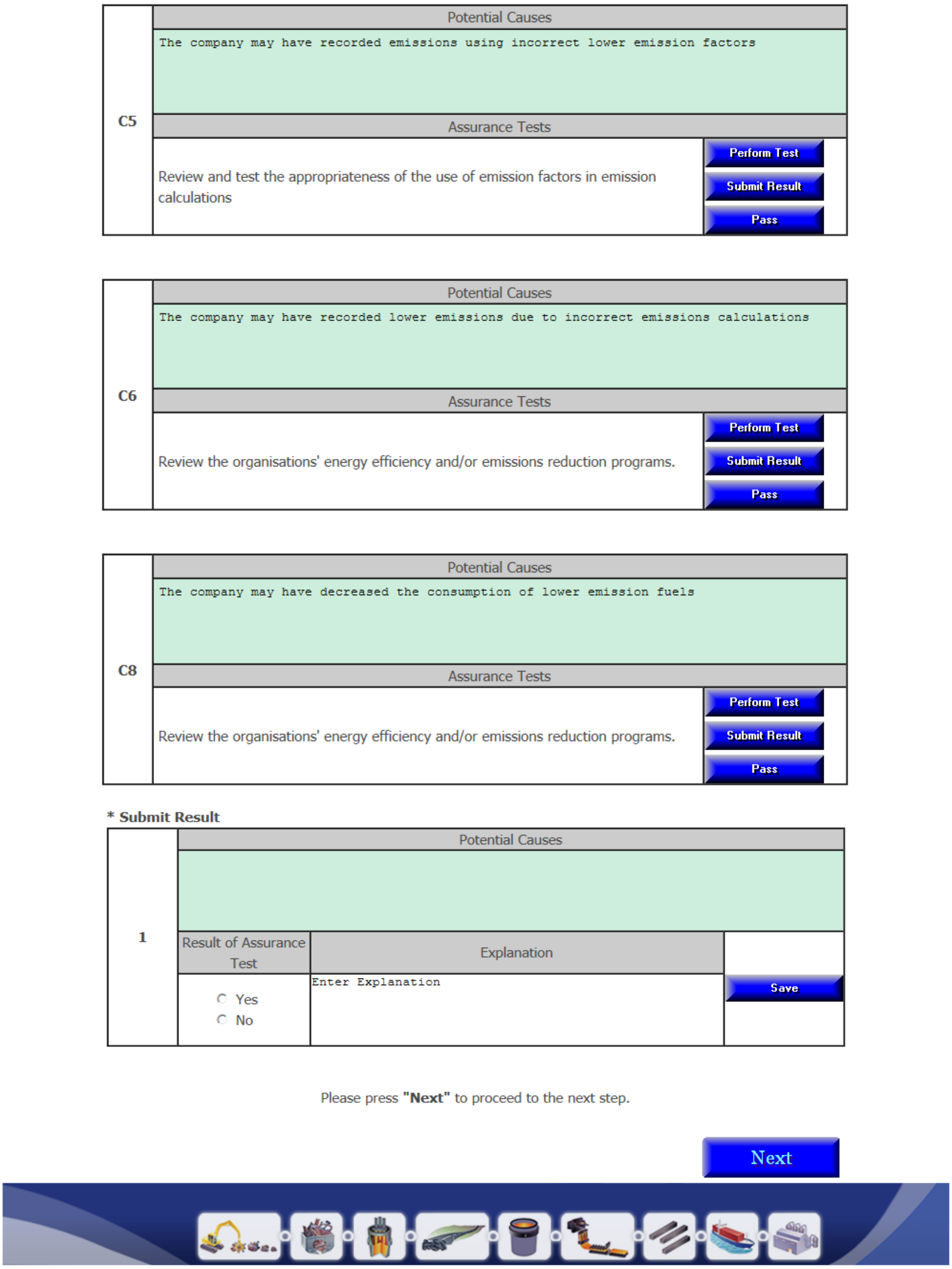
You have 15 minutes to do this step for each of your potential causes and selected tests.

C1	Potential Causes	
	`Remsco may have recorded incomplete emissions.`	
	Assurance Tests	
	Compare reported energy consumption to summary in financial reports and agree to source documents.	Perform Test Submit Result Pass

C2	Potential Causes	
	`Remsco may have recorded inaccurate emissions.`	
	Assurance Tests	
	By type of energy and facility, compare the energy included in the emission calculations to reported energy consumption.	Perform Test Submit Result Pass

C3	Potential Causes	
	`Remsco may have recorded emissions using incorrect lower unit measurement.`	
	Assurance Tests	
	Review and test the correctness of unit measurement to emission calculations.	Perform Test Submit Result Pass

C4	Potential Causes	
	`Remsco may decrease the consumption of lower emission fuels.`	
	Assurance Tests	
	Review the organisations' energy efficiency and/or emissions reduction programs.	Perform Test Submit Result Pass



C5	Potential Causes	
	The company may have recorded emissions using incorrect lower emission factors	
	Assurance Tests	
	Review and test the appropriateness of the use of emission factors in emission calculations	Perform Test Submit Result Pass

C6	Potential Causes	
	The company may have recorded lower emissions due to incorrect emissions calculations	
	Assurance Tests	
	Review the organisations' energy efficiency and/or emissions reduction programs.	Perform Test Submit Result Pass

C8	Potential Causes	
	The company may have decreased the consumption of lower emission fuels	
	Assurance Tests	
	Review the organisations' energy efficiency and/or emissions reduction programs.	Perform Test Submit Result Pass

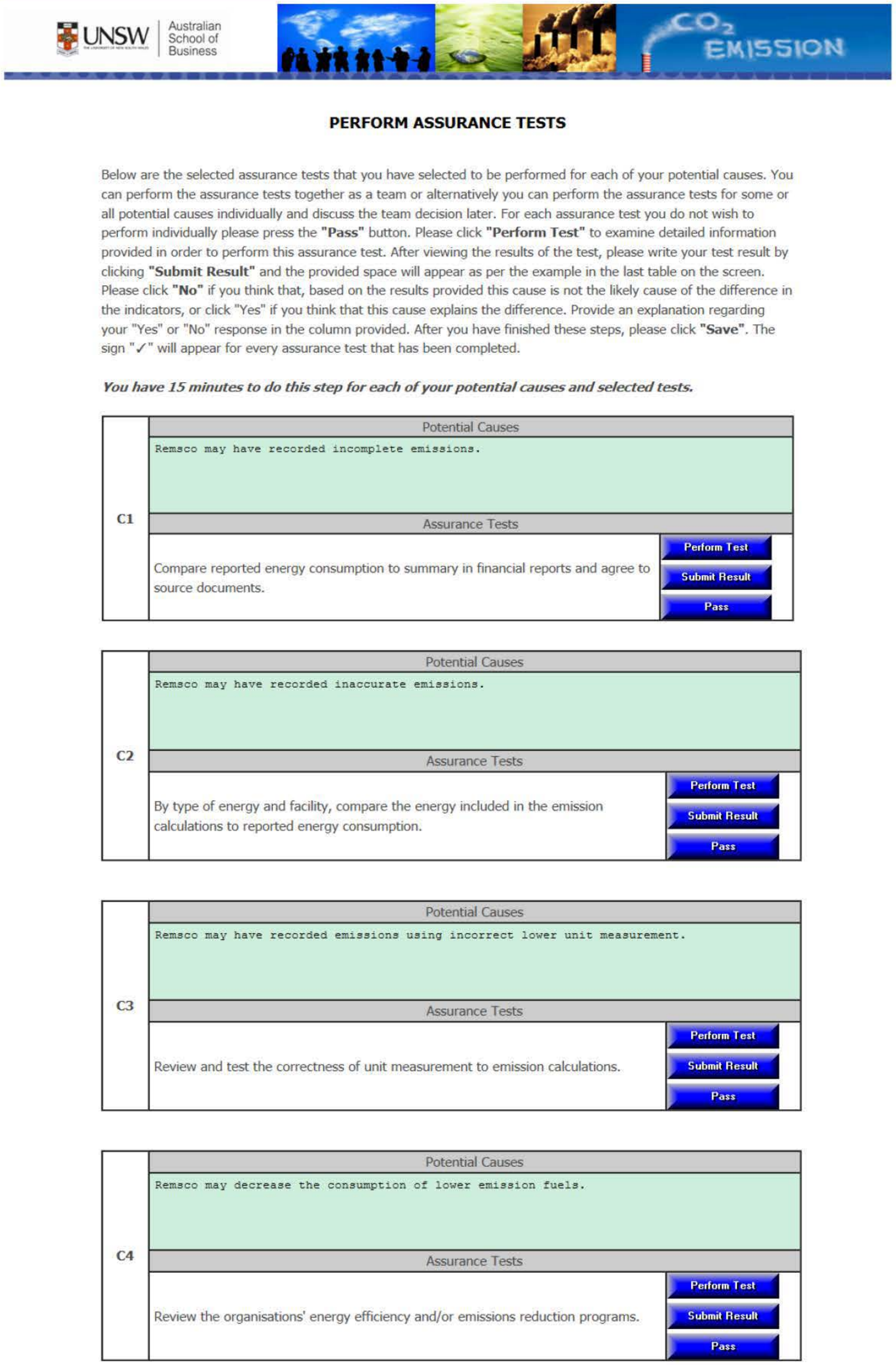
*** Submit Result**

1	Potential Causes		
	Result of Assurance Test	Explanation	
	○ Yes ○ No	Enter Explanation	Save

Please press **"Next"** to proceed to the next step.

Next

A.11.3.4 Instruction for Scientist/Engineer Member of Team (Member B)



PERFORM ASSURANCE TESTS

Below are the selected assurance tests that you have selected to be performed for each of your potential causes. You can perform the assurance tests together as a team or alternatively you can perform the assurance tests for some or all potential causes individually and discuss the team decision later. For each assurance test you do not wish to perform individually please press the **"Pass"** button. Please click **"Perform Test"** to examine detailed information provided in order to perform this assurance test. After viewing the results of the test, please write your test result by clicking **"Submit Result"** and the provided space will appear as per the example in the last table on the screen. Please click **"No"** if you think that, based on the results provided this cause is not the likely cause of the difference in the indicators, or click "Yes" if you think that this cause explains the difference. Provide an explanation regarding your "Yes" or "No" response in the column provided. After you have finished these steps, please click **"Save"**. The sign "✓" will appear for every assurance test that has been completed.

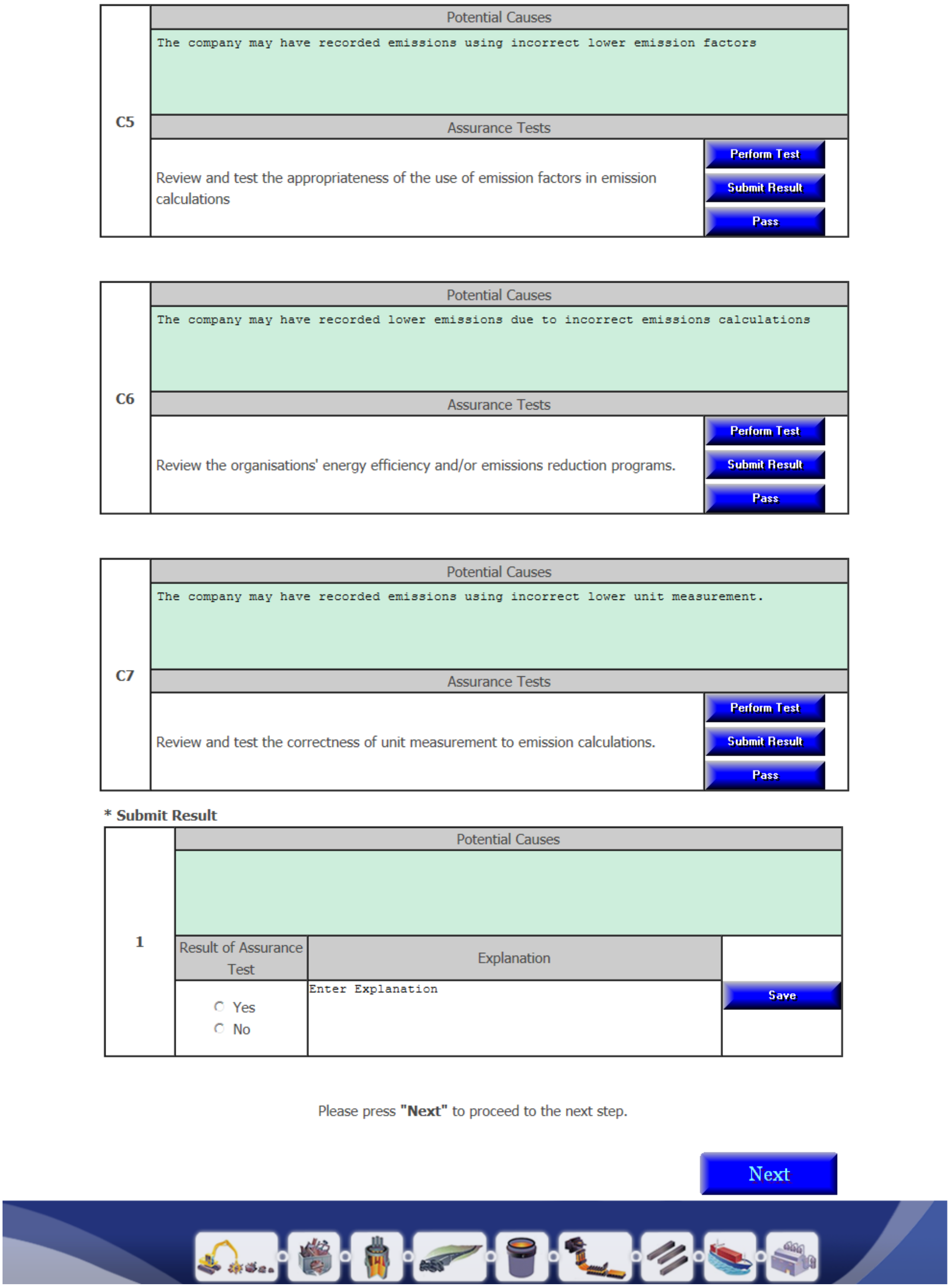
You have 15 minutes to do this step for each of your potential causes and selected tests.

	Potential Causes	
C1	`Remsco may have recorded incomplete emissions.`	
	Assurance Tests	
	Compare reported energy consumption to summary in financial reports and agree to source documents.	Perform Test Submit Result Pass

	Potential Causes	
C2	`Remsco may have recorded inaccurate emissions.`	
	Assurance Tests	
	By type of energy and facility, compare the energy included in the emission calculations to reported energy consumption.	Perform Test Submit Result Pass

	Potential Causes	
C3	`Remsco may have recorded emissions using incorrect lower unit measurement.`	
	Assurance Tests	
	Review and test the correctness of unit measurement to emission calculations.	Perform Test Submit Result Pass

	Potential Causes	
C4	`Remsco may decrease the consumption of lower emission fuels.`	
	Assurance Tests	
	Review the organisations' energy efficiency and/or emissions reduction programs.	Perform Test Submit Result Pass



C5	Potential Causes
	The company may have recorded emissions using incorrect lower emission factors
	Assurance Tests
	Review and test the appropriateness of the use of emission factors in emission calculations

C6	Potential Causes
	The company may have recorded lower emissions due to incorrect emissions calculations
	Assurance Tests
	Review the organisations' energy efficiency and/or emissions reduction programs.

C7	Potential Causes
	The company may have recorded emissions using incorrect lower unit measurement.
	Assurance Tests
	Review and test the correctness of unit measurement to emission calculations.

*** Submit Result**

1	Potential Causes	
	Result of Assurance Test	Explanation
	○ Yes ○ No	Enter Explanation

Please press **"Next"** to proceed to the next step.

A.11.3.5 Assurance Tests and Results of Assurance Tests

A.11.3.5.1 Assurance Test 1:

SELECTED TEST

By type of energy and facility, compare the energy included in the emission calculations to reported energy consumption.

RESULT

You make a comparison between reported consumption and the energy included in the emission calculations as per the following table:

Type of energy	Reported energy consumption based on unassured GHG Statement (in energy unit: gigajoule)	Energy consumption included in the emission calculations	
		Consumption of purchased electricity (in kWh) and natural gas (in gigajoule)	In energy unit (gigajoule)
Energy from electricity	2,488,550	691,264,000	2,488,550
Energy from natural gas	1,495,130	1,495,130	1,495,130
Total	**3,983,680**		**3,983,680**

Based on this comparison, you conclude that all energy consumed has been included.

A.11.3.5.2 Assurance Test 2:

SELECTED TEST

Review and test the appropriateness of the use of emission factors in emission calculations.

RESULT

The calculation tool used is an automated worksheet. In calculating emissions, it is only necessary to insert energy data into the worksheets and to select an appropriate emission factor or factors. Default emission factors are provided, but it is also possible to insert customized emission factors that are more representative of the reporting company’s operations. All emission factors used are correct.

A.11.3.5.3 Assurance Test 3:

SELECTED TEST

Review and test the organisation’s method for determining facilities and emission sources under its operational control.

RESULT

Management has appropriately determined facilities under its operational control. Direct GHG emissions and indirect GHG emissions from electricity have been reported from entities where the Company has operational control. Management has determined the emission sources properly. 100% of emissions for entities within its control have been reported.

A.11.3.5.4 Assurance Test 4:

SELECTED TEST

Review and test the correctness of unit measurement to emission calculations.

RESULT

Emission information processing is centralised in head office. However, the reporting format from the facilities is not a standardised format. There is no uniformity in unit measurement used by facilities. For instance, Plant A uses MWh as the unit measurement for electricity instead of kWh as used by other facilities.

You decided that additional test of details should be performed for a sample of calculation to ensure the correct unit measurement. In selecting samples, you decided to take samples for electricity because you observe that the current years’ production increased by 19 percent compared to prior year’s production but the current year’s total emissions only increased by 1 percent and you note this fluctuation was due to a decrease in the electricity emissions by 4 percent.

You gather information related to detailed emissions from electricity and the changes of emissions and production compared to that of last year in four facilities as per the following table:

Facilities	Emissions (kg CO^2)	Changes in emissions from electricity	Changes in production
Plant A	141,252	Decrease 99%	Decrease 8%
Plant B	19,399,600	Decrease 32%	Decrease 33%
Plant C	151,831,200	Increase 59%	Increase 56%
Plant D	238,764,800	Increase 96%	Increase 103%

You select a sample of calculations from Plant D because this is the facility with highest emissions from electricity and you reperform the calculations, to check the correct unit measurement has been used. You find no error in this sample of calculations.

A.11.3.5.5 Assurance Test 5:

SELECTED TEST

Review and test the organisation’s method for measuring and calculating energy consumption.

RESULT

Management systematically collects data for energy use and emission sources. For example, there is a systematic regular data collection process which includes direct entry of activity data by operational staff onto spreadsheet templates and emailed to a central point where data can be processed.

In addition, to ensure that activity data is accurate, energy meters are calibrated regularly.

The assurance tests of the management system for measuring and calculating energy consumption revealed that the system functioned effectively throughout the year.

A.11.3.5.6 Assurance Test 6:

SELECTED TEST

Review and test the organisation’s energy efficiency program.

RESULT

The facility manager indicates that the company continuously identify the most effective energy and emission reduction opportunities. The company has implemented a variety of strategies that would reduce either their demand for purchased energy or the GHG intensity of that purchased energy. One strategy has been to pursue the renewable energy market to reduce the GHG intensity of its purchased electricity. A facility (Plant B) succeeded in reducing its GHG emissions, even though energy use stayed relatively constant, through a contract for renewable electricity with an electricity company. Starting in June 2012, this five-year contract is for 5.25 million kWh of wind-power per year. This zero emission power lowered the facility’s emissions. In two months (June and July 2012), this strategy lowered the facility’s emissions by more than 1,760 tonnes of CO^2 compared to the previous year. Remsco expects to continue to gain benefits from this contract in the coming year.

A.11.3.5.7 Assurance Test 7:

SELECTED TEST

Compare reported energy consumption to summary in financial reports and agree to source documents.

RESULT

You make a comparison between reported consumption and the summary in the financial report as per the following table:

Type of energy	Reported energy consumption based on unassured GHG Statement (in energy unit: gigajoule)	Reported energy consumption on audited financial statement	
		In monetary unit (dollar)	In energy unit (gigajoule) = Energy consumption in monetary unit / cost per unit energy × energy content factor
Energy from electricity	2,488,550	96,776,960	2,488,550
Energy from natural gas	1,495,130	6,130,033	1,495,130
Total	**3,983,680**	**102,906,993**	**3,983,680**

You also test the recording by agreeing recorded energy consumption back to source documents. You find that all energy consumption was correctly recorded.

A.11.3.5.8 Assurance Test 8:

SELECTED TEST

Review and test the processing steps in calculating and aggregating emissions.

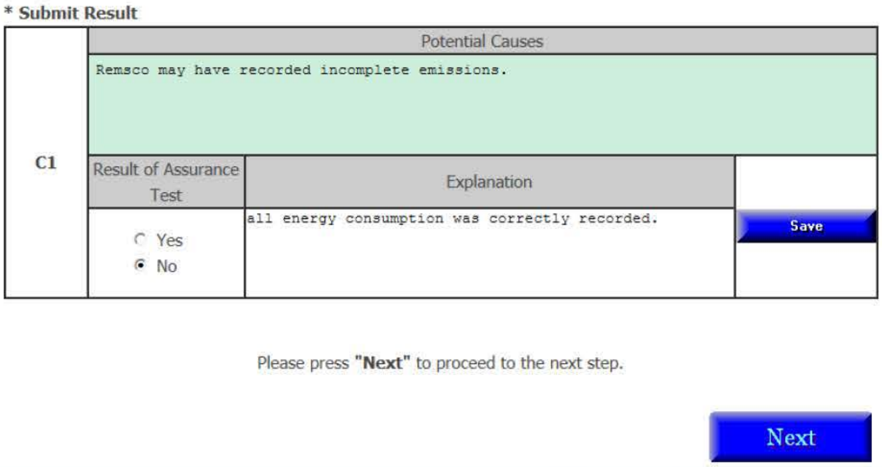
RESULT

In processing the emissions data, the best available calculation tool is used. Test of emission calculations by checking the data processing steps (e.g., equations) in the spreadsheets revealed that the calculations functioned properly. A similar result is also found from testing the aggregation of data across source categories and facilities.

You also examine the calculation of industrial process emissions. These emissions are not related to energy consumption and involve some estimation. However, the calculations are in accordance with iron and steel industry guideline.

A.11.4 Hypothesis Evaluation: Stage 4d

A.11.4.1 Team Member A’s Evaluation



* **Submit Result**

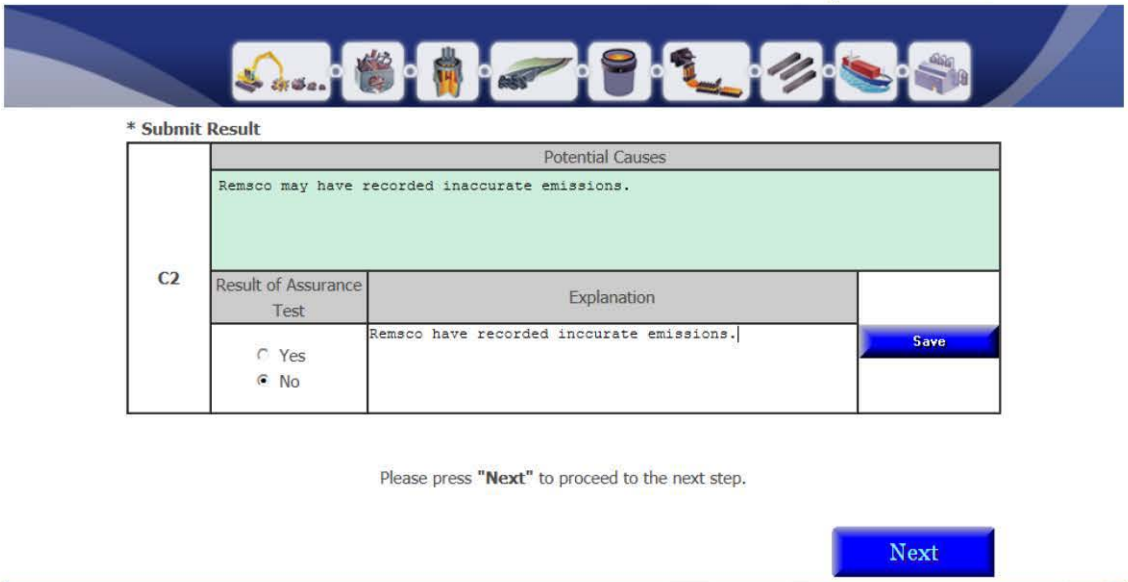
C1

Potential Causes: Remsco may have recorded incomplete emissions.

Result of Assurance Test: ○ Yes ● No

Explanation: all energy consumption was correctly recorded.

Please press **"Next"** to proceed to the next step.



* **Submit Result**

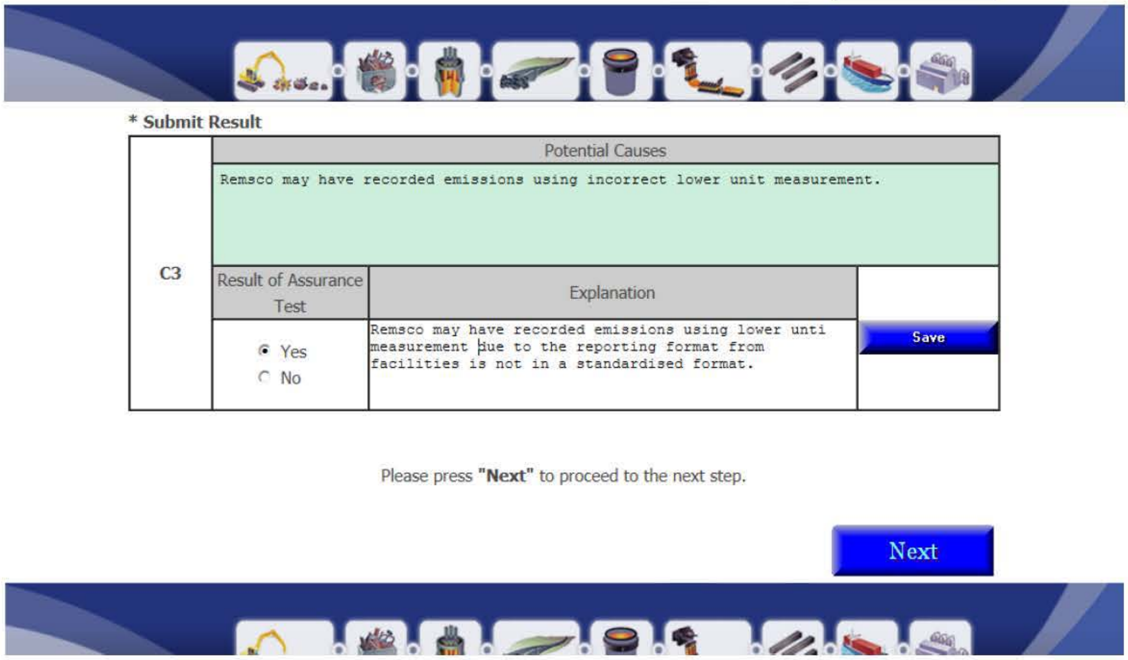
C2

Potential Causes: Remsco may have recorded inaccurate emissions.

Result of Assurance Test: ○ Yes ● No

Explanation: Remsco have recorded incurate emissions.

Please press **"Next"** to proceed to the next step.



* **Submit Result**

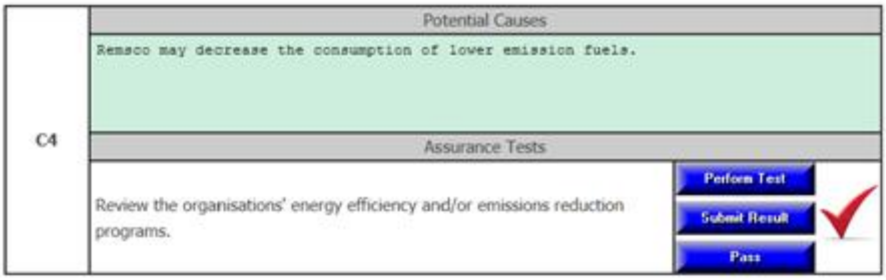
C3

Potential Causes: Remsco may have recorded emissions using incorrect lower unit measurement.

Result of Assurance Test: ● Yes ○ No

Explanation: Remsco may have recorded emissions using lower unti measurement due to the reporting format from facilities is not in a standardised format.

Please press **"Next"** to proceed to the next step.

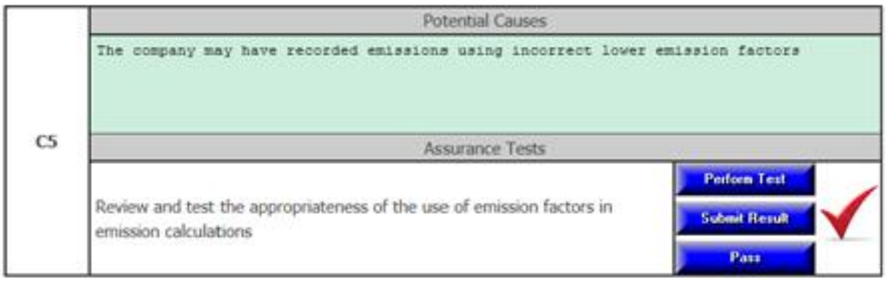

C4

Potential Causes

`Remsco may decrease the consumption of lower emission fuels.`

Assurance Tests

Review the organisations' energy efficiency and/or emissions reduction programs.

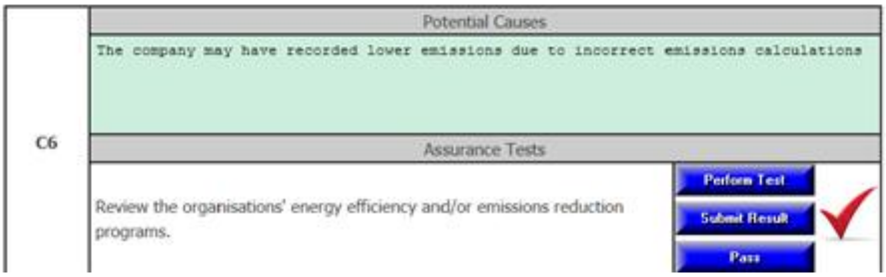

C5

Potential Causes

`The company may have recorded emissions using incorrect lower emission factors`

Assurance Tests

Review and test the appropriateness of the use of emission factors in emission calculations

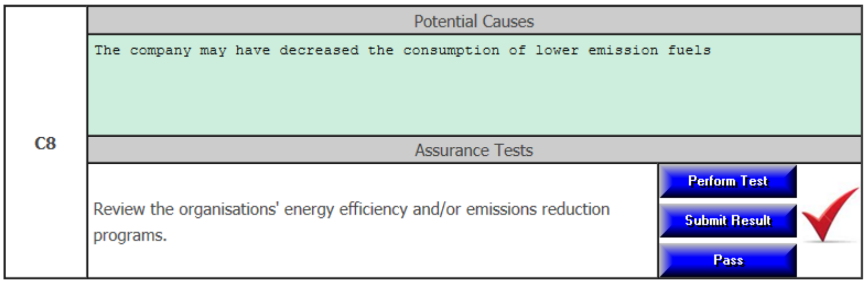

C6

Potential Causes

`The company may have recorded lower emissions due to incorrect emissions calculations`

Assurance Tests

Review the organisations' energy efficiency and/or emissions reduction programs.


C8

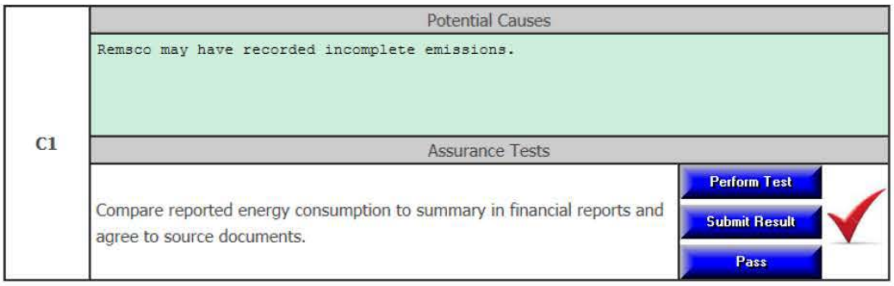
Potential Causes

`The company may have decreased the consumption of lower emission fuels`

Assurance Tests

Review the organisations' energy efficiency and/or emissions reduction programs.

A.11.4.2 Team Member B’s Evaluation

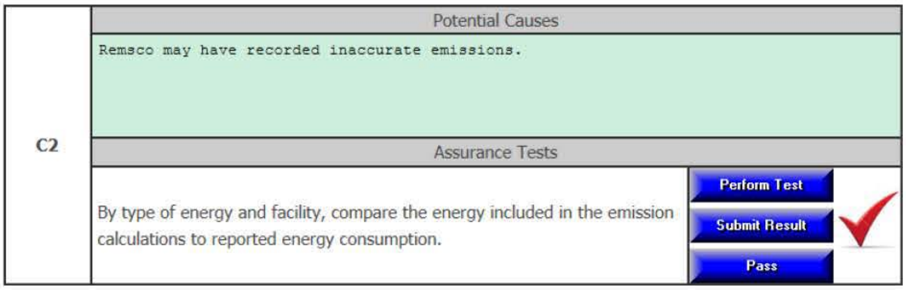

C1

Potential Causes

Remsco may have recorded incomplete emissions.

Assurance Tests

Compare reported energy consumption to summary in financial reports and agree to source documents.

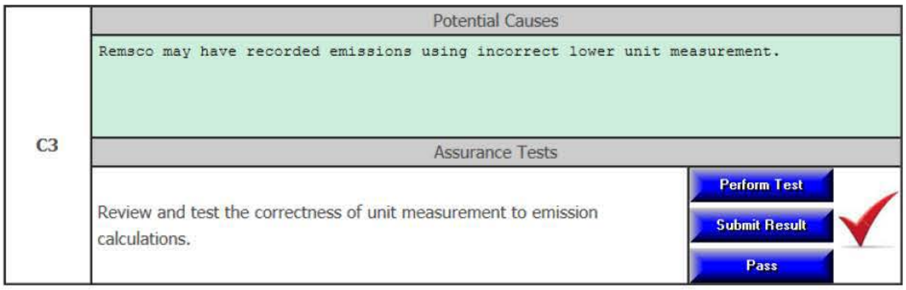

C2

Potential Causes

Remsco may have recorded inaccurate emissions.

Assurance Tests

By type of energy and facility, compare the energy included in the emission calculations to reported energy consumption.

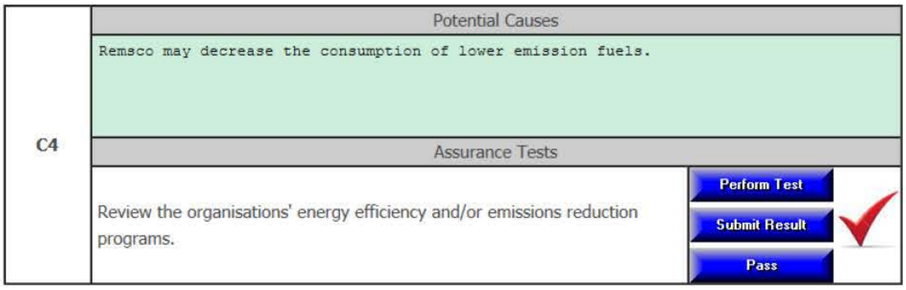

C3

Potential Causes

Remsco may have recorded emissions using incorrect lower unit measurement.

Assurance Tests

Review and test the correctness of unit measurement to emission calculations.

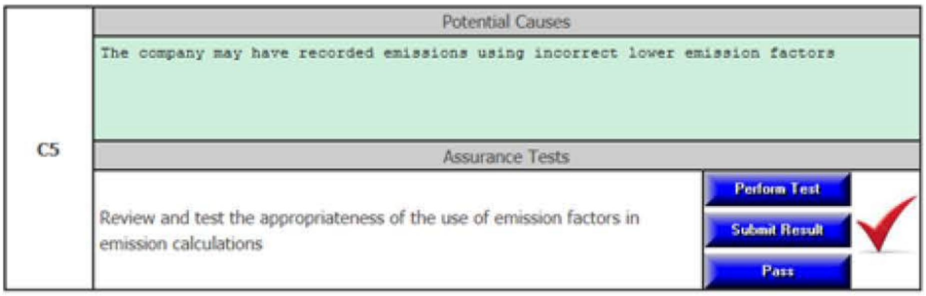

C4

Potential Causes

Remsco may decrease the consumption of lower emission fuels.

Assurance Tests

Review the organisations' energy efficiency and/or emissions reduction programs.

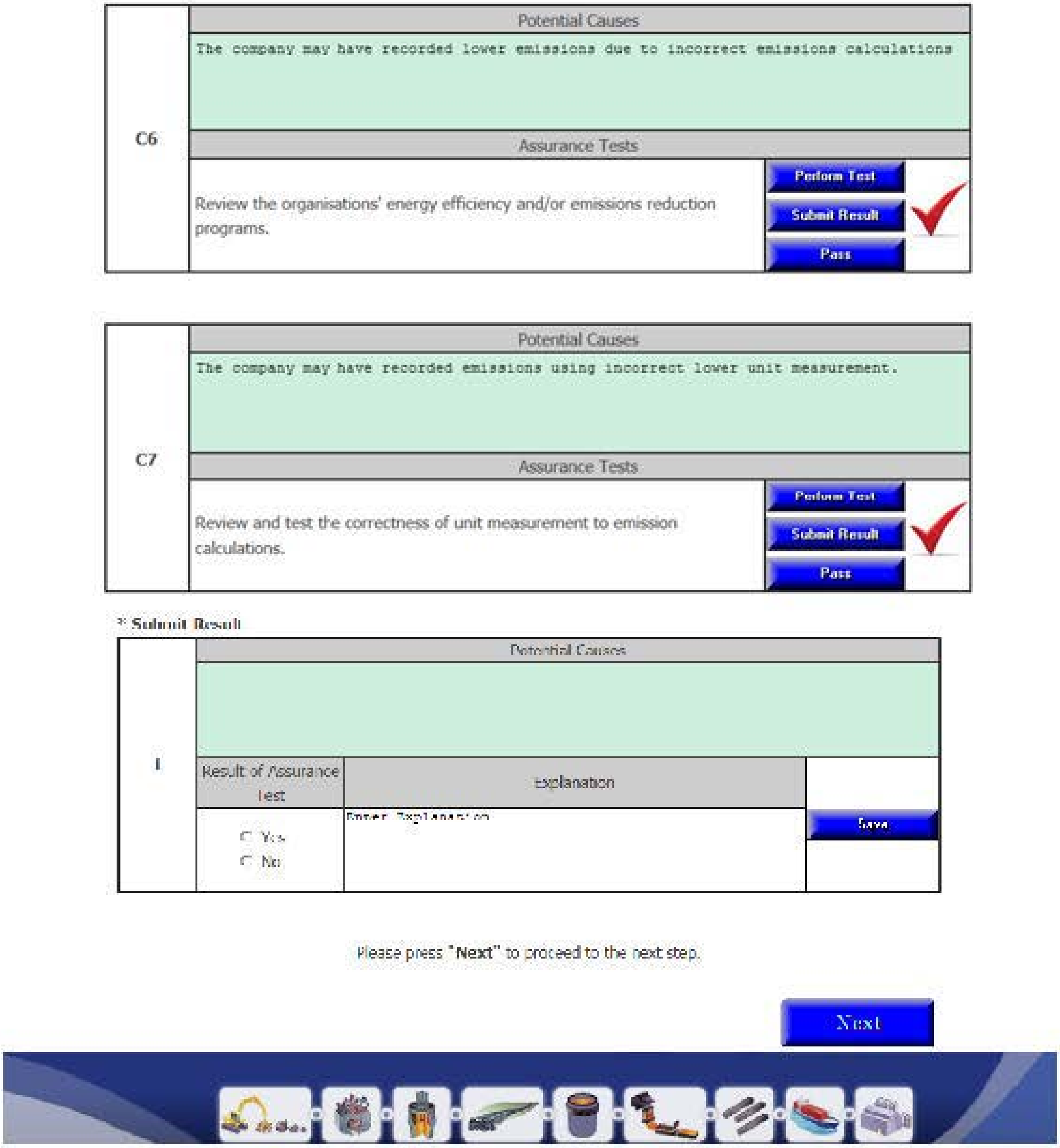

C5

Potential Causes

The company may have recorded emissions using incorrect lower emission factors

Assurance Tests

Review and test the appropriateness of the use of emission factors in emission calculations



	Potential Causes
C6	The company may have recorded lower emissions due to incorrect emissions calculations
	Assurance Tests
	Review the organisations' energy efficiency and/or emissions reduction programs. ✓

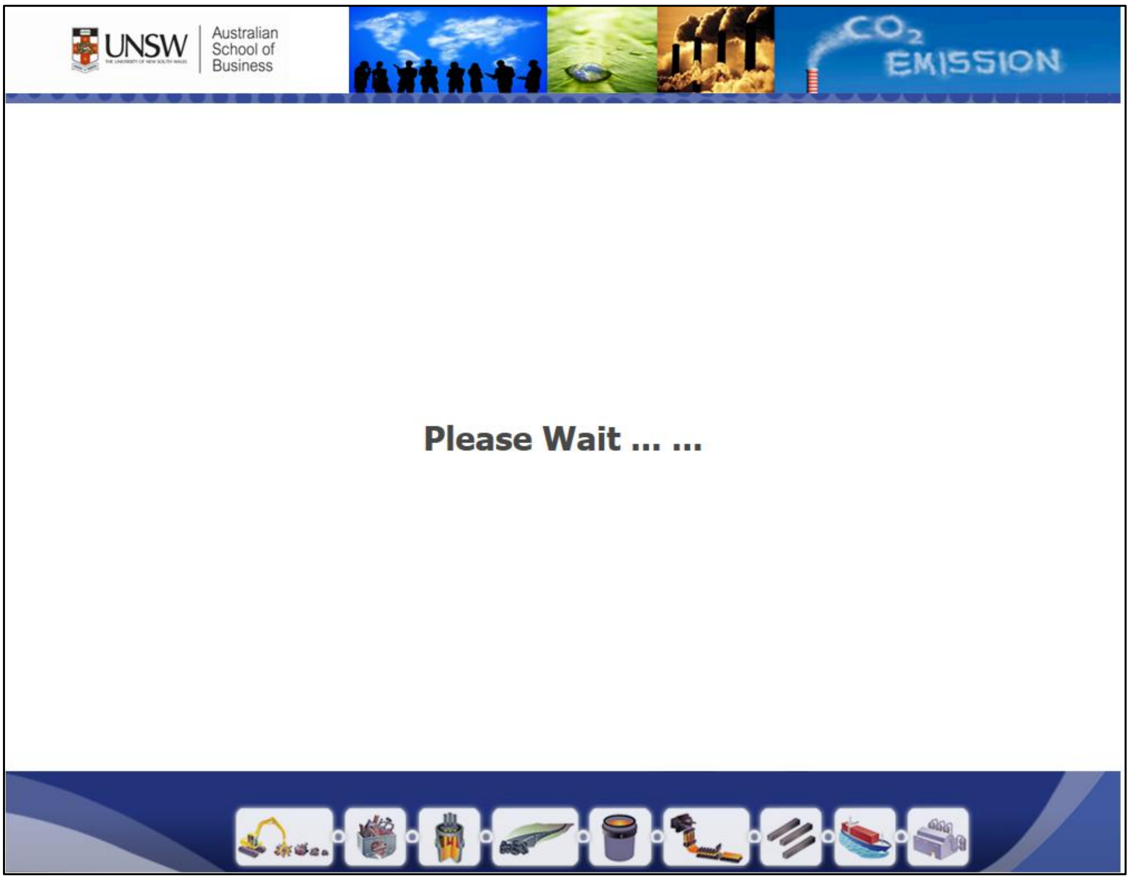
	Potential Causes
C7	The company may have recorded emissions using incorrect lower unit measurement.
	Assurance Tests
	Review and test the correctness of unit measurement to emission calculations. ✓

*** Submit Result**

	Potential Causes		
1			
	Result of Assurance Test	Explanation	
	○ Yes ○ No	Enter Explanation	Save

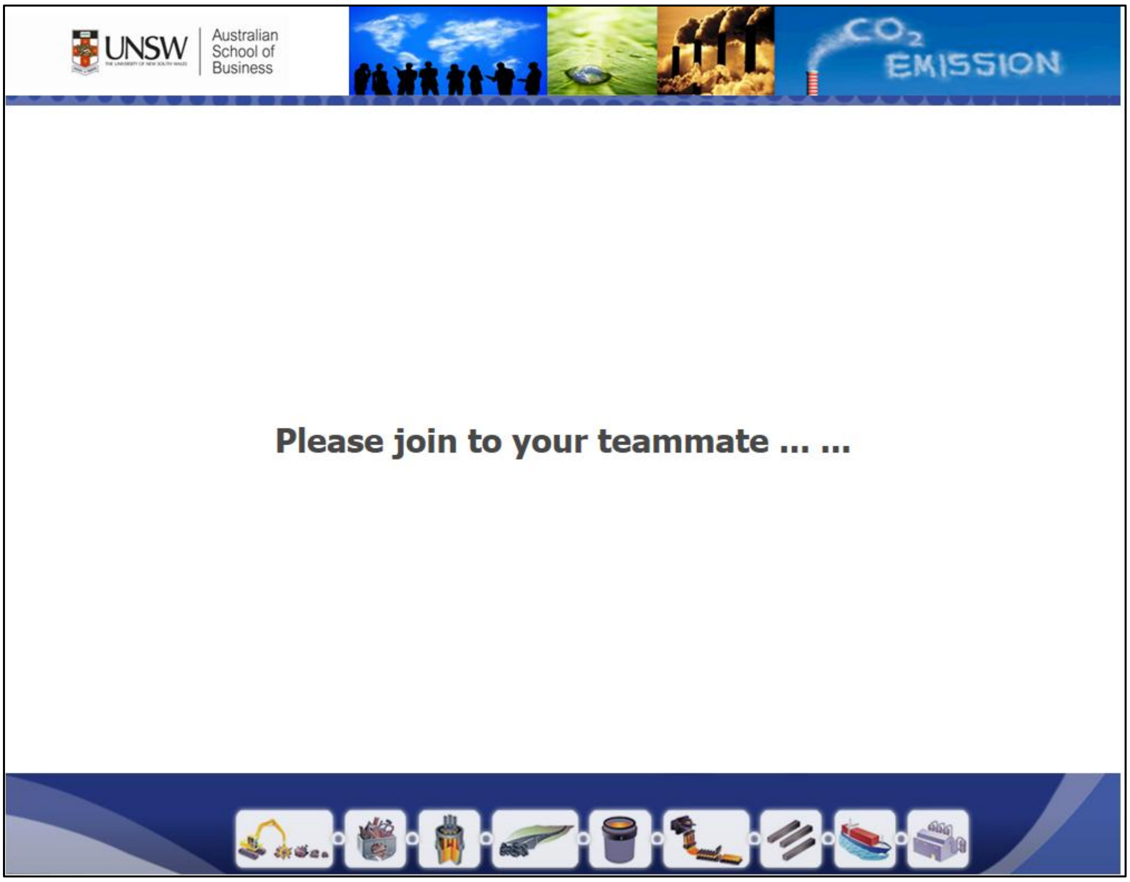
Please press "**Next**" to proceed to the next step.

A.11.4.3 Instruction to Wait for Other Member to Complete His or Her Hypothesis Evaluation



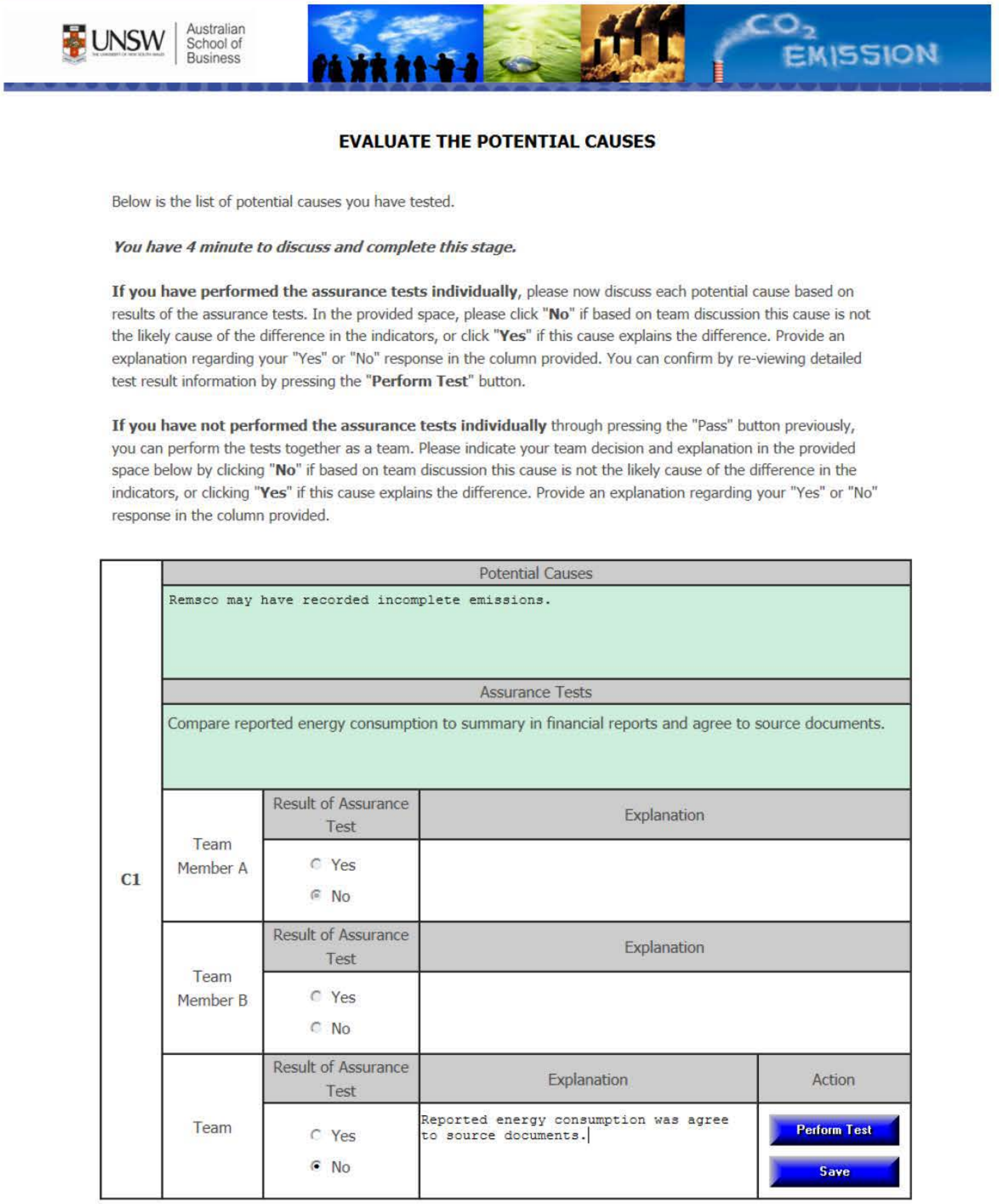
Please Wait ... ...

A.11.4.4 Instruction to Perform Team’s Evaluation



Please join to your teammate … …

A.11.4.5 Team’s Evaluation



EVALUATE THE POTENTIAL CAUSES

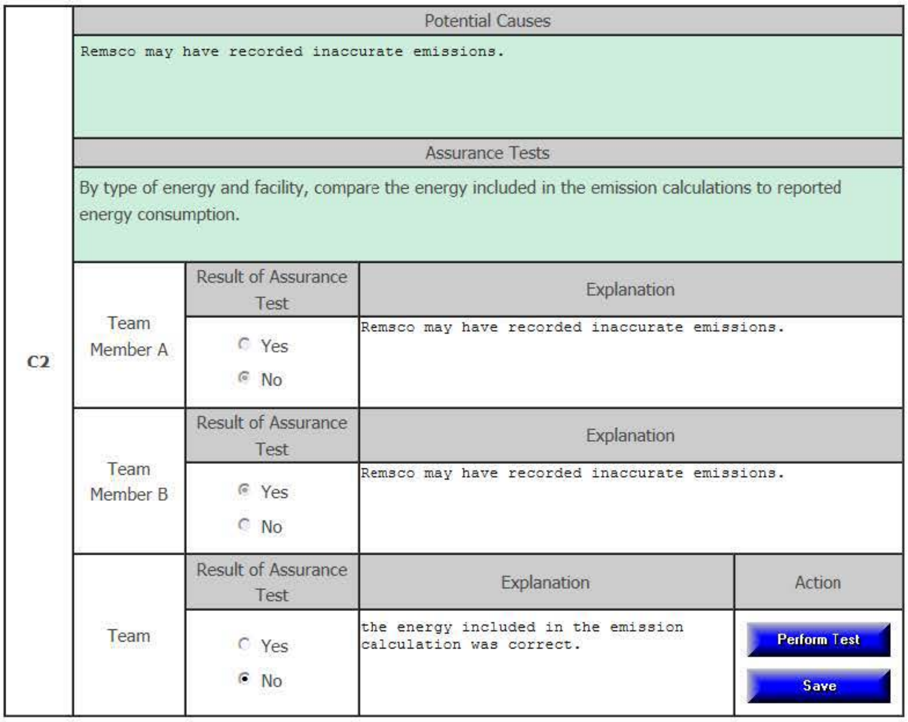
Below is the list of potential causes you have tested.

You have 4 minute to discuss and complete this stage.

If you have performed the assurance tests individually, please now discuss each potential cause based on results of the assurance tests. In the provided space, please click "**No**" if based on team discussion this cause is not the likely cause of the difference in the indicators, or click "**Yes**" if this cause explains the difference. Provide an explanation regarding your "Yes" or "No" response in the column provided. You can confirm by re-viewing detailed test result information by pressing the "**Perform Test**" button.

If you have not performed the assurance tests individually through pressing the "Pass" button previously, you can perform the tests together as a team. Please indicate your team decision and explanation in the provided space below by clicking "**No**" if based on team discussion this cause is not the likely cause of the difference in the indicators, or clicking "**Yes**" if this cause explains the difference. Provide an explanation regarding your "Yes" or "No" response in the column provided.

C1	Potential Causes			
	Remsco may have recorded incomplete emissions.			
	Assurance Tests			
	Compare reported energy consumption to summary in financial reports and agree to source documents.			
	Team Member A	Result of Assurance Test	Explanation	
		○ Yes ● No		
	Team Member B	Result of Assurance Test	Explanation	
		○ Yes ○ No		
	Team	Result of Assurance Test	Explanation	Action
		○ Yes ● No	Reported energy consumption was agree to source documents.	Perform Test Save



C2

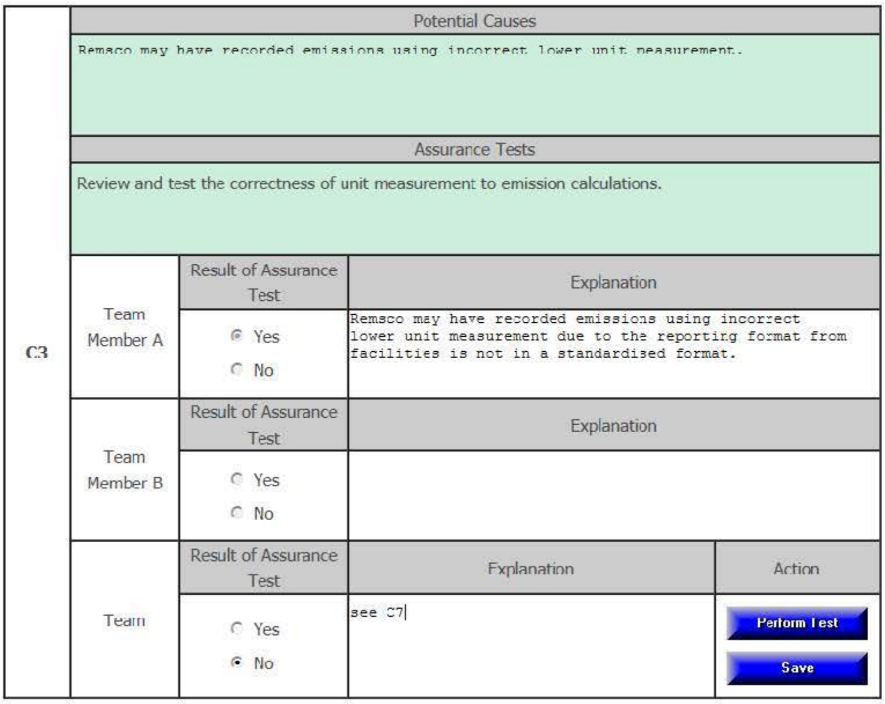
Potential Causes

Remsco may have recorded inaccurate emissions.

Assurance Tests

By type of energy and facility, compare the energy included in the emission calculations to reported energy consumption.

	Result of Assurance Test	Explanation	
Team Member A	○ Yes ● No	Remsco may have recorded inaccurate emissions.	
Team Member B	● Yes ○ No	Remsco may have recorded inaccurate emissions.	
Team	○ Yes ● No	the energy included in the emission calculation was correct.	Perform Test Save



C3

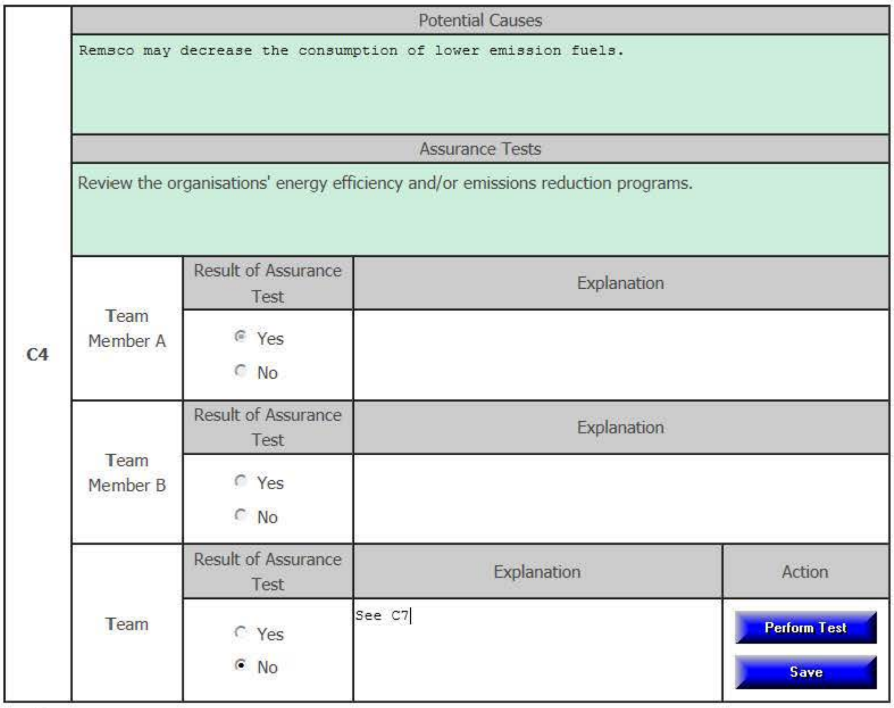
Potential Causes

Remsco may have recorded emissions using incorrect lower unit measurement.

Assurance Tests

Review and test the correctness of unit measurement to emission calculations.

	Result of Assurance Test	Explanation	
Team Member A	● Yes ○ No	Remsco may have recorded emissions using incorrect lower unit measurement due to the reporting format from facilities is not in a standardised format.	
Team Member B	○ Yes ○ No		
Team	○ Yes ● No	see C7	Perform Test Save



C4

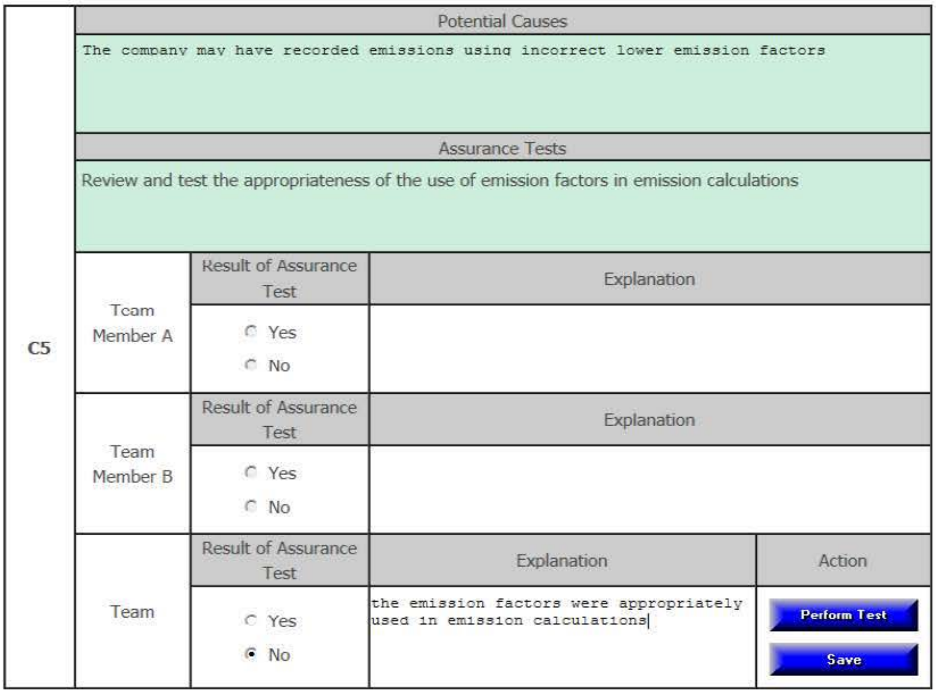
Potential Causes

`Remsco may decrease the consumption of lower emission fuels.`

Assurance Tests

Review the organisations' energy efficiency and/or emissions reduction programs.

	Result of Assurance Test	Explanation	Action
Team Member A	● Yes ○ No		
Team Member B	○ Yes ○ No		
Team	○ Yes ● No	See C7	Perform Test Save



C5

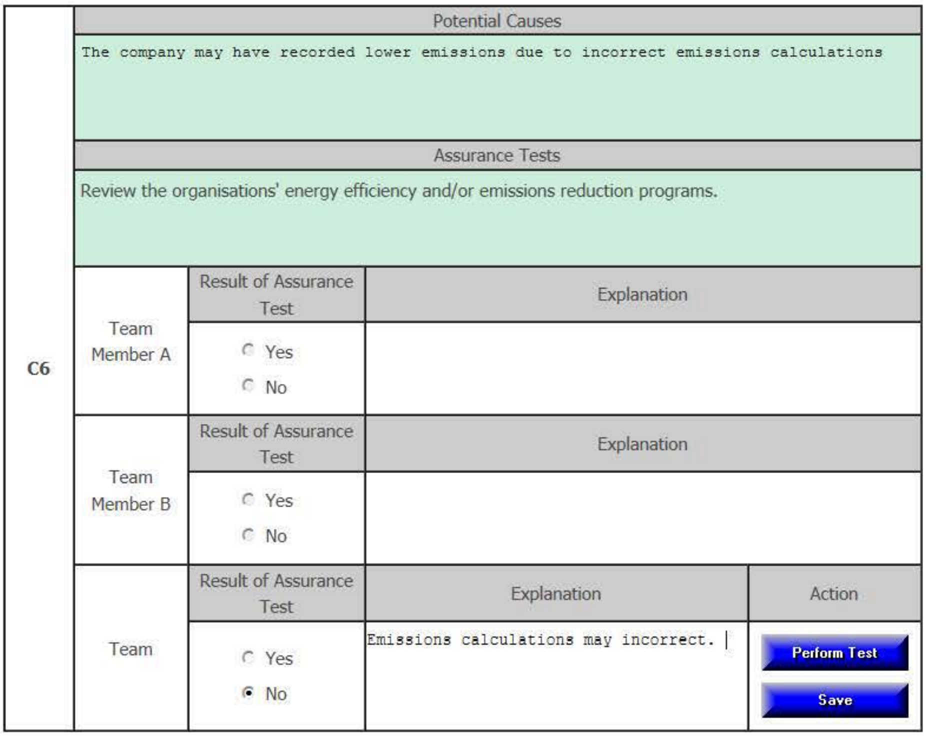
Potential Causes

`The company may have recorded emissions using incorrect lower emission factors`

Assurance Tests

Review and test the appropriateness of the use of emission factors in emission calculations

	Result of Assurance Test	Explanation	Action
Team Member A	○ Yes ○ No		
Team Member B	○ Yes ○ No		
Team	○ Yes ● No	the emission factors were appropriately used in emission calculations	Perform Test Save



C6

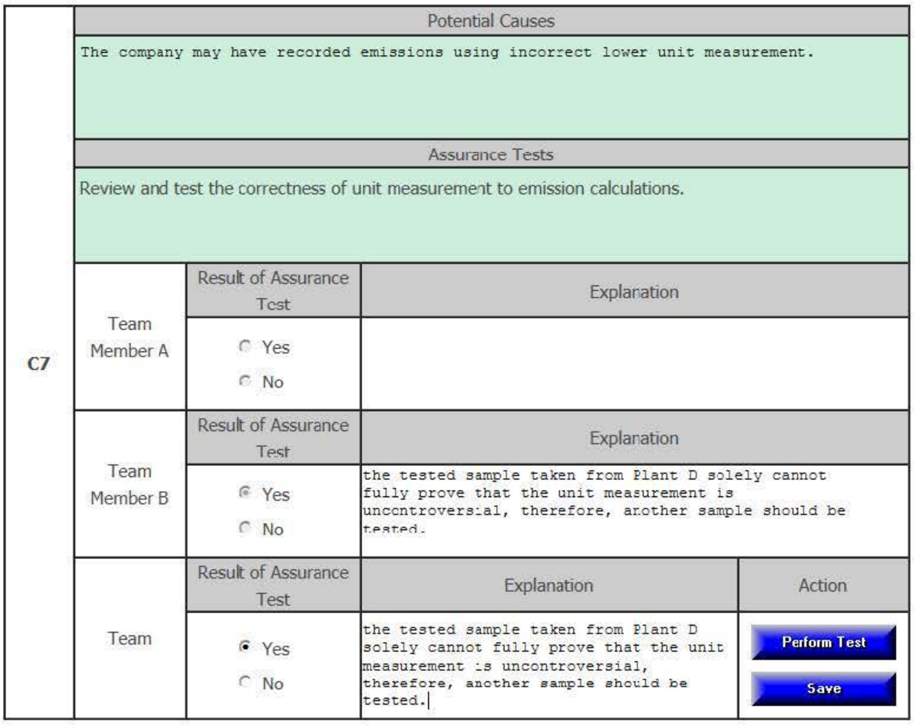
Potential Causes

The company may have recorded lower emissions due to incorrect emissions calculations

Assurance Tests

Review the organisations' energy efficiency and/or emissions reduction programs.

	Result of Assurance Test	Explanation
Team Member A	○ Yes ○ No	
Team Member B	○ Yes ○ No	
Team	○ Yes ● No	Emissions calculations may incorrect.



C7

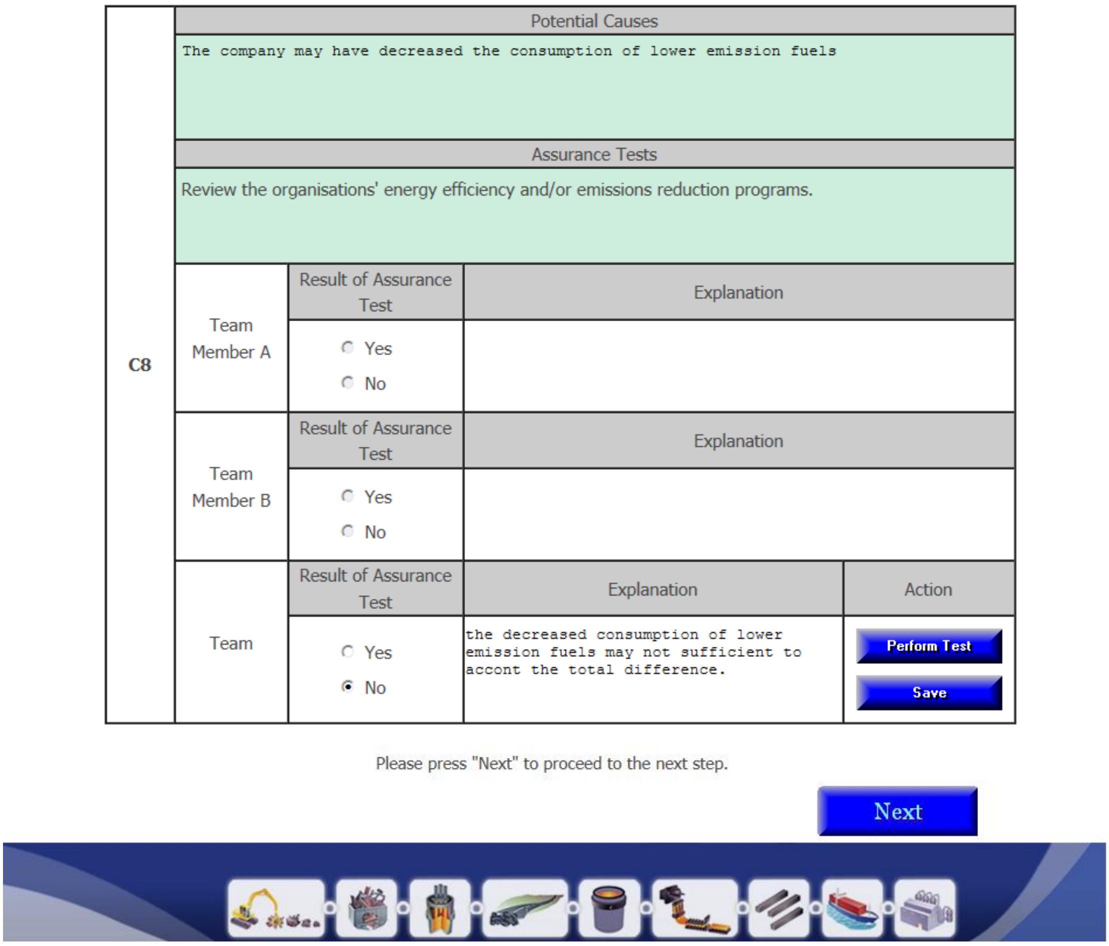
Potential Causes

The company may have recorded emissions using incorrect lower unit measurement.

Assurance Tests

Review and test the correctness of unit measurement to emission calculations.

	Result of Assurance Test	Explanation
Team Member A	○ Yes ○ No	
Team Member B	● Yes ○ No	the tested sample taken from Plant D solely cannot fully prove that the unit measurement is uncontroversial, therefore, another sample should be tested.
Team	● Yes ○ No	the tested sample taken from Plant D solely cannot fully prove that the unit measurement is uncontroversial, therefore, another sample should be tested.

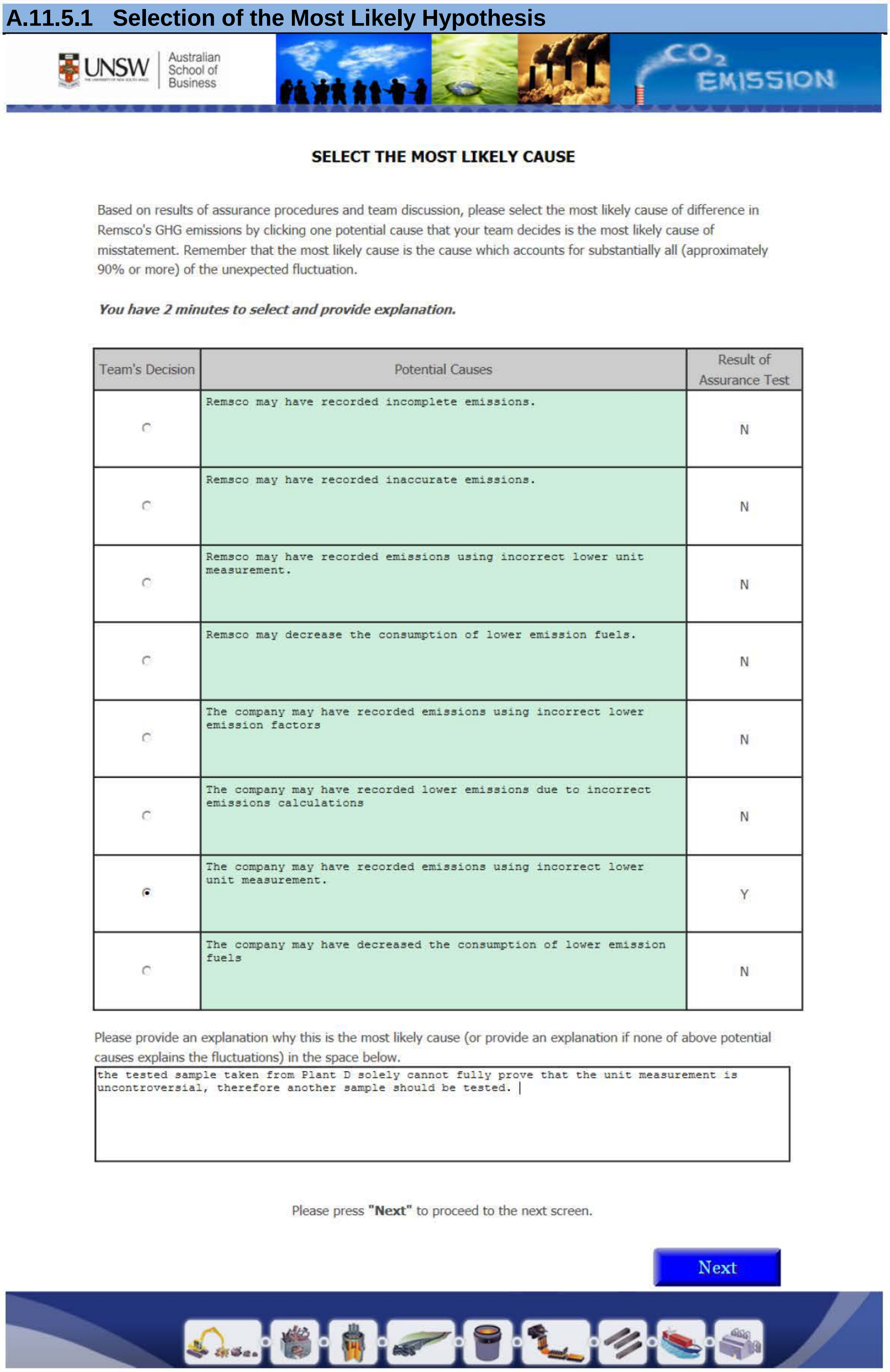


<table>
<tr><td rowspan="10">C8</td><td colspan="4">Potential Causes</td></tr>
<tr><td colspan="4">The company may have decreased the consumption of lower emission fuels</td></tr>
<tr><td colspan="4">Assurance Tests</td></tr>
<tr><td colspan="4">Review the organisations' energy efficiency and/or emissions reduction programs.</td></tr>
<tr><td rowspan="2">Team Member A</td><td>Result of Assurance Test</td><td colspan="2">Explanation</td></tr>
<tr><td>○ Yes
○ No</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Team Member B</td><td>Result of Assurance Test</td><td colspan="2">Explanation</td></tr>
<tr><td>○ Yes
○ No</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Team</td><td>Result of Assurance Test</td><td>Explanation</td><td>Action</td></tr>
<tr><td>○ Yes
● No</td><td>the decreased consumption of lower emission fuels may not sufficient to accont the total difference.</td><td>Perform Test
Save</td></tr>
</table>

Please press "Next" to proceed to the next step.

A.11.5 Final Judgment: Stage 4e

A.11.5.1 Selection of the Most Likely Hypothesis



SELECT THE MOST LIKELY CAUSE

Based on results of assurance procedures and team discussion, please select the most likely cause of difference in Remsco's GHG emissions by clicking one potential cause that your team decides is the most likely cause of misstatement. Remember that the most likely cause is the cause which accounts for substantially all (approximately 90% or more) of the unexpected fluctuation.

You have 2 minutes to select and provide explanation.

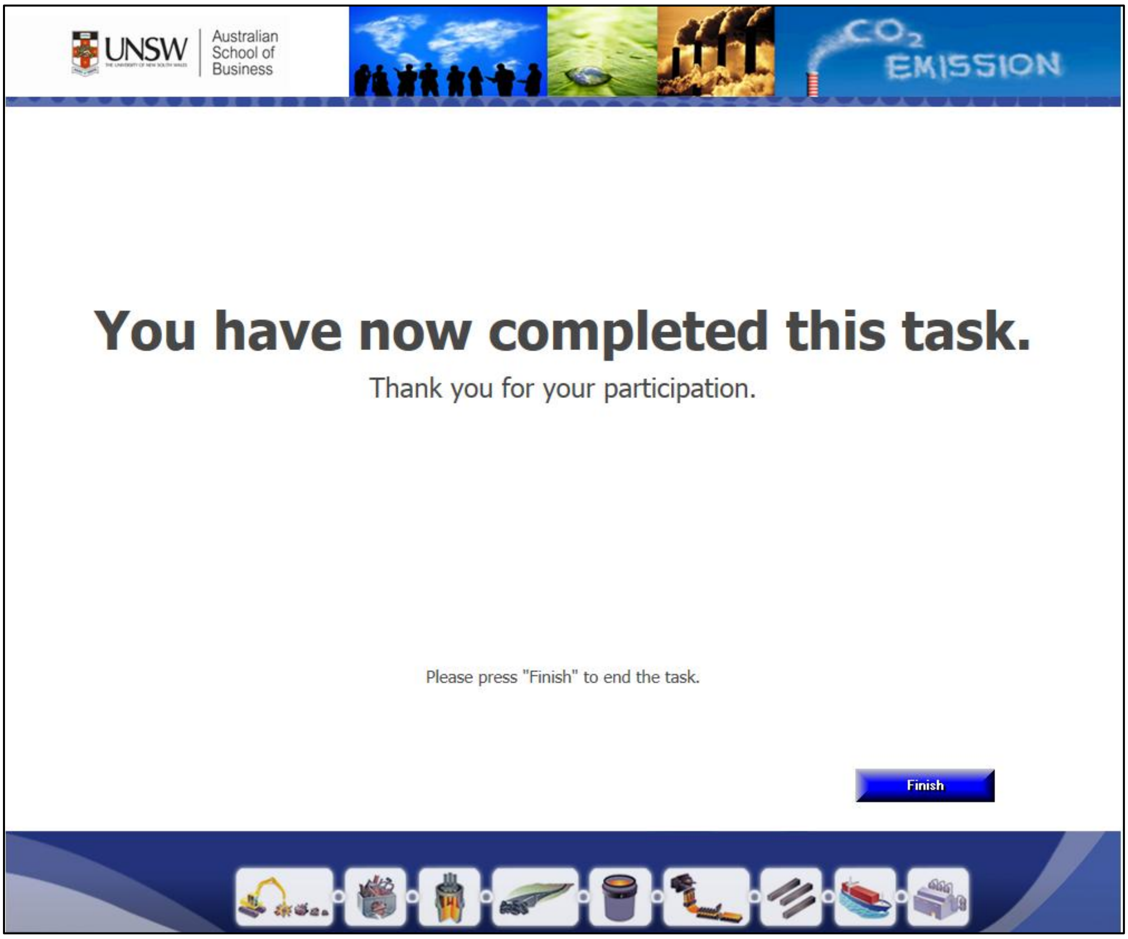
Team's Decision	Potential Causes	Result of Assurance Test
○	Remsco may have recorded incomplete emissions.	N
○	Remsco may have recorded inaccurate emissions.	N
○	Remsco may have recorded emissions using incorrect lower unit measurement.	N
○	Remsco may decrease the consumption of lower emission fuels.	N
○	The company may have recorded emissions using incorrect lower emission factors	N
○	The company may have recorded lower emissions due to incorrect emissions calculations	N
●	The company may have recorded emissions using incorrect lower unit measurement.	Y
○	The company may have decreased the consumption of lower emission fuels	N

Please provide an explanation why this is the most likely cause (or provide an explanation if none of above potential causes explains the fluctuations) in the space below.

the tested sample taken from Plant D solely cannot fully prove that the unit measurement is uncontroversial, therefore another sample should be tested.

Please press **"Next"** to proceed to the next screen.

A.11.5.2 Completing the Task

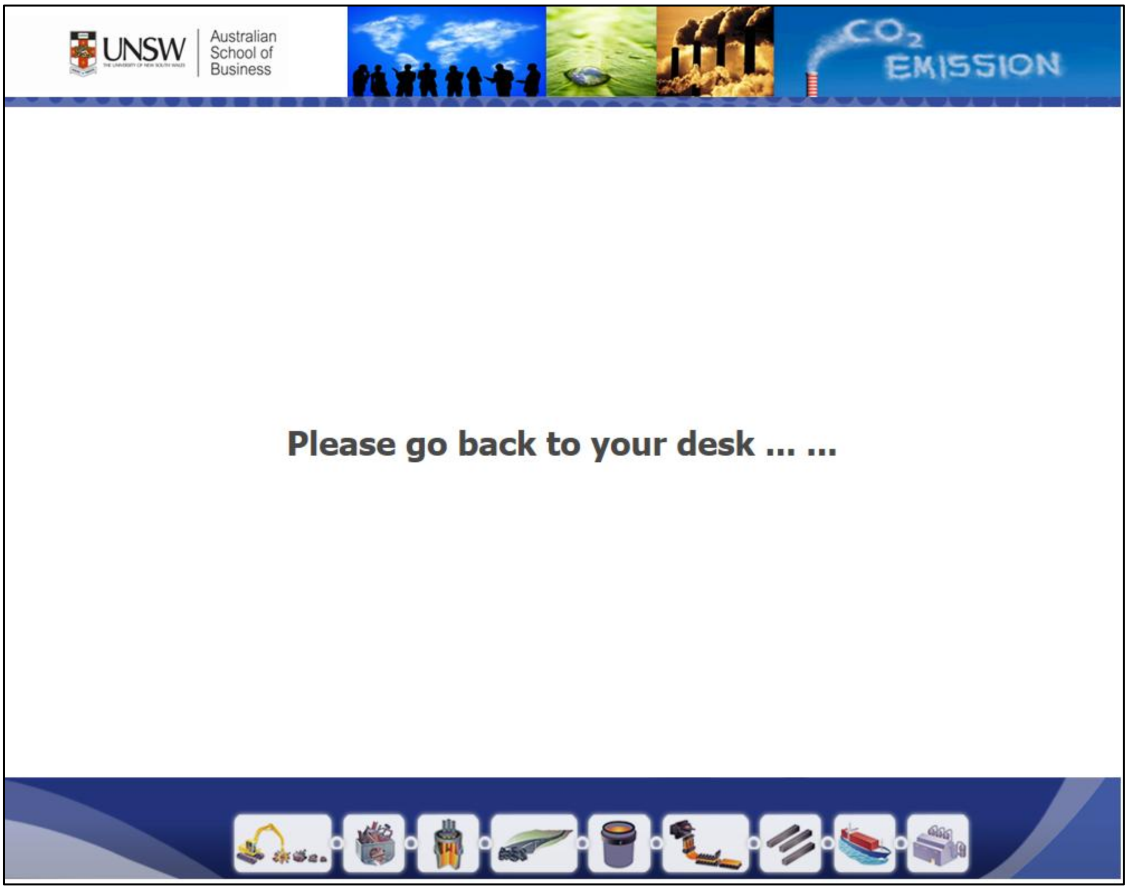


You have now completed this task.

Thank you for your participation.

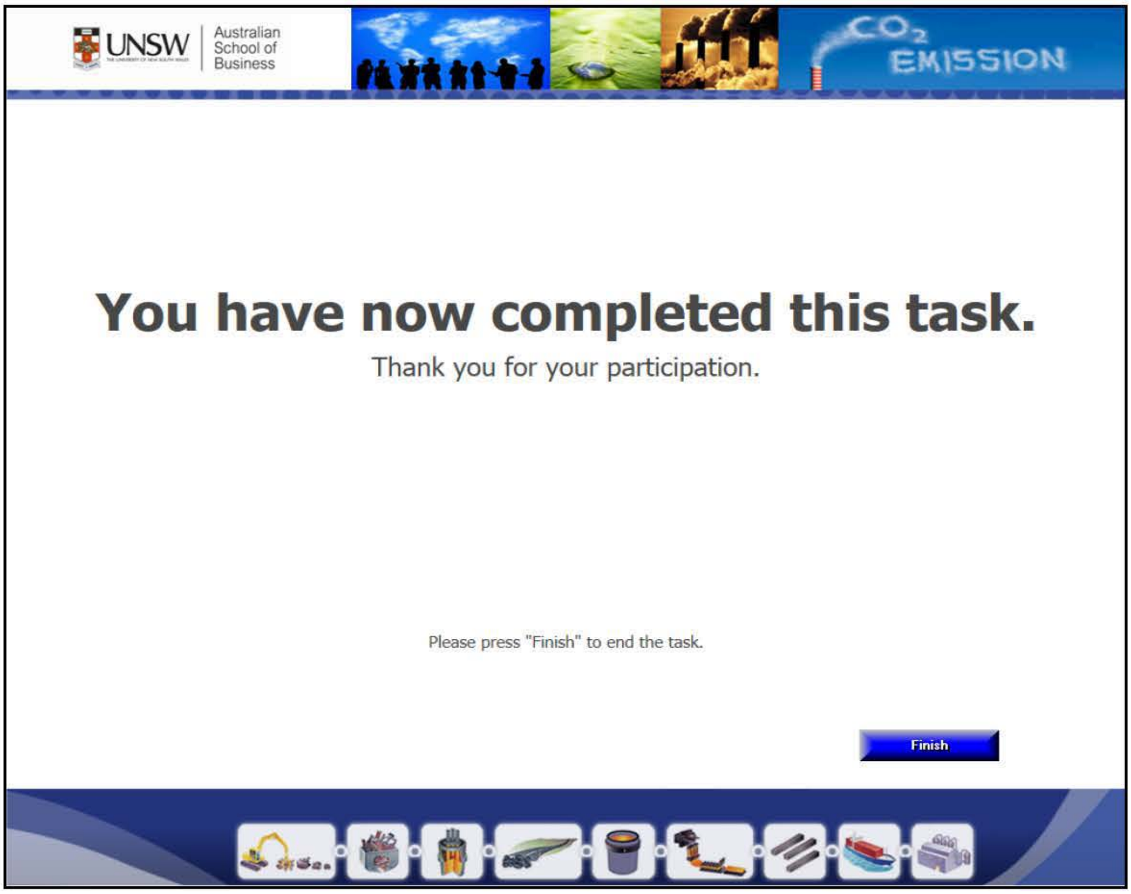
Please press "Finish" to end the task.

A.11.5.3 Completing the Task for Team Member A



Please go back to your desk ... ...

A.11.5.4 Completing the Task for Team Member B



You have now completed this task.

Thank you for your participation.

Please press "Finish" to end the task.

APPENDIX 12: POST-EXPERIMENT QUESTIONNAIRE

A.12.1 Demographic Questionnaire

A.12.2 Debriefing Questionnaire

A.12.1 Demographic Questionnaire

Please fill in the following demographic details in the spaces provided.

1. Please indicate your gender: ☐ Male ☐ Female

2. Please indicate your age: ☐ <20 ☐ 20 – 25 ☐ 26 – 30 ☐ 31 – 40 ☐ 41 – 50 ☐ 50+

3. Please indicate your residency: ☐ Domestic student ☐ International student

4. Please indicate the program you are currently enrolled in:
   - ☐ Master of Professional Accounting
   - ☐ Master of Financial Analysis
   - ☐ Master of Accounting and Business Information Technology
   - ☐ Master of Commerce
   - ☐ Master of Engineering
   - ☐ Master of Built Environment – Sustainable Development
   - ☐ Master of Environmental Management
   - ☐ Others, please specify

5. Please indicate your majors in undergraduate studies:

6. Please indicate your overall weighted average mark (WAM) in all classes you have taken:

7. Please indicate your primary language: ☐ English
   ☐ Others, please specify

8. How often have you worked together with other people in a group or a team?

Never	Once	2 – 3 times	4 – 5 times	6 – 7 times	8 – 9 times	Very often (>10)
1	2	3	4	5	6	7

9. Do you have work experience?

   ☐ No

   ☐ Yes. Please indicate which firm you work(ed) for?

   ☐ Accounting firm
   Please indicate how long you worked for this firm. ______ Years _______ Month

   ☐ Engineering consulting firm
   Please indicate how long you worked for this firm. ______ Years _______ Month

	☐ Commercial company, please specify industry sector Please indicate how long you worked for this company. ______ Years _______ Month ☐ Others, please specify Please indicate how long you worked for this organisation. ______ Years _______ Month
10.	Have you been involved in GHG emissions reporting? ☐ No ☐ Yes. Please indicate how long you have been involved in this area ______ Years _______ Month Please indicate the nature of this involvement
11.	Have you been involved in GHG emissions assurance? ☐ No ☐ Yes. Please indicate how long you have been involved in this area ______ Years _______ Month Please indicate the nature of this involvement

A.12.2 Debriefing Questionnaire

Thank you for completing our experiment. We are now going to ask you a few questions about the task you just completed.

1. Please rate how difficult you found the team task?

Extremely Easy			Undecided			Extremely Difficult
1	2	3	4	5	6	7

2. How familiar are you with the other team member in your team before the experimental sessions today?

Very Unfamiliar			Familiar			Very Familiar
1	2	3	4	5	6	7

Please indicate by assigning the appropriate number, how much you agree with the following statements:

3. *Members of my team discussed our goal(s) in this task.*

Strongly Disagree			Undecided			Strongly Agree
1	2	3	4	5	6	7

4. *Members of my team discussed what we can do to achieve our goals.*

Strongly Disagree			Undecided			Strongly Agree
1	2	3	4	5	6	7

5. *Members of my team discussed our analysis of provided information in order to achieve our goals.*

Strongly Disagree			Undecided			Strongly Agree
1	2	3	4	5	6	7

6. *Members of my team took the time we needed to share task-related information.*

Strongly Disagree			Undecided			Strongly Agree
1	2	3	4	5	6	7

7. *Members of my team actively learnt from one another.*

Strongly Disagree			Undecided			Strongly Agree
1	2	3	4	5	6	7

8. *Members of my team effectively communicated with each other throughout the task.*

Strongly Disagree			Undecided			Strongly Agree
1	2	3	4	5	6	7

9. *Members of my team created an environment of openness and trust.*

Strongly Disagree			Undecided			Strongly Agree
1	2	3	4	5	6	7

10. *Members of my team really trust each other.*

Strongly Disagree			Undecided			Strongly Agree
1	2	3	4	5	6	7

11. *Members of my team think in terms of what is best for the team.*

Strongly Disagree			Undecided			Strongly Agree
1	2	3	4	5	6	7

REFERENCES

Ancona, D. G., and D. F. Caldwell. 1992. Demography and design: Predictors of new product team performance. *Organization Science* 3 (3):321-341.

Anderson, J. R. 1993. *Rules of the Mind*. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Anderson, J. R. 2010. *Cognitive Psychology and its Implications*. 7th ed. New York, NY: Worth Publishers.

Anderson, U., and L. Koonce. 1998. Evaluating the sufficiency of causes in audit analytical procedures. *Auditing: A Journal of Practice & Theory* 17 (1):1-12.

Andersson, J., and J. Rönnberg. 1995. Recall suffers from collaboration: Joint recall effects of friendship and task complexity. *Applied Cognitive Psychology* 9 (3):199-211.

Asare, S. K., and A. M. Wright. 1995. Normative and substantive expertise in multiple hypotheses evaluation. *Organizational Behavior and Human Decision Processes* 64 (2):171-184.

———. 1997a. Evaluation of competing hypotheses in auditing. *Auditing: A Journal of Practice & Theory* 16 (1):1-13.

———. 1997b. Hypothesis revision strategies in conducting analytical procedures. *Accounting, Organizations and Society* 22 (8):737-755.

———. 2001. Design considerations for research on analytical procedures. *International Journal of Auditing* 5 (3):205-214.

———. 2003. A note on the interdependence between hypothesis generation and information search in conducting analytical procedures. *Contemporary Accounting Research* 20 (2):235-251.

Asch, S. 1952. *Social Psychology*. Englewood Cliffs, NJ Prentice-Hall.

Atkinson, R. K., S. J. Derry, A. Renkl, and D. Wortham. 2000. Learning from examples: Instructional principles from the worked examples research. *Review of Educational Research* 70 (2):181-214.

Austin, J. R. 2003. Transactive memory in organizational groups: the effects of content, consensus, specialization, and accuracy on group performance. *Journal of Applied Psychology* 88 (5):866-878.

Baddeley, A. D. 1999. *Essentials of Human Memory*. Hove: Psychology Press.

Badke-Schaub, P., A. Neumann, K. Lauche, and S. Mohammed. 2007. Mental models in design teams: a valid approach to performance in design collaboration? *CoDesign* 3 (1):5-20.

Barber, S. J., S. Rajaram, and A. Aron. 2010. When two is too many: Collaborative encoding impairs memory. *Memory & Cognition* 38 (3):255-264.

Baron, R. M., and D. A. Kenny. 1986. The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology* 51 (6):1173-1182.

Basden, B. H., D. R. Basden, S. Bryner, and R. L. Thomas III. 1997. A comparison of group and individual remembering: Does collaboration disrupt retrieval strategies? *Journal of Experimental Psychology: Learning, Memory, and Cognition* 23 (5):1176-1189.

Bedard, J. C., and S. F. Biggs. 1991. Pattern recognition, hypotheses generation, and auditor performance in an analytical task. *The Accounting Review* 66 (3):622-642.

Bedard, J. C., S. F. Biggs, and J. J. Maroney. 1998. Sources of process gain and loss from group interaction in performance of analytical procedures. *Behavioral Research in Accounting* 10:207-233.

Bedwell, W. L., E. Salas, G. J. Funke, and B. A. Knott. 2014. Team workload: A multilevel perspective. *Organizational Psychology Review* 4 (2):99-123.

Bettman, J. R., E. J. Johnson, and J. W. Payne. 1990. A componential analysis of cognitive effort in choice. *Organizational Behavior and Human Decision Processes* 45 (1):111-139.

Bhattacharjee, S., T. Kida, and D. M. Hanno. 1999. The impact of hypothesis set size on the time efficiency and accuracy of analytical review judgments. *Journal of Accounting Research* 37 (1):83-100.

Bierstaker, J. L., and S. Wright. 2001. A research note concerning practical problem-solving ability as a predictor of performance in auditing tasks. *Behavioral Research in Accounting* 13 (1):49-62.

Biggs, S. F., T. J. Mock, and P. R. Watkins. 1988. Auditor's use of analytical review in audit program design. *The Accounting Review* 63 (1):148-161.

Blickensderfer, E., J. A. Cannon-Bowers, and E. Salas. 1998. Cross-training and team performance. In *Making Decisions Under Stress: Implications for Individual and Team Training*, edited by J. Cannon-Bowers and E. Salas. Washington, DC: Americal Psychological Association.

Bonner, S., R. Libby, and M. Nelson. 1997. Audit category knowledge as a precondition to learning from experience. *Accounting, Organizations and Society* 22 (5):387-410.

Bonner, S. E. 1994. A model of the effects of audit task complexity. *Accounting, Organizations and Society* 19 (3):213-234.

———. 2008. *Judgment and Decision Making in Accounting*. Upper Saddle River, NJ: Prentice Hall.

Bonner, S. E., and B. L. Lewis. 1990. Determinants of auditor expertise. *Journal of Accounting Research* 28 (Supplement):1-20.

Bonner, S. E., R. Libby, and M. W. Nelson. 1996. Using decision aids to improve auditors' conditional probability judgments. *The Accounting Review* 71 (2):221-240.

Bonner, S. E., and N. Pennington. 1991. Cognitive processes and knowledge as determinants of auditor expertise. *Journal of Accounting Literature* 10 (1):1-50.

Bonner, S. E., and P. L. Walker. 1994. The effects of instruction and experience on the acquisition of auditing knowledge. *The Accounting Review* 69 (1):157-178.

Boritz, J. E., L. A. Robinson, C. Wong, and N. Kochetova-Kozloski. 2014. Use of specialists during an audit. *University of Waterloo Working Paper*.

Borthick, A. F., M. B. Curtis, and R. S. Sriram. 2006. Accelerating the acquisition of knowledge structure to improve performance in internal control reviews. *Accounting, Organizations and Society* 31 (4):323-342.

Bose, S., W. Green, and M. Balatbat. 2014. Capital market impact of the disclosure, assurance and management of greenhouse gas (GHG) emissions: an international study. *UNSW Australian School of Business Research Paper*.

Brandon, D. P., and A. B. Hollingshead. 2004. Transactive memory systems in organizations: Matching tasks, expertise, and people. *Organization Science* 15 (6):633-644.

Brewer, M. B. 1979. In-group bias in the minimal intergroup situation: A cognitive-motivational analysis. *Psychological Bulletin* 86 (2):307-324.

Brewster, B. E. 2011. How a systems perspective improves knowledge acquisition and performance in analytical procedures. *The Accounting Review* 86 (3):915-943.

Brodbeck, F. C., R. Kerschreiter, A. Mojzisch, and S. Schulz-Hardt. 2007. Group decision making under conditions of distributed knowledge: The information asymmetries model. *Academy of Management Review* 32 (2):459-479.

Brooks, L. R. 1987. Decentralized control of categorization: The role of prior processing episodes. In *Concepts and Conceptual Development: The Ecological and Intellectual Factors in Categorization*, edited by U. Neisser. Cambridge, England: Cambridge University Press.

Brooks, L. R., G. R. Norman, and S. W. Allen. 1991. Role of specific similarity in a medical diagnostic task. *Journal of Experimental Psychology: General* 120:278-287.

Brown, R., and J. C. Turner. 1981. Interpersonal and intergroup behavior. In *Intergroup Behavior*, edited by J. C. Turner and H. Giles. Oxford: Basil Blackwell.

Bruning, R. H., G. Schraw, M. Norby, and R. Ronning. 2004. *Cognitive Psychology and Instruction*. 4th ed. Upper Saddle River, NJ: Pearson/Merrill/Prentice Hall.

Buckless, F. A., and S. P. Ravenscroft. 1990. Contrast coding: A refinement of ANOVA in behavioral analysis. *The Accounting Review* 65 (4):933-945.

Burtscher, M. J., M. Kolbe, J. Wacker, and T. Manser. 2011. Interactions of team mental models and monitoring behaviors predict team performance in simulated anesthesia inductions. *Journal of Experimental Psychology: Applied* 17 (3):257-269.

Cannon-Bowers, J. 2007. Fostering mental model convergence through training. *Research in Multi Level Issues* 6:149-157.

Cannon-Bowers, J., E. Salas, and S. Converse. 1993. Shared mental models in expert team decision making. In *Individual and Group Decision Making: Current Issues*, edited by N. Castellan. Hillsdale, NJ: Erlbaum.

Cannon-Bowers, J. A., and E. Salas. 1997. A framework for developing team performance measures in training. In *Team Performance Assessment and Measurement: Theory, Methods, and Applications*, edited by M. T. Brannick, E. Salas and C. Prince. Mahwah, NJ: Lawrence Erlbaum Associates.

Cannon-Bowers, J. A., E. Salas, E. Blickensderfer, and C. A. Bowers. 1998. The impact of cross-training and workload on team functioning: A replication and extension of initial findings. *Human Factors: The Journal of the Human Factors and Ergonomics Society* 40 (1):92-101.

Cannon-Bowers, J. A., S. I. Tannenbaum, E. Salas, and C. E. Volpe. 1995. Defining competencies and establishing team training requirements. In *Team Effectiveness and Decision-Making in Organizations*, edited by R. Guzzo and E. Salas. San Fransisco: Jossey-Bass.

Carley, K. M. 1997. Extracting team mental models through textual analysis. *Journal of Organizational Behavior* 18 (s1):533-558.

Casey, J. T., C. F. Gettys, R. M. Pliske, and T. Mehle. 1984. A partition of small group predecision performance into informational and social components. *Organizational Behavior and Human Performance* 34 (1):112-139.

Catrambone, R. 2002. The effects of surface and structural features matches on the access of story analogies. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 28:318-334.

Catrambone, R., and K. J. Holyoak. 1989. Overcoming contextual limitations on problem-solving transfer. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 15 (6):1147-1156.

CDP. 2003. Carbon Finance and the Global Equity Markets. London: Carbon Disclosure Project.

———. 2009. Carbon Disclosure Project 2009 Global 500 Report. London, UK: Carbon Disclosure Project.

———. 2013. Global 500 Climate Change Report 2013. London: Carbon Disclosure Project.

Chang, L. J., M. M. Cheng, and K. T. Trotman. 2013. The effect of outcome and process accountability on customer–supplier negotiations. *Accounting, Organizations and Society* 38 (2):93-107.

Chen, G., L. M. Donahue, and R. J. Klimoski. 2004. Training undergraduates to work in organizational teams. *Academy of Management Learning & Education* 3 (1):27-40.

Chi, M. T. 2000. Self-explaining expository texts: The dual processes of generating inferences and repairing mental models. *Advances in Instructional Psychology* 5:161-238.

———. 2009. Active-constructive-interactive: A conceptual framework for differentiating learning activities. *Topics in Cognitive Science* 1 (1):73-105.

Choo, F., and M. Curtis. 2000. Knowledge structure research in Accounting: A literature review. *Journal of Accounting Literature* 19:131-157.

Clark, R. C., F. Nguyen, and J. Sweller. 2006. *Efficiency in Learning: Evidence-based Guidelines to Manage Cognitive Load*. San Fransisco, CA: Pfeiffer.

Cohen, J. R., L. M. Gaynor, G. Krishnamoorthy, and A. Wright. 2011. The impact on auditor judgments of CEO influence on audit committee independence. *Auditing: A Journal of Practice & Theory* 30 (4):129-147.

Collins, L. M., J. J. Graham, and B. P. Flaherty. 1998. An alternative framework for defining mediation. *Multivariate Behavioral Research* 33 (2):295-312.

Converse, S. A., J. A. Cannon-Bowers, and E. Salas. 1991. Team member shared mental models: A theory and some methodological issues. Paper read at Proceedings of the Human Factors and Ergonomics Society Annual Meeting.

Cooke, N. J., P. A. Kiekel, and E. E. Helm. 2001. Measuring team knowledge during skill acquisition of a complex task. *International Journal of Cognitive Ergonomics* 5 (3):297-315.

Cooke, N. J., P. A. Kiekel, E. Salas, R. Stout, C. Bowers, and J. Cannon-Bowers. 2003. Measuring team knowledge: A window to the cognitive underpinnings of team performance. *Group Dynamics: Theory, Research, and Practice* 7 (3):179-199.

Cooke, N. J., E. Salas, J. A. Cannon-Bowers, and R. J. Stout. 2000. Measuring team knowledge. *Human Factors: The Journal of the Human Factors and Ergonomics Society* 42 (1):151-173.

Cowan, N. 2001. The magical number 4 in short-term memory: A reconsideration of mental storage capacity. *Behavioral and Brain Sciences* 24 (01):87-114.

———. 2010. The magical mystery four how is working memory capacity limited, and why? *Current Directions in Psychological Science* 19 (1):51-57.

Coyne, M. P., S. F. Biggs, and J. S. Rich. 2010. Priming/reaction-time evidence of the structure of auditors' knowledge of financial statement errors. *Auditing: A Journal of Practice & Theory* 29 (1):99-123.

Cryder, C. E., G. Loewenstein, and R. Scheines. 2013. The donor is in the details. *Organizational Behavior and Human Decision Processes* 120 (1):15-23.

Cummins, D. D. 1992. Role of analogical reasoning in the induction of problem categories. *Journal of experimental psychology: Learning, memory, and cognition* 18 (5):1103-1124.

Day, E. A., W. Arthur Jr, and D. Gettman. 2001. Knowledge structures and the acquisition of a complex skill. *Journal of Applied Psychology* 86 (5):1022-1033.

Day, S., R. L. Goldstone, and T. Hills. 2010. The effects of similarity and individual differences on comparison and transfer. Paper read at Proceedings of the Thirty-Second Annual Conference of the Cognitive Science Society.

DCCEE. 2010a. *National Greenhouse Accounts (NGA) Factors*. Canberra: Australian Government the Department of Climate Change and Energy Efficiency.

———. 2010b. *National Greenhouse and Energy Reporting – Audit Determination Handbook*. Canberra: Australian Government the Department of Climate Change and Energy Efficiency.

———. 2010c. *National Greenhouse and Energy Reporting (Measurement) 2008*. Canberra: Australian Government the Department of Climate Change and Energy Efficiency.

———. 2010d. *Technical Guidelines for the Estimation of GHG Emissions by Facilities in Australia*. Canberra: Australian Government the Department of Climate Change and Energy Efficiency.

De Dreu, C. K., and L. R. Weingart. 2003. Task versus relationship conflict, team performance, and team member satisfaction: a meta-analysis. *Journal of Applied Psychology* 88 (4):741-749.

DeChurch, L. A., and J. R. Mesmer-Magnus. 2010. The cognitive underpinnings of effective teamwork: a meta-analysis. *Journal of Applied Psychology* 95 (1):32-53.

DEFRA. 2009. *Guidance on How to Measure and Report Your Greenhouse Gas Emissions*. London: the UK Department for Environment, Food and Rural Affairs.

del Pino, S., and P. Bhatia. 2002. *Working 9 to 5 Climate Change: An Official Guide*. Washington DC: World Resources Institute.

del Pino, S., J. Larsen, and R. Levinson. 2006. *Hot Climate, Cool Commerce: A Service Sector Guide to Greenhouse Gas Management*. Washington DC: World Resources Institute (WRI).

DeLeeuw, K. E., and R. E. Mayer. 2008. A comparison of three measures of cognitive load: Evidence for separable measures of intrinsic, extraneous, and germane load. *Journal of Educational Psychology* 100 (1):223-234.

Deutsch, M., and H. B. Gerard. 1955. A study of normative and informational social influences upon individual judgment. *The Journal of Abnormal and Social Psychology* 51 (3):629.

Devolder, P. A. 1993. Adult age differences in monitoring of practical problem-solving performance. *Experimental Aging Research* 19 (2):129-146.

Dhaliwal, D. S., O. Z. Li, A. Tsang, and Y. G. Yang. 2011. Voluntary nonfinancial disclosure and the cost of equity capital: The initiation of corporate social responsibility reporting. *The Accounting Review* 86 (1):59-100.

Diehl, M., and W. Stroebe. 1987. Productivity loss in brainstorming groups: Toward the solution of a riddle. *Journal of Personality and Social Psychology* 53 (3):497-509.

———. 1991. Productivity loss in idea-generating groups: Tracking down the blocking effect. *Journal of Personality and Social Psychology* 61 (3):392-403.

Dillenbourg, P. 1999. What do you mean by collaborative learning? In *Collaborative-learning: Cognitive and Computational Approaches.*, edited by P. Dillenbourg. Oxford: Elsevier.

———. 2002. Over-scripting CSCL: The risks of blending collaborative learning with instructional design. In *Three Worlds of CSCL: Can We Support CSCL?*, edited by P. Kirschner. Heerlen: Open Universiteit Nederland.

Dorsey, D. W., G. E. Campbell, L. L. Foster, and D. E. Miles. 1999. Assessing knowledge structures: Relations with experience and posttraining performance. *Human Performance* 12 (1):31-57.

Dyer, J. L. 1984. Team research and team training: A state-of-art review. In *Human Factors Review: 1984*, edited by F. Muckler. Santa Monica,CA: Human Factors Society.

Edmondson, A. 1999. Psychological safety and learning behavior in work teams. *Administrative Science Quarterly* 44 (2):350-383.

Edwards, B. D., E. A. Day, W. Arthur Jr, and S. T. Bell. 2006. Relationships among team ability composition, team mental models, and team performance. *Journal of Applied Psychology* 91 (3):727-736.

Eilifsen, A., W. F. Messier, S. M. Glover, and D. F. Prawitt. 2013. *Auditing and Assurance Services*. New York, NY: McGraw-Hill Education.

Elliott, W. B., F. D. Hodge, J. J. Kennedy, and M. Pronk. 2007. Are M.B.A. students a good proxy for nonprofessional investors? *The Accounting Review* 82 (1):139-168.

Ellis, A. P. 2006. System breakdown: The role of mental models and transactive memory in the relationship between acute stress and team performance. *Academy of Management Journal* 49 (3):576-589.

Ellis, A. P., B. S. Bell, R. E. Ployhart, J. R. Hollenbeck, and D. R. Ilgen. 2005. An evaluation of generic teamwork skills training with action teams: Effects on cognitive and skill-based outcomes. *Personnel Psychology* 58 (3):641-672.

Elstein, A. S., L. S. Shulman, S. A. Sprafka, and L. Allal. 1978. *Medical Problem Solving: An Analysis of Clinical Reasoning*. Cambridge, MA: Harvard University Press.

Entin, E. E., and D. Serfaty. 1999. Adaptive team coordination. *Human Factors: The Journal of the Human Factors and Ergonomics Society* 41 (2):312-325.

EU. 2013. The EU Emissions Trading System (EU ETS). European Union.

Eylon, B.-S., and F. Reif. 1984. Effects of knowledge organization on task performance. *Cognition and Instruction* 1 (1):5-44.

Faraj, S., and L. Sproull. 2000. Coordinating expertise in software development teams. *Management science* 46 (12):1554-1568.

Favere-Marchesi, M. 2006. Audit review: The impact of discussion timing and familiarity. *Behavioral Research in Accounting* 18 (1):53-64.

Festinger, L. 1957. *A Theory of Social Comparison Processes*. Stanford, CA: Stanford University Press.

Fischer, F., I. Kollar, H. Mandl, and J. M. Haake. 2010. *Scripting Computer-Supported Collaborative Learning: Cognitive, Computational and Educational Perspectives*. Vol. 6. New York: Springer.

Fisher, D. M., S. T. Bell, E. C. Dierdorff, and J. A. Belohlav. 2012. Facet personality and surface-level diversity as team mental model antecedents: implications for implicit coordination. *Journal of Applied Psychology* 97 (4):825-841.

Fisher, S. D. 1987. Cue selection in hypothesis generation: Reading habits, consistency checking, and diagnostic scanning. *Organizational Behavior and Human Decision Processes* 40 (2):170-192.

Fisher, S. D., C. F. Gettys, C. Manning, T. Mehle, and S. Baca. 1983. Consistency checking in hypothesis generation. *Organizational Behavior and Human Performance* 31 (2):233-254.

Fonseca, B. A., and M. T. Chi. 2011. Instruction based on self-explanation. In *Handbook of Research on Learning and Instruction (Educational Psychology Series)*, edited by R. E. Mayer and P. Alexander. New York, NY: Routledge.

Forsyth, D. 2010. *Group Dynamics*. 5th. ed. Belmont, CA: Wadworth, Cengage Learning.

Fransen, T., P. Bhatia, and A. Hsu. 2007. *Measuring to Manage: A Guide to Designing GHG Accounting and Reporting Programs*. Washington DC: World Resources Institute.

Frederick, D. M., V. B. Heiman-Hoffman, and R. Libby. 1994. The structure of auditors knowledge of financial statement errors. *Auditing: A Journal of Practice & Theory* 13 (1):1-21.

Funke, G. J., and S. M. Galster. 2009. The effects of cognitive processing load and collaboration technology on team performance in a simulated command and control environment. *International Journal of Industrial Ergonomics* 39 (3):541-547.

Funke, G. J., B. A. Knott, E. Salas, D. Pavlas, and A. J. Strang. 2012. Conceptualization and measurement of team workload: A critical need. *Human Factors: The Journal of the Human Factors and Ergonomics Society* 54 (1):36-51.

Gentner, D. 1983. Structure-mapping: A theoretical framework for analogy. *Cognitive Science* 7 (2):155-170.

———. 1989. The mechanisms of analogical learning. In *Similarity and Analogical Reasoning*, edited by S. Vosniadou and A. Ortony. London: Cambridge University Press.

Gentner, D., J. Loewenstein, and L. Thompson. 2003. Learning and transfer: A general role for analogical encoding. *Journal of Educational Psychology* 95 (2):393-408.

Gentner, D., and A. B. Markman. 1997. Structure mapping in analogy and similarity. *American Psychologist* 52 (1):45-56.

Gentner, D., M. J. Ratterman, and K. D. Forbus. 1993. The roles of similarity in transfer: Separating retrievability and inferential soundness. *Cognitive Psychology* 25:524-575.

Gentner, D., M. J. Rattermann, and K. D. Forbus. 1993. The roles of similarity in transfer: separating retrievability from inferential soundness. *Cognitive Psychology* 25 (4):524-575.

Gettys, C. F., and S. D. Fisher. 1979. Hypothesis plausibility and hypothesis generation. *Organizational behavior and human performance* 24 (1):93-110.

Gettys, C. F., C. Manning, T. Mehle, and S. D. Fisher. 1980. Hypothesis generation: A final report of three years of research. DTIC Document.

Gettys, C. F., T. Mehle, and S. Fisher. 1986. Plausibility assessments in hypothesis generation. *Organizational Behavior and Human Decision Processes* 37 (1):14-33.

Gick, M. L., and K. J. Holyoak. 1980. Analogical problem solving. *Cognitive psychology* 12 (3):306-355.

———. 1983. Schema induction and analogical transfer. *Cognitive psychology* 15 (1):1-38.

Goldstein, I. L., and J. K. Ford. 2002. *Training in Organizations: Needs Assessment, Development, and Evaluation*. 4th ed. Belmont, CA: Wadsworth.

González, R., and R. Brown. 2003. Generalization of positive attitude as a function of subgroup and superordinate group identifications in intergroup contact. *European Journal of Social Psychology* 33 (2):195-214.

Green, W. J., and K. T. Trotman. 2003. An examination of different performance outcomes in an analytical procedures task. *Auditing: A Journal of Practice & Theory* 22 (2):219-235.

Greidler, M. 2009. *Learning and Intruction: Theory into Practice*. 6th ed. Upper Saddle River, NJ: Pearson.

Gruenfeld, D. H., E. A. Mannix, K. Y. Williams, and M. A. Neale. 1996. Group composition and decision making: How member familiarity and information distribution affect process and performance*. Organizational Behavior and Human Decision Processes* 67 (1):1-15.

Harrison, D. A., K. H. Price, J. H. Gavin, and A. T. Florey. 2002. Time, teams, and task performance: Changing effects of surface-and deep-level diversity on group functioning. *Academy of Management Journal* 45 (5):1029-1045.

Hausmann, R. G., B. van de Sande, and K. VanLehn. 2008. Are self-explaining and coached problem solving more effective when done by pairs of students than alone? In *Proceedings of the 30th Annual Conference of the Cognitive Science Society*, edited by B. Love, K. McRae and V. Sloutsky. New York: Erlbaum.

Heiman-Hoffman, V. B., D. V. Moser, and J. A. Joseph. 1995. The impact of an auditor's initial hypothesis on subsequent performance at identifying actual errors. *Contemporary Accounting Research* 11 (2):763-779.

Hill, G. W. 1982. Group versus individual performance: Are *N* + 1 heads better than one? *Psychological Bulletin* 91 (3):517-539.

Hirst, D., and L. Koonce. 1996. Audit analytical procedures: A field investigation. *Contemporary Accounting Research* 13 (2):457-486.

Hirst, D., L. Koonce, and S. Venkataraman. 2007. How disaggreagation enhances the credibility of management earnings forecasts. *Journal of Accounting Research* 45 (4):811-837.

Hodge, K., N. Subramaniam, and J. Stewart. 2009. Assurance of sustainability reports: impact on report users' confidence and perceptions of information credibility. *Australian Accounting Review* 19 (3):178-194.

Hofstede, G. 1980. *Culture's Consequences: International Differences in Work-Related Values*. Beverly Hills, CA: Sage.

Hollingshead, A. B. 1998a. Communication, learning, and retrieval in transactive memory systems. *Journal of experimental social psychology* 34 (5):423-442.

———. 1998b. Retrieval processes in transactive memory systems. *Journal of Personality and Social Psychology* 74 (3):659-671.

Holyoak, K. J., D. Gentner, and B. N. Kokinov. 2001. Introduction: The place of analogy in cognition. In *The Analogical Mind: Perspectives from Cognitive Science*, edited by D. Gentner, K. J. Holyoak and B. N. Kokinov. Cambridge, MA: MIT Press.

Homan, A. C., J. R. Hollenbeck, S. E. Humphrey, D. van Knippenberg, D. R. Ilgen, and G. A. van Kleef. 2008. Facing differences with an open mind: Openness to experience, salience of intragroup differences, and performance of diverse work groups. *Academy of Management Journal* 51 (6):1204-1222.

Homan, A. C., D. van Knippenberg, G. A. van Kleef, and C. K. De Dreu. 2007. Bridging faultlines by valuing diversity: diversity beliefs, information elaboration, and performance in diverse work groups. *Journal of Applied Psychology* 92 (5):1189-1199.

Huff, L., and L. Kelley. 2003. Levels of organizational trust in individualist versus collectivist societies: A seven-nation study. *Organization Science* 14 (1):81-90.

Huggins, A., W. J. Green, and R. Simnett. 2011. The competitive market for assurance engagements on greenhouse gas statements: Is there a role for assurers from the accounting profession? *Current Issues in Auditing* 5 (2):A1-A12.

IAASB. 2009. Identifying and Assessing the Risks of Material Misstatement through Understanding the Entity and its Environment. New York, NY: International Auditing and Assurance Standards Board.

———. 2012. Assurance Engagement on Greenhouse Gas Statements. New York: International Auditing and Assurance Standards Board.

ICAA. 2013. The benefits of assuring greenhouse gas emissions: Why it is important and how to get the most value from it. In *Audit Committee Series*. Sydney: The Institute of Chartered Accountants Australia.

Ilgen, D. R., J. R. Hollenbeck, M. Johnson, and D. Jundt. 2005. Teams in organizations: From input-process-output models to IMOI models. *Annual Review of Psychology* 56:517-543.

Ismail, Z., and K. T. Trotman. 1995. The impact of the review process in hypothesis generation tasks. *Accounting, Organizations and Society* 20 (5):345-357.

Jackson, M., and R. L. Moreland. 2009. Transactive memory in the classroom. *Small Group Research* 40 (5):508-534.

Jackson, S. E., A. Joshi, and N. L. Erhardt. 2003. Recent research on team and organizational diversity: SWOT analysis and implications. *Journal of Management* 29 (6):801-830.

Jackson, S. E., K. E. May, and K. Whitney. 1995. Understanding the dynamics of diversity in decision-making teams. In *Team Effectiveness and Decision-Making in Organizations*, edited by R. Guzzo, E. Salas and I. L. Goldstein. San Fransisco: Jossey-Bass.

Janis, I. 1982. *Groupthink*. 2nd ed. Boston, MA: Houghton-Mifflin.

Jehn, K. A., G. B. Northcraft, and M. A. Neale. 1999. Why differences make a difference: A field study of diversity, conflict and performance in workgroups. *Administrative Science Quarterly* 44 (4):741-763.

Jehn, K. A., and P. P. Shah. 1997. Interpersonal relationships and task performance: An examination of mediation processes in friendship and acquaintance groups. *Journal of Personality and Social Psychology* 72 (4):775-790.

Jeong, H., and M. T. Chi. 2007. Knowledge convergence and collaborative learning. *Instructional Science* 35 (4):287-315.

Joe, J. R., and S. D. Vandervelde. 2007. Do auditor-provided nonaudit services improve audit effectiveness? *Contemporary Accounting Research* 24 (2):467-487.

Johnson-Laird, P. N. 1983. *Mental Models: Towards a Cognitive Science of Language, Inference, and Consciousness*. Cambridge, MA: Harvard University Press.

Johnson, H. M., and C. M. Seifert. 1992. The role of predictive features in retrieving analogical cases. *Journal of Memory and Language* 31:648-667.

Joseph, G. M., and V. L. Patel. 1990. Domain knowledge and hypothesis genenation in diagnostic reasoning. *Medical Decision Making* 10 (1):31-46.

Judd, C. M., and D. A. Kenny. 2010. Data analysis in social psychology: Recent and recurring issues. In *The Handbook of Social Psychology*, edited by D. Gilbert, S. Fiske and G. Lindzey. New York: Wiley.

Kadous, K., S. Kennedy, and M. E. Peecher. 2003. The effect of quality assessment and directional goal commitment on auditors' acceptance of client-preferred accounting methods. *The Accounting Review* 78 (3):759-778.

Kalyuga, S., P. Chandler, and J. Sweller. 1999. Managing split-attention and redundancy in multimedia instruction. *Applied Cognitive Psychology* 13 (4):351-371.

Kellermanns, F. W., S. W. Floyd, A. W. Pearson, and B. Spencer. 2008. The contingent effect of constructive confrontation on the relationship between shared mental models and decision quality. *Journal of Organizational Behavior* 29 (1):119-137.

Keppel, G., and T. Wickens. 2004. *Design and Analysis: A Researcher's Handbook*. 4th ed. Upper Saddle River, NJ: Pearson Prentice-Hall.

Kerr, N. L., and R. S. Tindale. 2004. Group performance and decision making. *Annual Review of Psychology* 55:623-655.

Kirschner, F., F. Paas, and P. A. Kirschner. 2009a. A cognitive load approach to collaborative learning: United brains for complex tasks. *Educational Psychology Review* 21 (1):31-42.

———. 2009b. Individual and group-based learning from complex cognitive tasks: Effects on retention and transfer efficiency. *Computers in Human Behavior* 25 (2):306-314.

———. 2011. Task complexity as a driver for collaborative learning efficiency: The collective working-memory effect. *Applied Cognitive Psychology* 25 (4):615-624.

Kirschner, F., F. Paas, P. A. Kirschner, and J. Janssen. 2011. Differential effects of problem-solving demands on individual and collaborative learning outcomes. *Learning and Instruction* 21 (4):587-599.

Klimoski, R., and S. Mohammed. 1994. Team mental model: Construct or metaphor? *Journal of management* 20 (2):403-437.

Knapp, C. A., and M. C. Knapp. 2001. The effects of experience and explicit fraud risk assessment in detecting fraud with analytical procedures. *Accounting, Organizations and Society* 26 (1):25-37.

Koehler, D. J. 1991. Explanation, imagination, and confidence in judgment. *Psychological Bulletin* 110 (3):499-510.

Kollar, I., F. Fischer, and F. W. Hesse. 2006. Collaboration scripts–a conceptual analysis. *Educational Psychology Review* 18 (2):159-185.

Kolodner, J. L. 1997. Educational implications of analogy: A view from case-based reasoning. *American Psychologist* 52 (1):57-66.

Koonce, L. 1992. Explanation and counterexplanation during audit analytical review. *The Accounting Review* 67 (1):59-76.

———. 1993. A cognitive characterization of audit analytical review. *Auditing: A Journal of Practice & Theory* 12 (2):57-76.

Koonce, L., and F. Phillips. 1996. Auditors' comprehension and evaluation of client-suggested causes in analytical procedures. *Behavioral Research in Accounting* 8:32-48.

Kopp, L. S., and E. O'Donnell. 2005. The influence of a business-process focus on category knowledge and internal control evaluation. *Accounting, Organizations and Society* 30 (5):423-434.

Kounios, J. 1996. On the continuity of thought and the representation of knowledge: Electrophysiological and behavioral time-course measures reveal levels of structure in semantic memory. *Psychonomic Bulletin & Review* 3 (3):265-286.

Kozloski, T. M. 2011. Knowledge transfer in the fraud risk assessment task. *Journal of Forensic and Investigative Accounting* 3 (1):49-85.

Kozlowski, S. W., K. Brown, D. Weissbein, J. Cannon-Bowers, and E. Salas. 2000. A multi-level perspective on training effectiveness: Enhancing horizontal and vertical transfer. In *Multilevel Theory, Research, and Methods in Organizations: Foundations, Extensions, and New Directions*, edited by K. J. Klein and S. W. Kozlowski. San Fransisco: Jossey-Bass.

Kozlowski, S. W., and D. R. Ilgen. 2006. Enhancing the effectiveness of work groups and teams. *Psychological Science in the Public Interest* 7 (3):77-124.

KPMG. 2011. KPMG International Survey of Corporate Responsibility Reporting 2011.

———. 2013. The KPMG Survey of Corporate Responsibility Reporting 2013.

Kurtz, K. J., C.-H. Miao, and D. Gentner. 2001. Learning by analogical bootstrapping. *The Journal of the Learning Sciences* 10 (4):417-446.

Lambert, T., and C. Agoglia. 2011. Closing the loop: Review process factors affecting audit staff follow-through. *Journal of Accounting Research* 49 (5):1275-1306.

Langan-Fox, J. 2005. Skill acquisition and the development of a team mental model. In *The Essentials of Teamworking: International Perspectives*, edited by M. West, D. Tjosvold and K. Smith. Chichester: John Wiley & Sons Ltd.

Langan-Fox, J., S. Code, and K. Langfield-Smith. 2000. Team mental models: Techniques, methods, and analytic approaches. *Human Factors: The Journal of the Human Factors and Ergonomics Society* 42 (2):242-271.

Larson, J. R. 2010. *In Search of Synergy in Small Group Performance*. New York, NY: Psychology Press.

Lewis, K. 2003. Measuring transactive memory systems in the field: scale development and validation. *Journal of Applied Psychology* 88 (4):587-604.

———. 2004. Knowledge and performance in knowledge-worker teams: A longitudinal study of transactive memory systems. *Management science* 50 (11):1519-1533.

Lewis, K., M. Belliveau, B. Herndon, and J. Keller. 2007. Group cognition, membership change, and performance: Investigating the benefits and detriments of collective knowledge. *Organizational Behavior and Human Decision Processes* 103 (2):159-178.

Lewis, K., and B. Herndon. 2011. Transactive memory systems: Current issues and future research directions. *Organization Science* 22 (5):1254-1265.

Lewis, K., D. Lange, and L. Gillis. 2005. Transactive memory systems, learning, and learning transfer. *Organization Science* 16 (6):581-598.

Liang, D. W., R. Moreland, and L. Argote. 1995. Group versus individual training and group performance: The mediating role of transactive memory. *Personality and Social Psychology Bulletin* 21 (4):384-393.

Libby, R. 1985. Availability and the generation of hypotheses in analytical review. *Journal of Accounting Research* 23 (2):648-667.

———. 1995. The role of knowledge and memory in audit judgment. In *Judgment and Decision Making Research in Accounting and Auditing*, edited by R. Ashton and A. Ashton. Cambridge, UK: Cambridge University Press.

Libby, R., and D. M. Frederick. 1990. Experience and the ability to explain audit findings. *Journal of Accounting Research* 28 (2):348-367.

Libby, R., and J. Luft. 1993. Determinant of judgment performance in accounting settings: Ability, knowledge, motivation, and environment. *Accounting, Organizations and Society* 18 (5):425-450.

Libby, R., K. T. Trotman, and I. Zimmer. 1987. Member variation, recognition of expertise, and group performance. *Journal of Applied Psychology* 72 (1):81-87.

Lim, B. C., and K. J. Klein. 2006. Team mental models and team performance: a field study of the effects of team mental model similarity and accuracy. *Journal of Organizational Behavior* 27 (4):403-418.

Littlepage, G. E., and H. Silbiger. 1992. Recognition of expertise in decision-making groups effects of group size and participation patterns. *Small Group Research* 23 (3):344-355.

Liyanarachchi, G. A. 2007. Feasibility of using student subjects in accounting experiments: A review. *Pacific Accounting Review* 19 (1):47-67.

Loewenstein, J., L. Thompson, and D. Gentner. 1999. Analogical encoding facilitates knowledge transfer in negotiation. *Psychonomic Bulletin & Review* 6 (4):586-597.

———. 2003. Analogical learning in negotiation teams: Comparing cases promotes learning and transfer. *Academy of Management Learning & Education* 2 (2):119-127.

MacKinnon, D. P. 2000. Contrasts in multiple mediator models. In *Multivariate Applications in Substance Use Research*, edited by J. Rose, L. Chassin, C. Presson and S. Sherman. Mahwah, NJ: Erlbaum.

MacKinnon, D. P. 2008. *Introduction to Statistical Mediation Analysis*. New York, NY: Erlbaum and Taylor Francis Group.

MacKinnon, D. P., and A. J. Fairchild. 2009. Current directions in mediation analysis. *Current Directions in Psychological Science* 18 (1):16-20.

MacKinnon, D. P., J. L. Krull, and C. M. Lockwood. 2000. Equivalence of the mediation, confounding and suppression effect. *Prevention Science* 1 (4):173-181.

MacKinnon, D. P., C. M. Lockwood, J. M. Hoffman, S. G. West, and V. Sheets. 2002. A comparison of methods to test mediation and other intervening variable effects. *Psychological Methods* 7 (1):83-104.

Manning, C., C. Gettys, A. Nicewander, S. Fisher, and T. Mehle. 1980. Predicting individual differences in generation of hypotheses. *Psychological Reports* 47:1199-1214.

Mannix, E., and M. A. Neale. 2005. What differences make a difference? The promise and reality of diverse teams in organizations. *Psychological science in the public interest* 6 (2):31-55.

Marchant, G. 1989. Analogical reasoning and hypothesis generation in auditing. *The Accounting Review* 64 (3):500-513.

Marchant, G., J. R. Robinson, U. Anderson, and M. Schadewald. 1991. Analogical transfer and expertise in legal reasoning. *Organizational Behavior and Human Decision Processes* 48 (2):272-290.

Markman, A. B. 1999. *Knowledge Representation*. Mahwah, NJ: Lawrence Erlbaum Associates.

Markman, A. B., and D. Gentner. 2001. Thinking. *Annual Review of Psychology* 52 (1):223-247.

Marks, M. A., J. E. Mathieu, and S. J. Zaccaro. 2001. A temporally based framework and taxonomy of team processes. *Academy of Management Review* 26 (3):356-376.

Marks, M. A., M. J. Sabella, C. S. Burke, and S. J. Zaccaro. 2002. The impact of cross-training on team effectiveness. *Journal of Applied Psychology* 87 (1):3-13.

Marks, M. A., S. J. Zaccaro, and J. E. Mathieu. 2000. Performance implications of leader briefings and team-interaction training for team adaptation to novel environments. *Journal of Applied Psychology* 85 (6):971-986.

Mathieu, J., M. T. Maynard, T. Rapp, and L. Gilson. 2008. Team effectiveness 1997-2007: A review of recent advancements and a glimpse into the future. *Journal of management* 34 (3):410-476.

Mathieu, J. E., L. L. Gilson, and T. M. Ruddy. 2006. Empowerment and team effectiveness: an empirical test of an integrated model. *Journal of Applied Psychology* 91 (1):97.

Mathieu, J. E., T. S. Heffner, G. F. Goodwin, J. A. Cannon-Bowers, and E. Salas. 2005. Scaling the quality of teammates' mental models: equifinality and normative comparisons. *Journal of Organizational Behavior* 26 (1):37-56.

Mathieu, J. E., T. S. Heffner, G. F. Goodwin, E. Salas, and J. A. Cannon-Bowers. 2000. The influence of shared mental models on team process and performance. *Journal of Applied Psychology* 85 (2):273-283.

Mayer, R. E. 1996. Learners as information processors: Legacies and limitations of educational psychology's second. *Educational Psychologist* 31 (3-4):151-161.

Mayer, R. E. 2008. *Learning and Instruction*. 2nd ed. Upper Saddle River, NJ: Pearson Merrill Prentice Hall.

Mayer, R. E., and P. Chandler. 2001. When learning is just a click away: Does simple user interaction foster deeper understanding of multimedia messages? *Journal of Educational Psychology* 93 (2):390-397.

McGrath, J. E. 1984. *Groups: Interaction and Performance*. Englewood Cliffs, NJ: Prentice-Hall.

McNamara, T. P. 1994. Theories of priming: II. Types of primes. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 20 (3):507-520.

Medin, D. L., and B. H. Ross. 1989. The specific character of abstract thought: Categorization, problem solving, and induction. In *Advances in the Psychology of Human Intelligence*, edited by R. Sternberg. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Mehle, T. 1982. Hypothesis generation in an automobile malfunction inference task. *Acta Psychologica* 52 (1):87-106.

Mehle, T., C. F. Gettys, C. Manning, S. Baca, and S. Fisher. 1981. The availability explanation of excessive plausibility assessments. *Acta Psychologica* 49 (2):127-140.

Michinov, N., and E. Michinov. 2009. Investigating the relationship between transactive memory and performance in collaborative learning. *Learning and Instruction* 19 (1):43-54.

Miller, G. A. 1956. The magical number seven, plus or minus two: some limits on our capacity for processing information. *Psychological Review* 63 (2):81-97.

Milliken, F. J., and L. L. Martins. 1996. Searching for common threads: Understanding the multiple effects of diversity in organizational groups. *Academy of Management Review* 21 (2):402-433.

Miner, F. C. 1984. Group versus individual decision making: An investigation of performance measures, decision strategies, and process losses/gains. *Organizational Behavior and Human Performance* 33 (1):112-124.

Mock, T. J., A. Wright, R. P. Srivastava, and H. Lu. 2008. The framing and evaluation of multiple hypotheses. *Asia-Pacific Journal of Accounting & Economics* 15 (2):123-140.

Mohammed, S., and B. C. Dumville. 2001. Team mental models in a team knowledge framework: Expanding theory and measurement across disciplinary boundaries. *Journal of Organizational Behavior* 22 (2):89-106.

Mohammed, S., and L. Ferzandi. 2007. Team mental models. In *Encyclopedia of Industrial/Organizational Psychology*, edited by S. Rogelberg. Thousand Oaks, CA: Sage.

Mohammed, S., L. Ferzandi, and K. Hamilton. 2010. Metaphor no more: A 15-year review of the team mental model construct. *Journal of management* 36 (4):876-910.

Mohammed, S., and K. Hamilton. 2007. Input-Process-Output model of team effectiveness. In *Encyclopedia of Industrial/Organizational Psychology*, edited by S. Rogelberg and C. Reeve. Thousand Oaks, CA: Sage.

Moreland, R. 1999. Transactive memory: Learning who knows what in work groups and organizations. In *Shared Cognition in Organizations: The Management of Knowledge*, edited by L. Thompson, J. Levine and D. Messick. Mahwah, NJ: Lawrence Erlbaum Associates.

Moreland, R. L. 2010. Are dyads really groups? *Small Group Research* 41 (2):251-267.

Moreland, R. L., L. Argote, and R. Krishnan. 1996. Socially shared cognition at work: Transactive memory and group performance. In *What's Social about Social Cognition? Research on Socially Shared in Small Groups*, edited by J. Nye and M. Brower. Thousand Oaks, CA: Sage.

———. 1998. Training people to work in groups. In *Theory and Research on Small Groups*, edited by R. S. Tindale, L. Heath, J. Edwards, E. Posavac, F. Bryant, Y. Suarez-Balcazar, E. Henderson-King and J. Myers. New York: Plenum.

Moreland, R. L., and L. Myaskovsky. 2000. Exploring the performance benefits of group training: Transactive memory or improved communication? *Organizational Behavior and Human Decision Processes* 82 (1):117-133.

Moreno, K. K., S. Bhattacharjee, and D. M. Brandon. 2007. The effectiveness of alternative training techniques on analytical procedures performance. *Contemporary Accounting Research* 24 (3):983-1014.

Morgan, B., A. Glickman, E. Woodard, A. Blaiwes, and E. Salas. 1986. Measurement of team behaviors in a navy environment. In *Team Evolution and Maturation (TEAM)*. Orlando, FL: Naval Training Systems Center.

Mortensen, T., R. Fisher, and G. Wines. 2012. Students as surrogates for practicing accountants: Further evidence. *Accounting Forum* 36:251-265.

Murnighan, J. K., and D. E. Conlon. 1991. The dynamics of intense work groups: A study of British string quartets. *Administrative science quarterly*:165-186.

Nelson, M., and H.-T. Tan. 2005. Judgment and decision making research in auditing: A task, person, and interpersonal interaction perspective. *Auditing: A Journal of Practice & Theory* 24 (s-1):41-71.

Nelson, M. W., R. Libby, and S. E. Bonner. 1995. Knowledge structure and the estimation of conditional probabilities in audit planning. *The Accounting Review* 70 (1):27-47.

Nemeth, C. 1992. Minority dissent as a stimulant to group performance. In *Group Process and Productivity*, edited by S. Worchel, W. Wood and J. Simpson. London: Sage.

Nemeth, C. J. 1986. Differential contributions of majority and minority influence. *Psychological Review* 93 (1):23-32.

Nemeth, C. J., and J. L. Kwan. 1985. Originality of word associations as a function of majority vs. minority influence. *Social Psychology Quarterly* 48 (3):277-282.

———. 1987. Minority influence, divergent thinking and detection of correct solutions. *Journal of Applied Social Psychology* 17 (9):788-799.

Nemeth, C. J., and B. Staw. 1989. The tradeoffs of social control and innovation within groups and organizations. In *Advances in experimental social psychology*, edited by L. Berkowitz. New York, NY: Academic Press.

Nemeth, C. J., and J. Wachtler. 1983. Creative problem solving as a result of majority vs minority influence. *European Journal of Social Psychology* 13 (1):45-55.

Novick, L. 1988. Analogical transfer, problem similarity, and expertise. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 14:510-520.

Nugent, M. 2008. IAASB main agenda (December): Issues paper - Emissions assurance.

O'Donnell, E., and E. N. Johnson. 2001. The effects of auditor gender and task complexity on information processing efficiency. *International Journal of Auditing* 5 (2):91-105.

O'Reilly, C. A., D. F. Caldwell, and W. P. Barnett. 1989. Work group demography, social integration, and turnover. *Administrative Science Quarterly* 34 (1):21-37.

O’Donnell, A. M., and D. F. Dansereau. 1992. Scripted cooperation in student dyads: A method for analyzing and enhancing academic learning and performance. In *Interaction in Cooperative Groups: The Theoretical Anatomy of group learning*, edited by L. RH and N. Miller. Cambridge, MA: Cambridge University Press.

O’Dwyer, B. 2011. The case of sustainability assurance: constructing a new assurance service. *Contemporary Accounting Research* 28 (4):1230-1266.

O’Dwyer, B., D. Owen, and J. Unerman. 2011. Seeking legitimacy for new assurance forms: The case of assurance on sustainability reporting. *Accounting, Organizations and Society* 36 (1):31-52.

Olson, E. G. 2010. Challenges and opportunities from greenhouse gas emissions reporting and independent auditing. *Managerial Auditing Journal* 25 (9):934-942.

Olson, J. R., and K. J. Biolsi. 1991. Techniques for representing expert knowledge. In *Toward a General Theory of Expertise: Prospects and Limits*, edited by K. Ericsson and J. Smith. Cambridge: Cambridge University Press.

Osborn, A. 1957. *Applied Imagination*. New York: Scribner.

Paas, F., A. Renkl, and J. Sweller. 2003. Cognitive load theory and instructional design: Recent developments. *Educational psychologist* 38 (1):1-4.

———. 2004. Cognitive load theory: Instructional implications of the interaction between information structures and cognitive architecture. *Instructional Science* 32 (1):1-8.

Paas, F. G., and J. J. van Merriënboer. 1993. The efficiency of instructional conditions: An approach to combine mental effort and performance measures. *Human Factors: The Journal of the Human Factors and Ergonomics Society* 35 (4):737-743.

Paharia, N., K. D. Vohs, and R. Deshpandé. 2013. Sweatshop labor is wrong unless the shoes are cute: Cognition can both help and hurt moral motivated reasoning. *Organizational Behavior and Human Decision Processes* 121 (1):81-88.

Palincsar, A., and A. Brown. 1984. Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction* 1 (2):117-175.

Pearsall, M. J., and A. P. J. Ellis. 2006. The effects of critical team member assertiveness on team performance and satisfaction. *Journal of Management* 32 (4):575-594.

Pelled, L. H., K. M. Eisenhardt, and K. R. Xin. 1999. Exploring the black box: An analysis of work group diversity, conflict and performance. *Administrative science quarterly* 44 (1):1-28.

Peltokorpi, V. 2008. Transactive memory systems. *Review of General Psychology* 12 (4):378-113.

Pflugrath, G., P. Roebuck, and R. Simnett. 2011. Impact of assurance and assurer's professional affiliation on financial analysts' assessment of credibility of corporate social responsibility information. *Auditing: A Journal of Practice & Theory* 30 (3):239-254.

Pirolli, P. L., and J. R. Anderson. 1985. The role of learning from examples in the acquisition of recursive programming skills. *Canadian Journal of Psychology* 39:240-272.

Preacher, K. J., and A. F. Hayes. 2004. SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behavior Research Methods, Instruments, & Computers* 36 (4):717-731.

———. 2008. Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior research methods* 40 (3):879-891.

Rajaram, S. 2011. Collaboration both hurts and helps memory: A cognitive perspective. *Current Directions in Psychological Science* 20 (2):76-81.

Rajaram, S., and L. P. Pereira-Pasarin. 2010. Collaborative memory: Cognitive research and theory. *Perspectives on Psychological Science* 5 (6):649-663.

Rapp, T. L., and J. E. Mathieu. 2007. Evaluating an individually self-administered generic teamwork skills training program across time and levels. *Small Group Research* 38 (4):532-555.

Reed, S. K. 1987. A structure-mapping model of word problems. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 13:124-139.

Reeves, L., and R. W. Weisberg. 1994. The role of content and abstract information in analogical transfer. *Psychological Bulletin* 115 (3):381-400.

Renkl, A. 2011. Instruction based on examples. In *Handbook of Research on Learning and Instruction (Educational Psychology Handbook Series)*, edited by R. E. Mayer and P. Alexander. New York, NY: Routledge.

Rentsch, J. R., L. A. Delise, and S. Hutchison. 2008. Cognitive similarity configurations in teams: In search of the team MindMeld. In *Team Effectiveness in Complex Organizations: Cross-Disciplinary Perspectives and Approaches*, edited by E. Salas, G. Goodwin and C. Burke. New York, NY: Routledge.

Rentsch, J. R., and R. J. Hall. 1994. Members of great teams think alike: A model of team effectiveness and schema similarity among team members. In *Advances in Interdisciplinary Studies of Work Teams: Theories of Self-Managing Work Teams*, edited by M. Beyerlein and D. Johnson. Greenwich: Elsevier Science/JAI Press.

Rentsch, J. R., and R. J. Klimoski. 2001. Why do ‘great minds’ think alike?: Antecedents of team member schema agreement. *Journal of Organizational Behavior* 22 (2):107-120.

Resick, C. J., M. W. Dickson, J. K. Mitchelson, L. K. Allison, and M. A. Clark. 2010. Team composition, cognition, and effectiveness: Examining mental model similarity and accuracy. *Group Dynamics: Theory, Research, and Practice* 14 (2):174-191.

Riordan, C. M., and L. M. Shore. 1997. Demographic diversity and employee attitudes: An empirical examination of relational demography within work units. *Journal of Applied Psychology* 82 (3):342-358.

Rittle-Johnson, B., and J. R. Star. 2011. The power of comparison in learning and instruction: Learning outcomes supported by different types of comparisons. In *Psychology of Learning and Motivation: Cognition in Education*, edited by J. Mestre and B. H. Ross. Waltham, MA: Elsevier.

Rosnow, R. L., and R. Rosenthal. 1995. “Some things you learn aren't so”: Cohen's paradox, Asch's paradigm, and the interpretation of interaction. *Psychological Science* 6 (1):3-9.

Ross, B. H. 1984. Remindings and their effects in learning a cognitive skill. *Cognitive Psychology* 16:371-416.

———. 1987. This is like that: The use of earlier problems and the separation of similarity effects. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 13:629-639.

———. 1989. Distinguishing types of superficial similarities: Different effects on the access and use of earlier problems. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 15:456-468.

Rouse, W. B., J. A. Cannon-Bowers, and E. Salas. 1992. The role of mental models in team performance in complex systems. *Systems, Man and Cybernetics, IEEE Transactions on* 22 (6):1296-1308.

Rouse, W. B., and N. M. Morris. 1986. On looking into the black box: Prospects and limits in the search for mental models. *Psychological Bulletin* 100 (3):349-363.

Rucker, D. D., K. J. Preacher, Z. L. Tormala, and R. E. Petty. 2011. Mediation analysis in social psychology: Current practices and new recommendations. *Social and Personality Psychology Compass* 5 (6):359-371.

Rulke, D. L., and D. Rau. 2000. Investigating the encoding process of transactive memory development in group training. *Group & Organization Management* 25 (4):373-396.

Rummel, N., and H. Spada. 2005. Learning to collaborate: An instructional approach to promoting collaborative problem solving in computer-mediated settings. *The Journal of the Learning Sciences* 14 (2):201-241.

Salas, E., and J. A. Cannon-Bowers. 2001. The science of training: A decade of progress. *Annual Review of Psychology* 52 (1):471-499.

Salas, E., D. R. Nichols, and J. E. Driskell. 2007. Testing three team training strategies in intact teams: A meta-analysis. *Small Group Research* 38 (4):471-488.

Salterio, S. 1996. The effects of precedents and client position on auditors’ financial accounting policy judgment. *Accounting, Organization and Society* 21 (5):467-486.

Salterio, S., and L. Koonce. 1997. The persuasiveness of audit evidence: The case of accounting policy decisions. *Accounting, Organizations and Society* 22 (6):573-587.

Selley, D. C. 1999. Use of Specialists in Assurance Engagements. In *Canadian Accounting and Assurance Service*: Canadian Institute of Chartered Accountants.

Shah, P. P., and K. A. Jehn. 1993. Do friends perform better than acquaintances? The interaction of friendship, conflict, and task. *Group Decision and Negotiation* 2 (2):149-165.

Shrout, P. E., and N. Bolger. 2002. Mediation in experimental and nonexperimental studies: new procedures and recommendations. *Psychological Methods* 7 (4):422-445.

Simnett, R., M. Nugent, and A. L. Huggins. 2009. Developing an international assurance standard on greenhouse gas statements. *Accounting Horizons* 23 (4):347-363.

Simons, T., L. H. Pelled, and K. A. Smith. 1999. Making use of difference: Diversity, debate, and decision comprehensiveness in top management teams. *Academy of Management Journal* 42 (6):662-673.

Slavin, R. E. 2011. Instruction based on cooperative learning. In *Handbook of Research on Learning and Instruction (Educational Psychology Series)*, edited by R. E. Mayer and P. Alexander. New York, NY: Routledge.

Smith-Jentsch, K. A. 2009. Measuring team-related cognition: The devil is in the details. In *Team Effectiveness in Complex Organizations: Cross-Disciplinary Perspectives and Approaches*, edited by E. Salas, G. F. Goodwin and C. S. Burke. New York, NY: Routledge/Taylor & Francis Group.

Smith-Jentsch, K. A., G. E. Campbell, D. M. Milanovich, and A. M. Reynolds. 2001. Measuring teamwork mental models to support training needs assessment, development, and evaluation: two empirical studies†. *Journal of Organizational Behavior* 22 (2):179-194.

Smith-Jentsch, K. A., J. A. Cannon-Bowers, S. I. Tannenbaum, and E. Salas. 2008. Guided team self-correction impacts on team mental models, processes, and effectiveness. *Small Group Research* 39 (3):303-327.

Smith-Jentsch, K. A., J. E. Mathieu, and K. Kraiger. 2005. Investigating linear and interactive effects of shared mental models on safety and efficiency in a field setting. *Journal of Applied Psychology* 90 (3):523-535.

Smith-Jentsch, K. A., R. L. Zeisig, B. Acton, and J. A. McPherson. 1998. Team dimensional training: A strategy for guided team self-correction. In *Making Decisions Under Stress: Implications for Individual and Team Training*, edited by J. Cannon-Bowers and E. Salas. Washington, DC: American Psychological Association.

Sneath, P. H., and R. R. Sokal. 1973. *Numerical Taxonomy: The Principles and Practice of Numerical Classification*. San Fransisco: WH Freeman and Co.

Sniezek, J. A., and R. A. Henry. 1989. Accuracy and confidence in group judgment. *Organizational Behavior and Human Decision Processes* 43 (1):1-28.

Solomon, I., and M. D. Shields. 1995. Judgment and decision-making research in auditing. In *Judgment and Decision Making Research in Accounting and Auditing* edited by R. Ashton and A. Ashton. Cambridge, UK: Cambridge University Press.

Srivastava, R. P., T. J. Mock, K. V. Pincus, and A. M. Wright. 2012. Causal inference in auditing: A framework. *Auditing: A Journal of Practice & Theory* 31 (3):177-201.

StandardsAustralia. 2006a. AS ISO 14064.1 Greenhouse Gases - Specification with Guidance at the Organization Level for Quantification and Reporting of Greenhouse Gas Emissions and Removals. In *Greenhouse Gases Set*. Sydney: Standards Australia.

———. 2006b. AS ISO 14064.3 Greenhouse Gases - Specification with Guidance for the Validation of Greenhouse Gas Assertions. In *Greenhouse Gases Set*. Sydney: Standards Australia.

Stasser, G., and D. Stewart. 1992. Discovery of hidden profiles by decision-making groups: Solving a problem versus making a judgment. *Journal of Personality and Social Psychology* 63 (3):426-434.

Steiner, I. 1972. *Group Processes and Group Productivity*. New York: Academic.

Stevens, M. J., and M. A. Campion. 1994. The knowledge, skill, and ability requirements for teamwork: Implications for human resource management. *Journal of Management* 20 (2):503-530.

———. 1999. Staffing work teams: Development and validation of a selection test for teamwork settings. *Journal of Management* 25 (2):207-228.

Stokes, M. E., C. S. Davis, and G. G. Koch. 2009. *Categorical Data Analysis Using the SAS System*. 2nd ed. New York, NY: Wiley.

Sundstrom, E., K. P. De Meuse, and D. Futrell. 1990. Work teams: Applications and effectiveness. *American Psychologist* 45 (2):120-133.

Sundstrom, E., M. McIntyre, T. Halfhill, and H. Richards. 2000. Work groups: From the Hawthorne studies to work teams of the 1990s and beyond. *Group Dynamics: Theory, Research, and Practice* 4 (1):44-67.

Sweller, J., J. J. van Merrienboer, and F. G. Paas. 1998. Cognitive architecture and instructional design. *Educational Psychology Review* 10 (3):251-296.

Tajfel, H., and J. C. Turner. 1986. The social identity theory of intergroup behavior. In *Psychology of Intergroup Relations*, edited by S. Worchel and W. Austin. Chicago: Nelson-Hall.

Talberg, A., and K. Swoboda. 2013. Emissions trading schemes around the world. Canberra: Parliament of Australia–Department of Parliamentary Services.

Thibodeau, J. C. 2003. The development and transferability of task knowledge. *Auditing: A Journal of Practice & Theory* 22 (1):47-67.

Thompson, L., D. Gentner, and J. Loewenstein. 2000. Avoiding missed opportunities in managerial life: Analogical training more powerful than individual case training. *Organizational Behavior and Human Decision Processes* 82 (1):60-75.

Tindale, R. S. 1989. Group vs individual information processing: The effects of outcome feedback on decision making. *Organizational Behavior and Human Decision Processes* 44 (3):454-473.

———. 1993. Decision errors made by individuals in groups. In *Individual and Group Decision Making: Current Issues*, edited by N. Castellan. Hillsdale, NJ: Erlbaum.

Tindale, R. S., C. M. Smith, L. S. Thomas, J. Filkins, and S. Sheffey. 1996. Shared representations and asymmetric social influence processes in small groups. In *The Psychology of Group Influence*, edited by P. Paulus. Hillsdale, NJ: Erlbaum.

Tindale, R. S., and R. Starkel. 2010. Decision making. In *Encyclopedia of Group Process and Intergroup Relations*, edited by J. Levine and M. A. Hogg. Thousand Oaks, CA: Sage.

Tindale, R. S., M. Talbot, and R. Martinez. 2012. Decision making. In *Frontiers of Social Psychology: Group Processes*, edited by J. Levine. Florence, KY: Psychology Press.

Tjosvold, D. 1998. Cooperative and competitive goal approach to conflict: Accomplishments and challenges. *Applied Psychology* 47 (3):285-313.

Triandis, H. C. 1995. *Individualism and Collectivism*. Boulder, CO: Westview Press.

Trompeter, G., and A. Wright. 2010. The world has changed—Have analytical procedure practices? *Contemporary Accounting Research* 27 (2):669-700.

Trotman, K. T. 1996. *Research Methods for Judgment and Decision Making Studies in Auditing*. Melbourne, Australia: Coopers & Lybrand and Accounting Association of Australia and New Zealand.

Tsui, A. S., T. D. Egan, and C. A. O'Reilly. 1992. Being different: Relational demography and organizational attachment. *Administrative science quarterly* 37 (4):549-579.

Tubbs, R. M. 1992. The effect of experience on the auditor's organization and amount of knowledge. *The Accounting Review* 67 (4):783-801.

van der Kloot, W. A., and H. van Herk. 1991. Multidimensional scaling of sorting data: A comparison of three procedures. *Multivariate Behavioral Research* 26 (4):563-581.

Van der Vegt, G. S., and J. S. Bunderson. 2005. Learning and performance in multidisciplinary teams: The importance of collective team identification. *Academy of Management Journal* 48 (3):532-547.

Van der Vegt, G. S., E. Van de Vliert, and A. Oosterhof. 2003. Informational dissimilarity and organizational citizenship behavior: The role of intrateam interdependence and team identification. *Academy of Management Journal* 46 (6):715-727.

van Knippenberg, D., C. K. De Dreu, and A. C. Homan. 2004. Work group diversity and group performance: an integrative model and research agenda. *Journal of Applied Psychology* 89 (6):1008-1022.

VanderStoep, S., and C. Seifert. 1994. Learning 'how' versus learning 'when': Improving transfer of problem-solving principles. *Journal of the Learning Sciences* 3 (1):93-111.

Vera-Munoz, S. C. 1998. The effects of accounting knowledge and context on the omission of opportunity costs in resource allocation decisions. *The Accounting Review* 73 (1):47-72.

Vera-Munoz, S. C., W. R. Kinney Jr, and S. E. Bonner. 2001. The effects of domain experience and task presentation format on accountants' information relevance assurance. *The Accounting Review* 76 (3):405-429.

Volpe, C. E., J. A. Cannon-Bowers, E. Salas, and P. E. Spector. 1996. The impact of cross-training on team functioning: An empirical investigation. *Human Factors: The Journal of the Human Factors and Ergonomics Society* 38 (1):87-100.

Wagner, W. G., J. Pfeffer, and C. A. O'Reilly III. 1984. Organizational demography and turnover in top-management group. *Administrative science quarterly* 29 (1):74-92.

Waller, M. J., N. Gupta, and R. C. Giambatista. 2004. Effects of adaptive behaviors and shared mental models on control crew performance. *Management Science* 50 (11):1534-1544.

Warner, R. M. 2013. *Applied Statistics: From Bivariate Through Multivariate Techniques*. 2nd ed. Thousand Oaks, CA: Sage.

Watkins, H. S., and R. Liu. 1996. Collectivism, individualism and in-group membership: Implications for consumer complaining behaviors in multicultural contexts. *Journal of International Consumer Marketing* 8 (3/4):69-96.

WBCSD, and WRI. 2004. A Corporate Accounting and Reporting Standard. In *The Greenhouse Gas Protocol*. Washington DC: World Business Council for Sustainable Development (WBCSD) and World Resources Institute (WRI).

———. 2005. THe GHG Protocol for Project Accounting. In *The Greenhouse Gas Protocol*. Washington DC: World Business Council for Sustainable Development (WBCSD) and World Resources Institute (WRI).

Webber, S. S., G. Chen, S. C. Payne, S. M. Marsh, and S. J. Zaccaro. 2000. Enhancing team mental model measurement with performance appraisal practices. *Organizational Research Methods* 3 (4):307-322.

Wegner, D. M. 1986. Transactive memory: A contemporary analysis of the group mind. In *Theories of Group Behavior*, edited by B. Mullen and G. Goethals. New York, NY: Springer-Verlag.

———. 1995. A computer network model of human transactive memory. *Social cognition* 13 (3):319-339.

Wegner, D. M., T. Giuliano, and P. T. Hertel. 1985. Cognitive interdependence in close relationships. In *Compatible and Incompatible Relationships*, edited by W. Ickes. New York, NY: Springer-Verlag.

Weinberger, A., B. Ertl, F. Fischer, and H. Mandl. 2005. Epistemic and social scripts in computer–supported collaborative learning. *Instructional Science* 33 (1):1-30.

Weingart, L. R., and E. Weldon. 1991. Processes that mediate the relationship between a group goal and group member performance. *Human Performance* 4 (1):33-54.

Weldon, M. S., and K. D. Bellinger. 1997. Collective memory: collaborative and individual processes in remembering. *Journal of experimental psychology: Learning, memory, and cognition* 23 (5):1160-1175.

Williams, J. J., and T. Lombrozo. 2010. The role of explanation in discovery and generalization: evidence from category learning. *Cognitive Science* 34 (5):776-806.

Williams, K. D. 2010. Dyads can be groups (and often are). *Small Group Research* 41 (2):268-274.

Williams, K. Y., and C. A. O'Reilly. 1998. Demography and diversity in organizations: A review of 40 years of research. *Research in organizational behavior* 20:77-140.

Wilson, J. R., and A. Rutherford. 1989. Mental models: Theory and application in human factors. *Human Factors: The Journal of the Human Factors and Ergonomics Society* 31 (6):617-634.

WorldBank. 2012. State and Trends of the Carbon Market 2012. Washington DC: the World Bank.

———. 2014. State and Trends of Carbon Pricing. Washington DC: the WorldBank.

Yamagishi, T., N. Jin, and A. S. Miller. 1998. In-group bias and culture of collectivism. *Asian Journal of Social Psychology* 1:315-328.

Zeitz, C. M., and K. T. Spoehr. 1989. Knowledge organization and the acquisition of procedural expertise. *Applied Cognitive Psychology* 3 (4):313-336.

Zhao, X., J. G. Lynch, and Q. Chen. 2010. Reconsidering Baron and Kenny: Myths and truths about mediation analysis. *Journal of Consumer Research* 37 (2):197-206.

Zhou, S., R. Simnett, and W. Green. 2013. The effect of legal environment and corporate governance on the decision to assure and assurance provider choice: Evidence from the GHG assurance market. *UNSW Australian School of Business Research Paper*.