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Effect of Using Domain Ontologies to Facilitate Shared Understanding and Cross-Understanding in Groups

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Abstract

Shared cognition constructs, such as shared understanding and cross-understanding, are important factors for task performance in groups in organizations. Shared understanding defines the extent of common understanding of a topic among group members, whereas cross-understanding defines the extent to which group members accurately understand the mental model of another group member regarding a specific topic. Although research in different fields has focused on understanding the theoretical effects of these constructs, little emphasis has been placed on improving their development. In Information Systems and related fields, shared understanding of a domain is said to be facilitated using a domain ontology – a domain ontology is a description of concepts and their interrelationships in a domain, and are generally represented in a graphical way. However, there is a lack of empirical evidence to support the benefit of domain ontologies facilitating shared understanding. Accordingly, to address this knowledge deficit regarding the mechanisms to enhance shared understanding and cross-understanding, and the lack of empirical evidence regarding the effect of domain ontologies on shared understanding, this study aims to explore the effect of domain-ontology usage on shared understanding and cross-understanding in novice group members. Accordingly, we propose a theoretical model that describes the effect of domain-ontology usage on shared understanding and cross-understanding of domains in groups. To empirically test our model, we focus on a domain ontology developed specifically for providing shared understanding of the compliance management domain. We then tested our proposed model through an experimental research design. Our experimental research design considered a two-group, post-test only, randomized experimental design with a sample of student participants. The results of our experiments indicate that group members who use a domain ontology develop significantly higher levels of shared understanding than those who do not use a domain ontology. Secondly, group members who use a domain ontology have significantly better communication quality in terms of discussion efficiency and communication clarity than those who do not use a domain ontology. Our study also found that group members who use a domain ontology develop a significantly greater cross-understanding than those who do not use a domain ontology. The outcomes of this study are expected to contribute to both theory and practice. From a theoretical perspective, we contribute the model of domain-ontology effects in facilitating shared understanding and cross-understanding, as well as the operationalization and testing of the cross-understanding construct. From a practical

perspective, we contribute by improving the understanding of the role domain ontologies can play as a tool to help improve performance in groups.

Declaration by author

This thesis is composed of my original work, and contains no material previously published or written by another person except where due reference has been made in the text. I have clearly stated the contribution by others to jointly-authored works that I have included in my thesis.

I have clearly stated the contribution of others to my thesis as a whole, including statistical assistance, survey design, data analysis, significant technical procedures, professional editorial advice, and any other original research work used or reported in my thesis. The content of my thesis is the result of work I have carried out since the commencement of my research higher degree candidature and does not include a substantial part of work that has been submitted to qualify for the award of any other degree or diploma in any university or other tertiary institution. I have clearly stated which parts of my thesis, if any, have been submitted to qualify for another award.

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Publications during candidature

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Contributor	Statement of contribution
Henry N. Roa (Candidate)	Wrote and developed the paper (100%)
Shazia Sadiq	Edited the paper (50%)
Marta Indulska	Edited the paper (50%)

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Contributions by others to the thesis

Professor Shazia Sadiq and A/Professor Malta Indulska provided advice on conceptualization and development of the theoretical model, as well as reviewing and editing the publications and thesis prior to submission.

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Keywords

Conceptual modelling, domain ontology, shared understanding, cross-understanding, communication quality

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

CC	Communication Clarity
CE	Communication Effectiveness
CO	Communication Openness
CoMOn	Compliance Management Ontology
CQ	Communication Quality
CU	Cross-Understanding
SU	Shared Understanding
TDE	Task Discussion Effectiveness

1 INTRODUCTION

1.1 MOTIVATION

Practitioners and researchers consider *shared understanding* (SU) and *cross-understanding* (CU) as important constructs to enhance task performance in groups in organizations (Bittner & Leimeister, 2014; Briggs, 2014; Field, 2013; Huber & Lewis, 2010; Salas, Cooke, & Rosen, 2008). These group-understanding constructs are determined at the group level by considering the participation of all group members as contributors (Huber & Lewis, 2010). The first construct, SU, defines the extent of common or similar comprehension or understanding of a topic among group members (Ko, Kirsch, & King, 2005). Whereas, CU defines the extent to which group members accurately understand the mental model of another group member regarding a specific topic (Huber & Lewis, 2010). SU is considered of great importance in groups because differences between group member understandings can interfere with the productivity of collaborative work (Bittner & Leimeister, 2014; Langan-Fox, Anglim, & Wilson, 2004). Similarly, CU is considered of great importance in groups because, after it is achieved, it affects group processes and outcomes by: influencing the content and efficacy of member communication, elaborating or modifying member mental models, and affecting members individual and collaborative behaviors (Huber & Lewis, 2010). In sum, SU and CU are important enablers of a successful task performance in groups.

Given the importance of SU and CU, there is still a lack of studies that explore mechanisms of improvement for these group-understanding constructs (Bittner & Leimeister, 2014; Huber & Lewis, 2010). Most studies on SU and the few existing studies on CU are focused on defining and describing the effect of these constructs on groups, rather than providing alternatives to enhance these constructs – e.g. see the studies performed by Bierhals, Schuster, Kohler, and Badke-Schaub (2007), Cannon-Bowers and Salas (2001), Randolph-Seng and Norris (2011) and Wu and Keysar (2007). In brief, studies of the effectiveness of the existing mechanisms as well as the design of new mechanisms or artefacts to support and enhance SU and CU are still required.

Psychology studies indicate that group understanding constructs, such as SU and CU, can be achieved and enhanced through two different, but complementary approaches (Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000; Resnick, 1991; Stein, Wanstreet, & Glazer, 2011). The first approach requires the provision of a similar source of information to each group member about a topic in question (Resnick, 1991). The second approach requires that group members communicate with each other to exchange valuable information about the topic in quesion (Mathieu et al., 2000; Stein et al.,

2011). Independent of the approach, when the information (provided or exchanged) allows for group members to develop a similar understanding of a particular topic, SU is enhanced. Similarly, when the information (provided or exchanged) allows group members to understand what the other group members know about a topic, CU is enhanced. Concisely, SU and CU can be improved by providing appropriate mechanisms to share information among group members and by an appropriate communication between group members. We consider that one of those mechanisms might be domain ontologies. A domain ontology can be explained as "a description of concepts and their interrelationships in a particular domain" (Bera, Burton-Jones, & Wand, 2011, p. 884), which are generally represented in a graphical way (Bera et al., 2011). These domain ontologies are sources of information of a particular domain, hence domain ontologies should facilitate SU.

Our literature review shows that a domain ontology can be used for the support of computer systems, as well as for the support of human tasks, such as: to benchmark and explore the quality and representation capability of conceptual modelling grammars, to improve conceptual modelling tasks, to provide individual understanding of a particular domain, to facilitate the construction of domain ontologies, and to provide SU among users. In Information Systems (IS) and related fields, the latter – the facilitation of SU of the domain represented in this ontology – is one of the oft-cited benefits of the use of a domain ontology to support human tasks (Al-Debei & Fitzgerald, 2010; Innab, Kayed, & Sajeev, 2012; Lin, Harding, & Shahbaz, 2004; Uschold, King, Moralee, & Zorgios, 1998). However, our literature review also shows that despite the popularity and high number of existing domain ontologies, this phenomenon is not well described in literature and even less commonly explored empirically. Moreover, our literature review also indicates that current ontology development methodologies lack recommendations for evaluating effectiveness of ontologies for the purpose for which they were developed, such as, for the facilitation of SU. It is therefore important to explore whether the claimed effectiveness of domain ontologies in regards to facilitating SU is evident in practice.

First, it is important to note that SU and CU are the result of the individual understanding that each group member has. This individual understanding is affected by prior knowledge of the domain and of conceptual modeling (Burton-Jones & Meso, 2008). The combination and extent of this previous knowledge in users might vary significantly, and will therefore distinguish different types of users, namely those ones who are knowledgeable in (a) conceptual modeling, (b) the domain, (c) both or (d) neither (Burton-Jones & Meso, 2008). Table 1-1 shows the different types of users that can be involved with the use of a domain ontology.

Because varying levels of knowledge will affect an individual's understanding, and hence SU and CU, we focus our efforts on a particular group of users. Our selected users range from those who have no knowledge to low knowledge levels in both domain knowledge and conceptual modeling i.e. novice practitioners (Group A in Table 1-1). We selected this group of users for two reasons. First, the purpose of this study is to understand the effect of a domain ontology on SU and CU. This enhancement of understanding at the group level is more important and significant in novice users than expert users. Second, most practitioners do not possess knowledge or experience in conceptual modeling. However, like other studies in conceptual modeling, we recognize that perhaps the most interesting cases are those in which individuals have varying levels of knowledge, however such cases are also complex and we believe that it is first necessary to understand a context involving novices prior to introducing the effect of more complex knowledge (Burton-Jones & Meso, 2008).

Table 1-1. Type of Users of a Domain Ontology (Adapted from Burton-Jones & Meso, 2008)

		Domain Knowledge	
		None - Low	Medium -High
Conceptual Modelling Knowledge	None - Low	A. Novice practitioners	B. Senior management practitioners
	Medium -High	C. Novice practitioners with experience in IT or IS	D. Senior practitioners with formation in IT or IS

Finally, it is important to consider that group size might play an important role in our study. However, we consider groups of only two people. We recognize that it would be desirable to use larger groups, however such cases are also very complex and much more difficult to study. This difficulty is mainly down to two reasons. First, there is not an ideal number of members in a group. The best number of people in a group is defined by the task to be performed (Lim & Klein, 2006). And second, a higher number of participants affects the performance in groups (Mueller, 2012). Thus, it will be difficult to study our construct in such settings. Consequently, to make our goal achievable, we have deemed it necessary to define boundaries regarding group size and the type of members in our selected groups.

1.2 AIM OF RESEARCH

While many domain ontologies have been developed to facilitate the development of SU, there is a lack of empirical evidence to support such claims. Accordingly, to address this gap in the body of knowledge in the IS field, the aim of this research is to theoretically and empirically understand the effect of a domain ontology on SU and CU in novice groups. Specifically, our main research question in this study is *what is the effect of using a domain ontology on shared understanding and cross-understanding?*

To investigate our research question, we developed a theoretical model as a basis for the empirical testing of the impact of domain ontology use on SU and CU. The theoretical model is based on the

usage process of a domain ontology to facilitate SU and CU. This process uses theories of conceptual modelling (Burton-Jones, Wand, & Weber, 2009; Gemino, 2004) to describe the use of ontologies at the individual level, and theories of shared cognition to extend the use of ontologies at the group level (Cannon-Bowers & Salas, 2001; Resnick, 1991; Salas et al., 2008). Accordingly, the theoretical model and its operationalization theorizes the influence that a domain ontology has on SU and CU. Finally, through a laboratory experiment, we evaluate our operationalized model to explore the effect of a domain ontology in facilitating SU and CU. To do this, our study focuses on one instance of a domain ontology – the Compliance Management Ontology (CoMOn) (Syed Abdullah, Sadiq, & Indulska, 2012b) chosen specifically due to its relevance for the facilitation of shared understanding.

1.3 THESIS STRUCTURE

This thesis is composed of eight chapters, as follows.

Chapter 1 provides an overview of and the motivation for performing this study. This chapter presents the aim of the research, our main research question, and the research approach to perform this study.

Chapter 2 defines the main constructs involved in this research and provides a review of related research, exposing definitions, current research into domain ontologies and the group understanding constructs of *shared understanding* and *cross-understanding*, and existing gaps in literature.

Chapter 3 describes and operationalizes the theoretical model that we propose to explain the effects of a *domain ontology* on *shared understanding* and *cross-understanding*. Based on the theoretical model, we propose a set of six hypotheses, which are tested in the next chapter.

Chapter 4 presents the method used for the empirical validation of the research model. We proposed an experimental design to test our hypotheses. Specifically, details of the experiment design, participants, measures, procedures, and data processing are described in this chapter. Moreover, we present the validity evaluation of our empirical validation in terms of internal, external, and construct validity.

Chapter 5 presents the analysis and discussion of the results of the empirical validation. In this chapter, the results of each of our hypotheses is presented and discussed. Furthermore, we evaluate the conclusion validity of our results.

Chapter 6 presents the conclusions of the research. Expected contributions, limitations of the study and future research opportunities are also considered in this chapter.

2 LITERATURE REVIEW

To clarify relevant concepts, understand prior work related with this study, and facilitate the development of our theoretical model, we performed several independent literature review rounds with a systematic approach that includes a backward and forward search (Tamm, Seddon, Shanks, & Reynolds, 2011). First, we reviewed literature related to shared cognition to develop a comprehensive view of *shared understanding* (SU) and *cross-understanding* (CU) and how these can be enhanced. Second, a review of ontology literature contributed to defining what a *domain ontology* is, identifying various notions of domain ontology usage, and finding evidence of ontology use to support SU. Finally, we reviewed literature related to conceptual modelling to understand how domain ontologies facilitate domain understanding and what factors may affect this facilitation.

2.1 SHARED COGNITION CONSTRUCTS

To define SU and CU, understand their importance and find current mechanisms to improve these constructs, we used the *Scopus* database to search for highly cited publications that included the terms *"shared understanding", "shared cognition", "shared mental models", "common understanding", "common mental models", and "cross-understanding"*. We present the results of the systematic literature review in the following.

2.1.1 Shared Understanding

The first construct, *shared understanding* (SU), is frequently referred to as shared knowledge, shared cognition or a shared mental model (Cooke, Salas, Cannon-Bowers, & Stout, 2000; Mathieu et al., 2000). This construct is defined as "a knowledge structure held by members of a group that enables them to form accurate explanations and expectations for the task, and in turn, to coordinate their actions and adapt their behavior to demands of the task and other group members" (Levesque, Wilson, & Wholey, 2001). That is, shared understanding is a group members' shared, organized understanding and mental representation of knowledge/beliefs about key elements of the group's relevant environment (Mohammed, Klimoski, & Rentsch, 2000). In addition, at a specific time, group members can hold multiple mental models to actively conceptualize and process information about their group, group members, equipment, the environment, and/or the task (Levesque et al., 2001). Moreover, what is shared among group members can be diverse. The various types of knowledge that contribute to shared understanding include (Johnson et al., 2007):

- *Team knowledge:* knowledge pertaining to their individual responsibilities and required actions, and knowledge of the skills, abilities, behavioral tendencies, and knowledge of other group members.
- *Team task:* knowledge of task procedures, strategies, contingencies and scenarios, and environmental constraints.
- *Team interaction:* patterns of interaction and communication, and interdependencies among members, roles/responsibilities, information sources, interaction patterns, communication channels, role interdependencies, information flow.
- *Technology and equipment knowledge:* knowledge regarding equipment functioning and limitations, operating procedures, and likely failures.
- *Collective understanding of the current situation.*

Similarly, according to Cannon-Bowers and Salas (2001), knowledge to be shared falls into one of four categories:

- *Task-specific knowledge:* this knowledge allows group members to act in a coordinated manner without the need to communicate overtly.
- *Task-related knowledge:* common knowledge about task-related processes, but not necessarily to a single task. For example, what is group work, how it operates, and its importance.
- *Knowledge of groups:* group members need to understand each other to maximize performance.
- *Attitudes and beliefs:* when team members are similar in terms of their attitudes and beliefs, it will cause them to have compatible perceptions about the task/environment and ultimately reach effective decisions.

Prior research has also considered the exposition of shared understanding through a shared mental model for a group task. Fiore and Schooler (2004) provides the following as elements of a shared mental model:

- *Shared problem structure:* an overlapping organized knowledge held by team members such as declarative or procedural knowledge concerning the problem and decision rules associated with the problem.
- *Understanding of each team member's roles and skills:* the roles and skills of the group as they pertain to the problem and the shared awareness that each member of the group possesses this knowledge.

In summary, shared understanding (SU) refers to different types of knowledge being shared between members. Therefore, it is important to specify what type of knowledge is being shared among group members when the construct is being studied. In this study, following the above definitions, we consider SU as a type of shared mental model, that is, the extent of common knowledge of a topic among group members (Ko et al., 2005). That knowledge topic can refer to different aspects, such as task-specific knowledge, task-related knowledge, knowledge of groups, or attitudes and beliefs. Our study is focused on a specific kind of knowledge - domain knowledge - that will be explained later.

Shared understanding has been recognized to be of great importance because it contributes to better organizational outcomes, better task performance and more positive attitudes in groups (Cannon-Bowers & Salas, 2001) despite the motivational states and behavioral processes in groups (Wildman, Salas, & Scott, 2014). Indeed, through SU, members can interpret information in the same way, make compatible decisions, and take correct actions (Cannon-Bowers & Salas, 2001). For example, in software engineering, SU is essential for efficient development when the risk of unsatisfactory outcomes necessitating the rework of project results must be kept as low as possible (Glinz & Fricker, 2014). Similarly, achieving SU between business and IT is of great importance to succeed in the effective use of IT in organizations (Jentsch, Beimborn, Jungnickl, & Renner, 2014).

Regarding mechanisms to improve SU, in theory, there are two approaches than can contribute to enhancing SU in groups:

In the first approach, SU can be improved by *providing timely and accurate information to the group* (Langan-Fox et al., 2004). This approach is more appropriate when group members are not familiar with each other (Resnick, 1991). According to Resnick (1991), providing information to group members can facilitate the process of referential anchoring. This process ensures that members understand terminology or phrases similarly, aiding any future communication between them. Thus, future communication can be improved by initially providing a good quality source of information to group members, which will then enhance SU as we explain later in this section. Not only this, but we also consider that SU might be achieved before group members communicate with each other. For example, if group members individually achieve a correct understanding of the domain, each will have a similar understanding about the domain, and by definition, a domain SU.

The second approach to enhancing SU requires social interaction, which can be achieved through *communication among group members* (M. Tan, 1994; Van den Bossche, Gijselaers, Segers, & Kirschner, 2006). For example, a field study of twenty-eight pairs, comprising a practicing systems analyst and their clients from state government departments in Australia shows that communication

is an important factor to enhance shared understanding (M. Tan, 1994). According to M. Tan (1994), communication in groups to *manage transaction* and *establish rapport* has a positive relationship with shared understanding. *Managing transactions* is defined as the ability to handle the procedural aspects of structuring, controlling, and maintaining a conversation. While *establishing rapport* "is an aspect of an interpersonal relationships that may be defined as creating a state of harmony, accordance, and congruity developed in a relationship" (M. Tan, 1994, p. 165). Also, the results of an observational field study of an IS development project shows that shared understanding is achieved as a result of the communication process in requirements development (Corvera Charaf, Rosenkranz, & Holten, 2013). However, communication by itself cannot be sufficient to enhance SU (Resnick, 1991) and communication quality among group members is needed to allow them to achieve common comprehension of a particular topic. That is, group members must exchange information related to the topic in which SU is desired. However, over-communication or improper communication may inhibit SU. For example, during IS development projects, purely informal communication may not be effective when dealing with a large number of stakeholders and vast amount of information (Corvera Charaf et al., 2013). According to Langan-Fox et al. (2004) such communication problems can be improved by providing timely and accurate information to the group.

In summary, we consider that SU among groups can be developed by providing a good quality information – information related to the topic to be improved – to group members before they communicate with each other. Also, we consider that SU can be improved through a good communication between group members. The quality of the communication between group members can be improved through by providing good quality information. Thus, it is important to know the best method of delivering this information to group members, i.e. how the information should be presented.

Although some general recommendations have been suggested to improve SU, our literature review indicates a lack of empirically tested mechanisms for improving SU. In fact, most existing studies are focused on one of three aspects related to SU, namely: to define the construct properly, to understand how SU develops, and to explore the impact of SU on groups.

First, some authors focus on improving the definition of the construct. For example, Cannon-Bowers and Salas (2001) present some reflections on the definition of SU. According to their study, it is necessary to address four fundamental questions to improve the definition of SU, namely (1) what must be shared? (2) what does 'shared' mean? (3) how should 'shared' be measured? and (4) what outcomes do we expect shared cognition to affect?

Second, other authors focus on understanding the development of SU in groups. For example, Corvera Charaf et al. (2013) studied how SU develops from a linguistic communication perspective. That is, through an observational field study of an IS development project that developed an internet-based application, they investigated and analyzed the semantic alignment process by which stakeholders achieve shared understanding in requirements development. Similarly, He, Butler, and King (2007) analyzed the emergence and evolution of team cognition in software project groups, and examined how communication activity and group diversity impacted the formation of group cognition. In this study, through a longitudinal study of 51 database development groups, they show that group cognition in terms of both shared understanding task and awareness of expertise location are affected by some forms of communication and group diversity.

Finally, other studies are focused on the impact of SU in groups and the mechanisms to measure SU. For example, as the result of the analysis of group publications in a period of 50 years, Salas et al. (2008) highlight that there is an important impact of SU on team performance and better mechanisms to measure SU are required. Also, Cooke et al. (2000) after a literature review described several mechanisms to measure group knowledge in the context of mapping specific methods onto features of targeted group knowledge. They also present some empirical results concerning the relationship between group knowledge and performance. Another example is DeChurch and Mesmer-Magnus (2010b) who through a meta-analysis of 23 independent studies have empirically examined shared understanding in relation to group process and performance, and test three aspects of measurement as potential moderators, namely elicitation method, structure representation, and representation of emergence. Their results show that a shared mental model impacts the observed relationship between SU and group process. Also, their results show that SU is positively related to group performance regardless of the manner of operationalization. However, Jentsch et al. (2014) propose that more cognitive methods are needed to develop measures for complex constructs like shared understanding. Moreover, the authors develop a content validity proven survey instrument that measures the degree of shared business/IT understanding. Their instrument was validated through an experiment with students and a pilot study with practitioners. Similarly, Johnson et al. (2007) described the development process of an instrument to measure SU and the conceptual framework for factors associated with SU. Their final instrument consists of 42 items that are linked to five factors of SU, namely general task and team knowledge, general task and communication skills, attitude toward teammates and task, team dynamics and interactions, and team resources and working environment. Bierhals et al. (2007) presents two studies to gain insights into the cognitive processes of designers working together in a group, and to clarify the impact of SU on team performance. The authors applied process-oriented research strategies to groups of mechanical engineering students and to

multidisciplinary project groups in the automobile industry. Some of their results show that the SU of groups is related to group performance. Moreover, SU is operationalized in terms of group members' skill and the process of interaction. Similarly, Mathieu et al. (2000) test the influence of group members shared mental models on group process and performance. They use 56 undergraduate pairs who flew a series of missions on a personal-computer-based flight-combat simulation. The authors both conceptually and empirically distinguished between group members' task and group-based mental models, and indexed their SU by comparing paired-comparisons matrices. Their results illustrated that both shared group- and task-based mental models related positively to subsequent group process and performance. In the same way, Nelson and Cooprider (1996) explored the relation of shared knowledge between IS groups and their line customers as a contributor to IS performance. Accordingly, the authors tested the relationship of mutual trust, influence, and shared knowledge with IS performance using path analysis in a study of 86 IS departments. Their results show that shared knowledge mediates the relationship between IS performance and both mutual trust and mutual influence.

Throughout the literature review we only found one study that focused on providing and empirically testing a specific mechanism to improve shared understanding of a task. Bittner and Leimeister (2014) derived a validated collaboration process module to systematically support heterogeneous work groups in building shared understanding of their task. Moreover, Bittner and Leimeister (2014) conducted an action research study at a German car manufacturing company to test their approach. Their results show that with the use of the collaboration process module team learning behaviors occur, and SU of the task in a complex work process increases for experienced diverse tool and dye makers.

In summary, our review of the literature shows, most research in shared understanding is focused on three main aspects namely, to define the construct properly, to understand the development of shared understanding in teams, and the impact of SU on teams and mechanism to measure it. All of these studies measured shared understanding in a particular context or for a particular task. However, to the best of our knowledge, none have tried to improve SU through a particular mechanism. In fact, the only efforts undertaken to improve SU that we found were focused on the SU of the task rather than the domain. While there are some general recommendations to improve SU, we could not find much evidence of how those recommendations can be put into practice or any empirical evidence of their effectiveness. Thus, we consider it necessary to continue exploring specific mechanisms able to enhance shared understanding of domains.

2.1.2 Cross-Understanding

According to Huber and Lewis (2011), it is difficult to draw clear conclusions about group outcomes due to variations in group members' knowledge, beliefs, and perspectives. This difficulty arises from studies with contradictory results. For example, some studies mention that high levels of diversity have a positive effect on group performance while other studies conclude that low levels of diversity have a positive effect. To explain some of these inconsistences in literature about social cognition, Huber and Lewis (2011) recently defined cross-understanding (CU), another type of shared cognition construct. Huber and Lewis define CU as the extent to which group members have an accurate understanding of what other group members know about a particular phenomenon. Huber and Lewis (2011) argue that the CU construct explains certain inconsistencies in the literature and we further provide support for specific group outcomes and processes beyond the explanations currently existing in literature.

In a similar way to SU, CU is important in improving performance in groups (Randolph-Seng & Norris, 2011). The benefits of CU are improved communication between members, better elaboration or modification of members' mental models, and better individual and collaborative behaviors in members (Huber & Lewis, 2010). Each of these benefits, can improve group performance and outcomes with CU being principally useful to groups with diverse knowledge, beliefs or perspectives (Huber & Lewis, 2010). However, it is important to note that CU can also have a negative effect on groups when it is based on shared beliefs, preferences, and sensitives (Randolph-Seng & Norris, 2011). According to Randolph-Seng and Norris (2011), only an accurate, knowledge-based CU can have a positive effect on groups. Moreover, according to Huber and Lewis (2010), the benefits of CU are independent of shared knowledge. Thus, achieving a high level of CU does not imply that a high level of SU has been achieved. Accordingly, enhancing CU is also required regardless of SU achievement.

According to Huber and Lewis (2011), CU can be enhanced through team communication or interactive experiences, observations of members' communications or behaviors, and access to member's biographical information. Each of these approaches allows group members to understand the mental models of other members and, hence, to achieve CU. Because CU is a recently defined construct, there is a lack of studies that focus on establishing specific mechanisms to enhance CU and empirical evidence to support such enhancement. We have identified therefore, a need for studies that focus on mechanisms to enhance CU. Specifically, it is important to provide evidence of the effect that the mechanisms proposed by Huber and Lewis have on improving the construct. For example, to elucidate what effect group communication has on CU. Also, it would be of great interest to see what

effect providing high quality information to team members has on CU and compare this with the results for SU to see if CU can be similarly improved.

2.1.3 Other Constructs

There are several shared cognition constructs that have been studied extensively in psychology and management research other than SU and CU. Other examples of shared cognition constructs are *team mental models*, *team cognition*, *transactive memory systems,* and *group learning* (Cooke et al., 2000; Huber & Lewis, 2010; Mohammed, Ferzandi, & Hamilton, 2010; Mulder, Swaak, & Kessels, 2002; Van den Bossche et al., 2006). In this section, we define each one of these constructs and differentiate them from the constructs central to this study, i.e. SU and CU.

Team mental models are generally referred to as shared mental models by some authors – e.g. see Cooke et al. (2000), DeChurch and Mesmer-Magnus (2010b), Mohammed and Dumville (2001). However, it is important to also note that several other authors do not consider these two constructs to be equivalent. For example, some authors consider t*eam mental models* to refer to multiple levels or sets of shared mental models and to a synergistic functional aggregation of the teams mental functioning representing similarity, overlap, and complementarity (Langan-Fox et al., 2004; Langan-Fox, Wirth, Code, Langfield-Smith, & Wirth, 2001). In this study, we consider *team mental models* to be shared mental models, covering any study or performed effort that is related with shared understanding. However, although the *team mental model* construct can refer to SU, it differs completely from CU.

Transactive memory systems are defined as shared systems for encoding, storing, and retrieving knowledge from different but complementary areas of expertise (Huber & Lewis, 2010; Thompson & Fine, 1999). Moreover, a *transactive memory system* includes the knowledge held by a particular group member with a group awareness of who knows what (DeChurch & Mesmer-Magnus, 2010a). Therefore, if we compare the *transactive memory system* definition with our definitions of SU and CU, we can assert that a *transactive memory system* differs from both SU and CU.

Team cognition defines the result of the interplay between the individual cognition of each team member and team process behaviors. These team process behaviors, such as communication and coordination, transform a collection of an individual's knowledge to team knowledge that ultimately guides action (Fiore & Schooler, 2004). To illustrate, *team cognition* is an activity, not a property or a product (Cooke, Gorman, Myers, & Duran, 2013). In fact, team cognition can have many components such as shared understanding of the domain, shared understanding of the task, awareness

of expertise location among others (He et al., 2007). As a result, we can assert that *SU* is a component of *team cognition*; however, CU in unrelated to *team cognition*.

Group learning refers to a process of construction of new knowledge in a group and is defined in terms of both processes and outcomes of group interaction. (Mulder et al., 2002) (Mohammed & Dumville, 2001). As a process, group learning is characterized by an ongoing process of reflection and action, which involves asking questions, seeking feedback, experimenting, reflecting on results, and discussing errors (Mohammed & Dumville, 2001). As an outcome, group learning refers to changes in the knowledge and performance of an interdependent set of individuals associated with experience (Mohammed & Dumville, 2001). Thus, we can assert that group learning is different from both SU and CU.

In summary, both SU and CU are outcome constructs. SU is defined as a type of shared mental model, that is, the extent of common comprehension of a topic among group members (Ko et al., 2005) and CU is defined as the extent to which group members have an accurate understanding of what other group members know about a particular topic (Huber & Lewis, 2010). Consequently, if we compare the definitions of SU and CU with the other construct definitions, we can conclude that SU and CU are distinct constructs to *transactive memory systems*, *team cognition*, and *group learning*. However, *team mental model* can be considered as a synonym of SU. Indeed, SU and CU are a unique result, while either *transactive memory systems*, *team cognition*, and *group learning* are more complex constructs that not only includes an outcome, but also consider group processes and/or individual behaviors.

2.2 ONTOLOGY FOUNDATIONS

2.2.1 Ontology Definition

The Oxford English Dictionary defines ontology from three different perspectives, namely as a science of philosophy, as a theory relating to the nature of being, and as a logic system (Oxford University Press, 2015). Due to such varied uses of the term ‘ontology’, it is often difficult to understand what the term refers to in a particular research area – the term ‘ontology’ makes reference to different concepts depending of both the type and area of application. Thus, in the interest of clarity, we first provide a review of ontology definitions and a clarification of the concept as it is understood in this study.

In general, the term ‘ontology’ defines the branch of philosophy that studies the nature and structure of reality (Wand, Monarchi, Parsons, & Woo, 1995). However, this term is also used in other research

fields in science and engineering to express a range of diverse meanings. The proliferation of varying ontology definitions stems from the high number of ontology variants and how they are classified. Ontologies have been classified in different ways by researchers depending on their: level of generality, type of structure and conceptualization, appearance, scope, functionality and degree of formality. Although the classifications vary from one author to another, the two most commonly-used classifications are those based on the level of generality and the degree of formality.

According to the level of generality, ontologies can be top-level ontologies or domain ontologies. Top-level ontologies describe abstract and general concepts (Grimm, Abecker, Völker, & Studer, 2011) such as space, time, matter, objects, events, or actions. Because these ontologies are independent of any domain (Guarino, 1998), top-level ontologies can be shared across different domains and applications, and reused as a basis for developing domain ontologies (Grimm et al., 2011). Some examples of top-level ontologies are Cyc's Upper Ontology (Lenat & Guha, 1989), Standard Upper Merged Ontology (SUMO) (Milton & Smith, 2004), and the Basic Formal Ontology (Grenon & Smith, 2004). The second generality level, domain ontologies, capture the knowledge or describe the vocabulary related to a generic domain, such as medicine, geography or project management (Grimm et al., 2011). The number of ontologies that exist in this classification is high – these ontologies can be found in different fields of science and engineering, and are explained in the following sections. Normally, these ontologies should specialize the terms of a top-level ontology; however most ignore top-level ontologies and/or the work done in philosophical ontologies. This can be problematic because top-level ontologies contribute to the creation of better domain ontologies (Smith, 2008).

The representation of ontologies varies from the informal to the formal. The formality of an ontology determines to what extent it is acclimatized by means of logical statements about the domain (Grimm et al., 2011). In function of its formality, an ontology can be represented as a thesaurus, a concept schema, a taxonomy, a conceptual data model, a rule base, or a general logical theory (Sharman, Kishore, & Ramesh, 2004) (see Figure 2-1). For example, ontologies can be represented as a semantic network composed of interlinked concepts. While such a representation may be easy to interpret because of the simplified representation, it may lack important information, such as particular kinds of axioms (Grimm et al., 2011). Ontologies can also be represented through formal languages that allow the capture of all the knowledge related with the domain in question (Gómez-Pérez, Fernandez-Lopez, & Corcho, 2004). One example of such a language is the Web Ontology Language (OWL), which is commonly used in the formalization of ontologies. It is important to note that although ontologies can be represented in many informal ways, representations that lack an organized semantic structure cannot be considered ontologies (Guarino, Oberle, & Staab, 2009, p. 13). For example, a set

of terms without any kind of organization or structure that facilitate an understanding of the domain is just a set of terms and not an ontology.

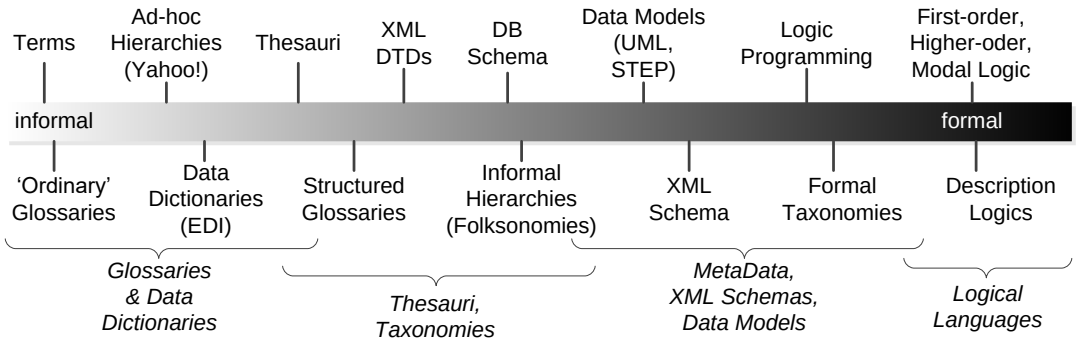

Figure 2-1. Ontology Representation (Guarino et al., 2009, p. 13)

This situation has made it difficult to achieve consensus about what ontologies are. To clarify this issue, efforts have been undertaken to define ontologies. For example, Almeida (2013), Fonseca (2007), Giaretta and Guarino (1995), Hepp (2008), Kishore and Sharman (2004), and Weber (2002) all contribute to the discussion of ontologies by providing their interpretation of what an ontology is. However, a lack of consensus still remains and, as a result, each field has adopted its own definition. Nonetheless, considering the general purpose of ontologies, ontologies can be broadly defined as a shared conceptualization of reality, which, according to Hepp (2008), can be represented by formal means or informal means. Therefore, in this study, we define an ontology as a specification of a shared conceptualization of reality, which has varying levels of generality and representation formality. In this definition, 'conceptualization' refers to an abstract model of reality through concepts and relations relevant to that reality (Studer, Benjamins, & Fensel, 1998); 'shared' refers to an ontology capturing consensual knowledge of reality by a group of experts in that reality (Studer et al., 1998); 'levels of generality' refers to the notion that ontologies can be very general (the whole reality) to very specific (a domain in particular); and 'formality' refers to how an ontology can be specified through formal means such as OWL (Bera et al., 2011), to informal means such as a graphical representation of concepts and their relationships (Grimm et al., 2011). Consequently, we refer to a domain ontology as the specification of a shared conceptualization of a domain, which can be established through formal or informal means.

2.2.2 Systematic Search of Ontology Use and Effective Use

To understand popular use of ontologies, as well as insights of effective use, we conducted a systematic search of literature to identify the most cited and relevant papers for our analysis (Webster & Watson, 2002). To identify relevant publications, we considered journals, papers, books, and book

chapters since 1985. The selected timeframe was chosen because the references to ontologies rose to prominence in the late 1990s and early 2000s (Figure 2-2). We therefore chose to commence our literature review in 1985 in order to encapsulate any early, but significant papers.

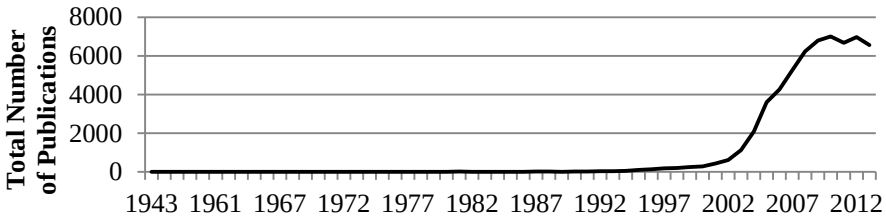

Figure 2-2. Number of Publications per Year Related to Ontologies in the Scopus Database

After establishing the time frame and publication sources, we used the terms 'ontology', 'ontologies', and 'ontological' to search publications in the Scopus database, which returned over 69,000 hits. To obtain a more focused result, as well as for analytical feasibility, we limited our search to titles only, which resulted in 23,618 publications. Given the volume of relevant work, we focused further on identifying the most impactful publications – i.e. to proxy a reasonable set of publications that can be analyzed. We considered two metrics: the age-weighted citation rate and the number of citations since publication. The age-weighted citation rate (AWCR) is calculated for each publication considering the paper age and the number of citations. Using a threshold of AWCR greater than 115 and the number of citations greater than 23, a set of 135 publications was selected for the final analysis. This threshold was considered because one of the most important publications in the ontology-engineering-field theory (Gruber, 1993) had a AWCR = 229 (We defined this value as AWCRg). Hence we wanted a set of publications with similar relevance, that is, at least 50% of the AWCRg or a number of citations greater than the 10% of the AWCRg if the previous condition does not hold.

Although the systematic review allowed us to find a set of relevant and highly impactful publications, this approach may have eliminated significant references because of the high threshold used. Therefore, we also used an exploratory search to find additional relevant publications related with the use and effective use of ontologies. This kind of search did not follow a strict approach, instead it involved using related keywords and phrases in online search tools, and doing backwards and forwards searches on the citations of references found in the first step (Tamm et al., 2011, p. 144).

Using Google Scholar, we searched for 'ontology usefulness', 'ontology use', 'ontology usability', and 'ontology applicability'. The results of these queries allowed us to identify 26 publications, which were added to the previously identified set (resulting in a total of 161 papers). The 161 publications were reviewed in full by one researcher to identify relevant insights about the use and effective use

of ontologies. To do this, each paper was coded through three different phases in order to reduce bias (Neuman, 2011). First, some preliminary codes were established and the publications codified. Then, these codes were organized in categories, new codes were considered, and some discharged. Finally, only six main codes, namely, field of application, nature of use, agent (system or human), type of ontology (domain ontology or top-level ontology), type of ontology representation (formal language or informal language), and type of effective-use evaluation (empirical, theoretical, none) were considered in the findings. The codes formed the criteria for our analysis, the results of which are presented in the next section.

Finally, to further reduce the risk of missing relevant papers, we performed an additional Scopus search using the terms 'ontology', 'ontologies' or 'ontological', and 'shared understanding', 'cross-understanding', 'common understanding', 'similar understanding' or 'joint understanding' in the title, abstract or keywords of publications since 1985. The query returned 319 results from which titles were compared with our initial 161-paper set and then reduced to 244 results after eliminating duplicates papers. Consequently, this set of papers was analyzed through the use of the NVivo[1]. First, we filtered papers that did not have stemmed words of the terms 'empirical', 'existential', 'experiential', 'experimental', 'objective' or 'observational'. We did so to find papers that provided empirical evidence. Second, in the filtered set of papers, we searched for stemmed words of 'person', 'member', 'individual', 'participant', 'subject' or 'group' to find papers that conducted empirical research with participants. This filtering process results in 216 additional papers that were analyzed in full text in order to identify empirical evidence. The results are presented in the next section.

2.2.3 Ontology Use

By definition, and as demonstrated by studies on ontology use (Guarino, 1998; Studer et al., 1998; Uschold & Jasper, 1999), ontologies can be applied to any area in which a representation of reality is required. Ontologies can also be applied to different situations and scenarios, such as the interoperability of computer systems, the development of better conceptual models for IS, or for improving domain understanding, among others.

To identify the types of uses that are common in practice we looked for the application of such ontologies in the set of publications that we selected. The results show that ontologies are used in many fields within science and engineering. For example, in IS, ontologies can be used to facilitate conceptual modelling (Wand, Storey, & Weber, 1999), as a basis for evaluation and improvement of process modelling notations (J. C. Recker, Rosemann, Indulska, & Green, 2009), as components of

[1] NVivo is a software package for qualitative data analysis: http://www.qsrinternational.com.

computer systems (Lutz & Klien, 2006), as repositories of information (Neches et al., 1991) and facilitators of interoperability of the semantic web (Berners-Lee, Hendler, & Lassila, 2001), among others. Similarly, in biology, ontologies can be used as repositories of information that contain vocabularies and classifications of genes, as components of computer systems for the retrieval and extraction of biological information, or for the integration and extension of gene databases (Horrocks & Patel-Schneider, 2011). Ontologies have also been used in industry in operations research and management science. In these settings, they are used to provide a SU of manufacturing-related terms, the reuse of knowledge resources within globally extended manufacturing teams (Lin et al., 2004), as part of the architecture of decision support systems (Niaraki & Kim, 2009), or to model knowledge related to product configuration (Yang, Miao, Wu, & Zhou, 2009).

When the different types of applications are considered, it is clear that there are two general uses of ontology: one relating to the use of ontologies for the support of computer systems and the other relating to the support of human tasks (Table 2-1). These findings are significant because the use of ontologies should not be generalized. Indeed, differences exist between the ontologies used to support systems and those used to support human tasks, and hence clarification is required.

Table 2-1. Use of Ontologies vs. Types of Representation

Types of Use	Types of Representation	
	Informal	Formal
Computer Systems Support	0.0%	100.0%
Information retrieval	0.0%	100.0%
Interoperability	0.0%	100.0%
Knowledge representation	0.0%	100.0%
Systems based on ontology	0.0%	100.0%
Other	0.0%	100.0%
Human Task Support	73.1%	26.9%
Analysis of Conceptual Modelling Grammars	100.0%	0.0%
Conceptual modelling	92.9%	7.1%
Domain Understanding	50.0%	50.0%
Ontology construction	0.0%	100.0%
Shared Understanding	60.0%	40.0%

Although the use of ontologies can be extensive in the two general types of use, for the support of computer systems, we found that ontologies can be used to facilitate information retrieval, to enable the interoperability or communication between computer systems (e.g. semantic web), to represent and store knowledge, as components of operation of computer systems (e.g. support decision systems based on ontology) among other uses. When it comes to ontology use for the support of human tasks, we found that ontologies are used to benchmark and explore the quality and representational capability of conceptual modelling grammars, to improve conceptual modelling tasks, to provide the individual understanding of a particular domain, to facilitate the construction of domain ontologies, and to provide shared understanding among users.

Table 2-1 also shows that both formal and informal representations of ontologies are used to support human tasks. For example, visual ontologies (Bera et al., 2011) and ontologies presented through the use of a computer system (Kim, 2012) have been found to provide support for knowledge identification (a task related with domain understanding). When ontologies are used to support systems, they, by necessity, must be represented in a formal language. For example, OWL is the common language that is used to implement ontologies that will work with the semantic web (Horrocks & Patel-Schneider, 2011). Although some studies show that formal ontologies are used to support human tasks, the ontologies in those studies are embedded in computer systems. Thus, in these studies, it is difficult to establish under what circumstances the ontology itself supports the human task, rather than the system supporting the task. In other words, it is unclear in these studies whether it is the ontology or the system, or both, that supports the human task.

While the benefits of ontologies in systems can be validated through prototypes and their functionality, the benefits of ontologies for support human tasks are more difficult to show, with only empirical evidence able to indicate their effective use. To clarify this aspect, we searched for empirical evidence that supports ontology effective use in supporting human tasks. Table 2-2 shows that there is considerable evidence that indicates that ontologies do indeed support tasks related to conceptual modelling, domain understanding, and ontology construction. For example, in the context of conceptual modelling, J. Recker, Rosemann, Green, and Indulska (2011) demonstrated how ontological deficiencies in modelling grammars affects conceptual modelling, Gašević, Kaviani, and Milanović (2009) assessed how ontologies can support some activities in the software development life cycle, and Sugumaran and Storey (2006) tested the use of ontologies as support for the design of databases. Despite these contributions, there is a lack of empirical evidence to support the claimed effective use of ontologies developed with the purpose of facilitating SU, even though many ontologies were developed with this aim in mind – e.g. the enterprise ontology (Uschold et al., 1998), manufacturing system engineering ontology (Lin et al., 2004), V4 service business model ontology (Al-Debei & Fitzgerald, 2010), the ontology for software requirements modelling (Innab et al., 2012), to name just a few. In fact, after the full text analysis of the additional 216 papers that we collected, we could not find any empirical evidence to justify the effectiveness of ontologies to facilitate SU.

Table 2-2. Empirical Evidence of Effective Use of Ontologies

Types of Use	Empirical Evidence of Effective Use	
	Yes	No
Systems Support	64.0%	36.0%
Information retrieval	75.0%	25.0%
Interoperability	40.9%	59.1%
Knowledge representation	67.3%	32.7%
Systems based on ontology	100.0%	0.0%
Other	50.0%	50.0%
Human Task Support	30.8%	69.2%
Analysis of Conceptual Modelling Grammars	50.0%	50.0%
Conceptual modelling	28.6%	71.4%
Domain Understanding	100.0%	0.0%
Ontology construction	33.3%	66.7%
Shared Understanding	0.0%	100.0%
Total	56.5%	43.5%

Because of the lack of empirical evidence for the effective use of ontologies in establishing shared domain understanding, we analyzed whether highly-cited methodologies for building and evaluating ontologies include any approach for evaluation of effective use in such settings. In this analysis, we considered that ontology evaluation may occur at two distinct stages. The first is related to the evaluation of the ontology before it is put into use, that is, the *desired effective use* of the ontology. Whereas the second scenario is related to the evaluation of the ontology after it is put into use, that is, the *resulting effective use* of the ontology. The results of the analysis show that most ontology development methodologies lack the evaluation of ontology's resulting effective use, i.e. evaluation of the ontology post-implementation. Table 2-3 summarizes selected characteristics of these methodologies. Although some methodologies consider an evaluation of the ontology, these approaches are more focused on only assessing the quality of the ontology content, and do not pay particular attention to understanding whether the ontology itself is useful. For example, the methodology used for developing the enterprise ontology (Uschold & King, 1995) has four phases of development: to identify the purpose of the ontology, to build the ontology, to evaluate the ontology, and to document the ontology. Despite this multi-stage process, in the evaluation phase the methodology prescribes evaluation from a knowledge-representation point of view, which is more likely related to a desired quality parameter rather than actual effective use. Similarly, OntoClean (Guarino & Welty, 2009) is an evaluation methodology that allows validation of the ontological adequacy and logical consistency of taxonomic relationships, but it lacks recommendations to evaluate other aspects, such as the effective use of the ontology.

Of those methodologies that propose to evaluate ontology effective use, the evaluation purpose is focused on the perceived effective use of the ontology and/or effective use through application systems instead of the ontology's effective use for human tasks. One example of this is the methodology used in the development of the DO4MG ontology (Delir Haghighi, Burstein, Zaslavsky,

& Arbon, 2013), which evaluates the effective use of the ontology through a decision support system that uses the ontology; however, empirical evidence of its application by users is not considered. Also, although the NeON methodology (Suárez-Figueroa, Gómez-Pérez, & Fernández-López, 2012) suggests the evaluation of effective use, it is orientated towards the evaluation of the application in which the ontology is applied. In addition, in the methodology used to develop the Compliance Management Ontology (CoMOn) (Syed Abdullah, Sadiq, & Indulska, 2013), effective use is evaluated as perceived by users; however, they do not attempt to explore actual ontology effective use. Thus, although there are many methodologies for the construction and evaluation of ontologies, they lack a well-structured prescription of how to evaluate the effective use of ontologies for the specific purpose of shared domain understanding.

Table 2-3. Ontology Development Methodologies

Methodology Name	Development Process	'Desired' Effectiveness Evaluation	'Resulting' Effectiveness Evaluation
Cyc (Guha & Lenat, 1990)	✓		
N/A- (Gruber, 1995)			
Based in Enterprise Ontology (Uschold & King, 1995)	✓	✓	
Based in TOVE (Grüninger & Fox, 1995)	✓	✓	
KACTUS (Gómez-Pérez et al., 2004)	✓		
METHONTOLOGY (Fernández-López, Gómez-Pérez, & Juristo, 1997)	✓	✓	
Based in SENSUS (Swartout, Patil, Knight, & Russ, 1996)	✓		
Ontology Development 101 (Noy & McGuinness, 2001)	✓		
Based in On-To-Knowledge (Staab, Studer, Schnurr, & Sure, 2001)	✓	✓	
DILIGENT (Tempich, Pinto, Sure, & Staab, 2005)	✓	✓	
HCOME (Kotis & Vouros, 2006)	✓	✓	
OntoClean (Guarino & Welty, 2009)		✓	
UPON (De Nicola, Missikoff, & Navigli, 2009)	✓	✓	
DOGMA (Jarrar & Meersman, 2009)	✓		
Based on DO4MG (Delir Haghighi et al., 2013)	✓	✓	✓
NeOn (Suárez-Figueroa et al., 2012)	✓	✓	✓
Based on CoMOn (Syed Abdullah et al., 2013)	✓	✓	✓

As our literature review shows, there is a lack of theoretical and empirical evidence of the real benefits of domain ontologies to support and enhance shared understanding. Thus, it is necessary to explore such benefits, especially considering the high number of ontologies that have been developed for such benefits.

2.3 CONCEPTUAL MODELS AND DOMAIN UNDERSTANDING

Recall we define an ontology as a specification of a shared conceptualization of reality, which has varying levels of generality and representation formality. According to our definition, domain

ontologies are similar to traditional conceptual models used in IS and related fields. Conceptual models – also named as conceptual schemas or conceptual scripts – are representations of a real-world domain[2] (Allen & March, 2006; Wand & Weber, 2002). In IS and related fields, conceptual models are used generally to document the common understanding that stakeholders have about a domain that is intended to be supported by an information system (J. Recker et al., 2011). Thus, by considering a domain ontology as a particular type of conceptual model, we conducted a review of conceptual modelling literature to understand what factors can affect the understanding of a conceptual model.

To represent conceptual models, modelers (analysts and designers) use a modelling method and a modelling grammar. The modelling method specifies the procedure for constructing the conceptual models (J. Recker et al., 2011). While the modelling grammar defines the constructs and rules to combine those constructs (Allen & March, 2006; Wand & Weber, 2002). For example, by using entity-relationship grammar, database designers develop entity-relationship diagrams that can represent data requirements of a particular domain.

As aforementioned, conceptual models have been used extensively to facilitate domain understanding by users. However, domain understanding can be considerably affected by external and internal elements to the conceptual model. For example, the way in which those conceptual models are represented can affect domain understanding (Burton-Jones & Meso, 2008). As a result, graphical representations are most often used to provide understandability of the conceptual model (Burton-Jones & Weber, 2014; Mayer, 2009).

Conceptual modelling research has dealt with understanding this issue from two perspectives: how to improve the development of conceptual models and how to improve the understanding of conceptual models (Vijay Khatri, Vessey, Ramesh, Clay, & Park, 2006). An example of these studies is: how to improve the semantics of conceptual modelling grammars to facilitate users developing a better understanding of the domain the models represent (Clarke, Burton-Jones, & Weber, 2013). This research indicates that conceptual modelling grammars should not only follow the principles of ontological clarity (J. Recker et al., 2011; Saghafi & Wand, 2014), but also those of logical clarity. In addition to the effect of the conceptual model itself, there are also external factors that may affect the understandability of the domain. For example, prior knowledge of both conceptual modelling and of the application domain will affect the understandability of the domain depending of the cognitive fit with the kind of task (Vijay Khatri et al., 2006). Similarly, prior research shows that not only the

[2] From here on out, we use the term "domain" to refer to the expression: “real-world domain”.

semantics of conceptual models is important, but also the pragmatics in which the model is created and used (Bera, Burton-Jones, & Wand, 2014). Based on these perspectives, we summarize the different types of factors that can affect the understandability of conceptual models (See Table 2-4).

Table 2-4. Factors Affecting Understandability of Conceptual Models

Factor Category	Factor	Supporting Theory or Literature	Operationalization
Conceptualization of the domain	Level of captured knowledge	Theory of knowledge representation (Sowa, 2000)	Taxonomy (low-level knowledge) Taxonomy plus semantic relations (medium-level knowledge) Taxonomy plus semantic relations, plus axioms (High-level knowledge)
	Quality of captured knowledge (Conceptual semantic quality)	Theory of knowledge representation (Sowa, 2000)	Quality of captured knowledge
Representation of the conceptual model	Formality of representation grammar	Multimedia learning theory (Mayer, 2005)	Natural language (Informal) Visual language (Semiformal) OWL language (Formal)
	Ontological completeness	Theory of ontological expressiveness (Wand & Weber, 1995)	Construct deficit
	Ontological clarity	Theory of ontological expressiveness (Wand & Weber, 1995)	Construct redundancy Construct overload Construct excess
	Quality of represented knowledge (Representation semantic quality)	Theory of knowledge representation (Sowa, 2000)	Quality of represented knowledge
Visualization of the represented conceptual model	Semiotic clarity	D. Moody (2007)	Symbol redundancy Symbol overload Symbol excess Symbol deficit
	Perceptual discriminability	D. Moody (2007)	Visual distance Primacy of shape
	Semantic transparency	D. Moody (2007)	Icons Semantically transparent relations
	Graphic complexity	D. Moody (2007) Cognitive load theory (D. L. Moody, 2004)	Modularization Hierarchy
Involved task	Type of understanding task	Cognitive fit theory (Vessey & Galletta, 1991)	Level of understanding questions
	Cognitive load	Cognitive load theory (D. L. Moody, 2004)	Comprehension time Comprehension accuracy Verification time Verification accuracy
Previous knowledge	Previous domain knowledge	Cognitive fit theory (Vessey & Galletta, 1991)	People with different domain knowledge levels
	Previous conceptual modelling knowledge	Cognitive fit theory (Vessey & Galletta, 1991)	Individuals with and without conceptual modelling knowledge

As shown in Table 2-4, there are several factors affecting the understandability or interpretation of conceptual models (e.g., domain ontologies). First, the interpretation of a conceptual model is affected by the conceptualization of the domain. Examples of factors involved in the conceptualization are the level of knowledge captured and the quality of captured knowledge for the modeler (Sowa 2000). Second, the representation of the conceptual model also affects the interpretation of the conceptual model. Examples of these affecting factors include the formality of the representation grammar used to represent the conceptual model (Mayer 2005), the ontological completeness and the ontological clarity of the grammar used to represent the conceptual model (Wand 1995), and the quality of represented knowledge (Sowa 2000). Third, the visualization of the represented conceptual model is another factor affecting interpretation. Examples of these factors are semiotic clarity perceptual discriminability, semantic transparency, and graphic complexity (Moody 2007; Moody 2004). Fourth, the interpretation of a conceptual model is also affected by involved task factors. For example, the type of interpretative or understanding task given to users (Vessey and Galletta 1991) or the cognitive load that the task exerts on the users (Moody 2004). Finally, previous knowledge of the user also affects the understandability or interpretation of a conceptual model. For example, factors involved in conceptual model understandability are previous domain knowledge and conceptual modeling knowledge (Vessey and Galletta 1991).

In summary, as our literature review shows, conceptual models (e.g., domain ontologies) can facilitate domain understanding. However, it is important to note that many factors may also affect such benefits.

2.4 CHAPTER SUMMARY

In this chapter, we presented the results of our literature reviews. Through a systematic approach, we found literature that allowed us the clarify important concepts, which are used later in this study. First, we introduced two shared cognition constructs of interest - shared understanding (SU) and cross-understanding (CU). We also provided definitions of these constructs, their importance, and ways of enhancing them, in addition to identifying current gaps in literature. Second, we introduced ontology foundations by defining what ontologies are, providing types of use, and exploring evidence of effective ontology use. Finally, we provided insights into conceptual models and their use in facilitating domain understanding. The literature analysis allowed us to establish the required foundations to develop our theoretical model, which is presented in the next chapter.

3 RESEARCH MODEL AND HYPOTHESES DEVELOPMENT

Our main research question in this study is *what is the effect of using a domain ontology on shared understanding (SU) and cross-understanding (CU)?* To address this question, we describe a domain ontology usage process to facilitate SU and CU. This process describes the different stages and activities that team members perform to achieve SU and CU through the use of domain ontologies. Then, considering the aforementioned process, we develop a theoretical model that describes the effect of domain ontology on SU and CU through the mediator of *communication quality* (CQ). According to our theoretical model, domain ontologies also affect CQ, which is an enabler of SU improvement and CU development.

3.1 DOMAIN-ONTOLOGY USAGE PROCESS

As we concluded in our literature review, the facilitation of group understanding constructs, such as SU and CU, through the use of conceptual models is not well described in existing conceptual modelling research. Most of research in this field is focused on the development of conceptual models and facilitating domain understanding between individuals through the use of those conceptual models (V. Khatri, Vessey, Ram, & Ramesh, 2006). Hence, there is still a lack of understanding of how SU and CU develop through the use of conceptual models. To address this problem, first, we describe how using a domain ontology can enhance SU and CU. Then, we will theorize the effects of domain ontologies in facilitating SU and CU based on this description.

Accordingly, in this section, we describe a process through which a domain ontology facilitates SU and CU (Figure 3-1). Based on literature and theory related to conceptual modelling, group communication and shared cognition, we describe and support our usage process. Our process specifies that the facilitation of SU and CU via a domain ontology implies three main phases: *Individual Ontology Interpretation*, *No Team Interaction*, and *Team Communication* (see Figure 3-1). In the next sections, we describe in detail each of the phases of our domain ontology usage process.

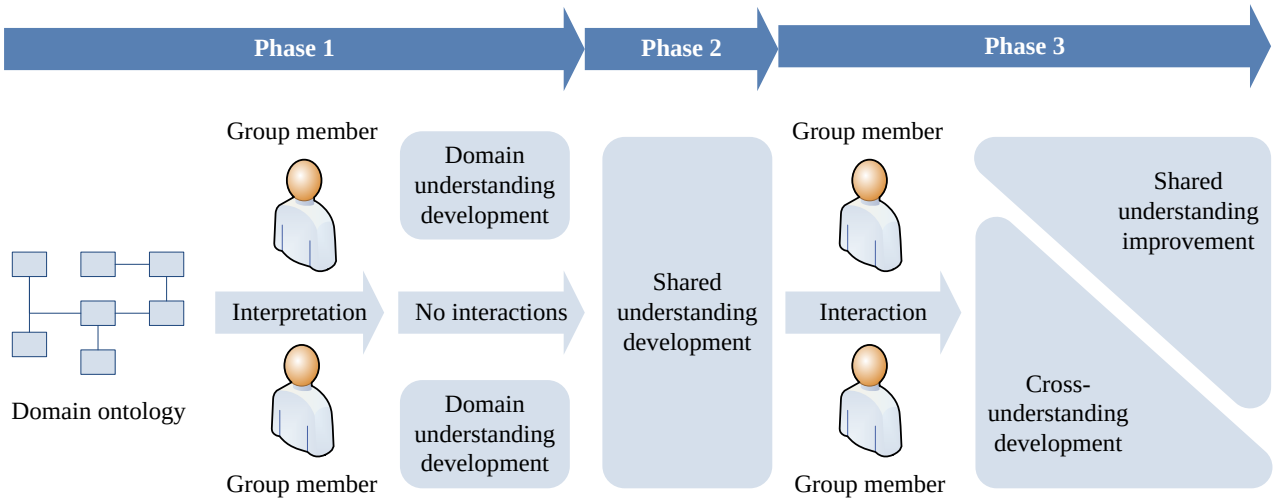

Figure 3-1. Domain Ontology Usage Process to Facilitate Shared Understanding and Cross-Understanding

3.1.1 Individual Ontology Interpretation

The first phase of our domain ontology usage process model is the *Individual Ontology Interpretation* phase. During this phase, each group member is required to interpret the domain ontology. Previous studies in conceptual modelling have already established that users can develop an understanding of a domain through interpreting a representation of said domain (Burton-Jones et al., 2009; Gemino, 2004). For example, visual (graphically represented) domain ontologies can help users to learn relevant concepts and relationships about the represented domain (Bera et al., 2011). As result of this ontology interpretation, group members develop an individual mental model of the domain represented in the ontology.

The *Individual Ontology Interpretation* phase is important for successful development of SU and CU. SU and CU are group constructs that require a domain understanding (Huber & Lewis, 2010; Ko et al., 2005). According to the definition of these constructs, SU and CU cannot be established if team members do not individually develop an understanding of the domain. Thus, it is important to consider external and internal factors that could affect the ontology interpretation.

As we have explained in our literature review, representation formality, representation quality, visualization approaches, ontology quality, user knowledge, and user experience, among others, could affect ontology interpretation. In this study however, we are not focused on understanding how these factors affect ontology interpretation. Rather, we are focused on understanding how well an ontology can facilitate SU and CU. Previous studies, including Bera et al. (2011) and Burton-Jones et al. (2009), show that a well-represented graphical ontology improves domain understanding to a greater extent than ontologies without graphical representations. Accordingly, our first assumption is that

graphical ontologies will be better at facilitating SU and CU of a domain than textual descriptions of that domain.

3.1.2 No-Group Interaction

The *No-group Interaction* phase occurs immediately after each group member develops a shared understanding of the domain through the use of the ontology but before group members communication between one another. In this phase, we theorize that SU development can be achieved.

In our literature review, we theorized that a common comprehension of a domain can be achieved when an appropriate source of information is provided to group members. We based this assumption on the definition of SU. Shared cognition research defines and measures SU as the similarity among the domain understandings between individual team members (Johnson & O'Connor, 2008; Salas et al., 2008; F. B. Tan & Hunter, 2002). Accordingly, if, through the use of a source of information, group members correctly understand the information, they will have a common comprehension of the domain.

Based on the previous assumption, we theorize that by providing a graphical domain ontology as a source of information to group members, they will develop SU before they communicate with each other. That is, group members will develop an individual mental model of the domain represented in the ontology as a result of the *Individual Ontology Interpretation*. If we compare those mental models in the group once they are formed, we can establish whether SU was developed or not in the group. Thus, if a domain ontology is provided to group members to help understand a domain, they will develop an initial level of SU.

It is important to note that during this phase – different of the previous one – external or internal factors to the ontology do not affect the development of shared understanding because this is just a measure of the mental models achieved during the first phase. Thus, the individual ontology interpretation phase is one of the most important in which to achieve SU.

3.1.3 Team Communication

Finally, during the Team Communication phase, group members must communicate with each other to improve SU and develop CU. However, normal communication will not result in achieving these goals. As we mentioned in the literature review, high quality communication in terms of exchanging information related to the domain is desired (Resnick 1991) – e.g., points of view about the domain (Mathieu et al. 2000; Stein et al. 2011). Literature shows that team communication can be improved when team members have some common knowledge about the discussion topic (Wu and Keysar

2007). Thus, if a domain ontology allows team members to develop some shared understanding about the domain, communication will be improved in that team members will exchange more information about the domain, i.e. a higher communication quality.

Hence, if the exchanged information allows team members to achieve a more similar point of view of the represented domain, SU will be improved. Additionally, if the information exchanged allows team members to understand the other's point of view about the domain, CU will be developed.

3.2 MODEL DEVELOPMENT AND HYPOTHESES

The key purpose of this study is to understand what the effect of a domain ontology as support tool on SU and CU is. Accordingly, we propose a theoretical model that uses the main assumption of domain ontologies following the ontology-usage process described in the previous section.

The model we propose (Figure 3-2) is grounded in theory and literature regarding conceptual modelling, multimedia learning, team communication, and shared cognition, as described later in this section. These theoretical principles lead us to propose that the usage of a domain ontology as an information tool in group teams facilitates SU development (H1) and enhances Communication Quality (H2). The model also proposes that Communication Quality mediates the effect of domain ontology usage on SU (H3 and H4) and CU (H5 and H6). The impact and influence of Communication Quality (CQ) is further described in depth in subsequent sections. In the following subsections, we also provide a more detailed description of our theoretical model and hypotheses.

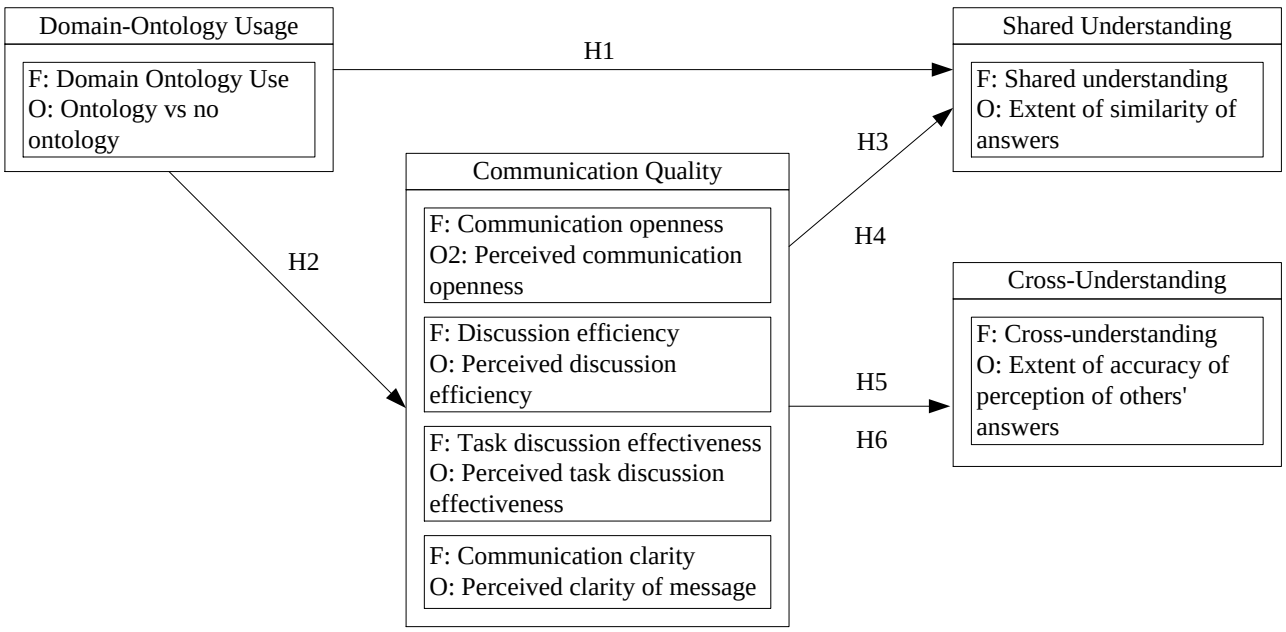

Figure 3-2. Domain-Ontology Usage Effect Model (F: Theoretical factor; O: Operationalization of factor)

3.2.1 Impact of Domain-Ontology Usage on Developed Shared Understanding

In this section, we assert that domain ontology usage will contribute to the development of SU before team members communicate with each other. We further explain our prediction of the effect of the ontology use on SU development through theory of conceptual modelling, shared cognition, and multimedia learning.

As previously established, conceptual models facilitate the development of domain understanding in team members (Bera et al., 2011; Burton-Jones & Meso, 2008). Also, group-level understanding constructs such as SU can be achieved without team interaction by providing similar sources of information to team members (Resnick, 1991). Thus, when the same domain ontology is used as an information tool by team members without interaction, they are likely to gain a similar level of domain understanding, which leads to SU development.

Although other sources of information also might enhance the development of SU, we assert that a graphical domain ontology is more effective than a written description of a domain. We based our prediction on the Multimedia Learning Theory which states that "users understand much better from graphical representations that a set of words" (Mayer, 2009). In this study, we are considering graphical representations of domain ontologies. Specifically, we are using a graphical representation of OWL grammar similarly to a previous study by Bera et al. (2011). We theorize that through the use of a domain ontology rather than a written description of a domain, team members will develop a better understanding of the domain. Through a better understanding of the domain, team members can reduce the likelihood of a differential understanding of the domain and hence gain similar facts about the domain, leading to SU development. Therefore, we propose the following hypothesis:

> *H1. Group members who use a domain ontology develop higher levels of shared understanding than those who do not use a domain ontology.*

As previously discussed, SU is a direct result of the similarity in users' domain understanding. Thus, this study establishes SU through comparing the individual understandings of group members (F. B. Tan & Hunter, 2002), and operationalizes SU through establishing the extent of similarity of answers to comprehension questions between group members.

3.2.2 Impact of Domain-Ontology Usage on Communication Quality

As specified in our domain ontology usage process, group members require good communication to enhance SU and create CU. In this section, we assert that domain ontology usage enhances

Communication Quality (CQ) during team communication. We further explain our prediction based on communication theory and conceptual modelling.

Previous studies of computer mediated communication have defined CQ as an important factor that affects the performance of group members in particular tasks (Kahai & Cooper, 2003; Kayworth & Leidner, 2002; Lowry, Romano, Jenkins, & Guthrie, 2009; O'Reilly & Roberts, 1977). In these studies, CQ is defined in terms of *Communication Openness*, *Discussion Efficiency*, *Task Discussion Effectiveness*, and *Communication Clarity*. Accordingly, we follow previous studies and define CQ using the same lenses. This definition allows us to consider whether relevant information is exchanged between group members during group communication, in addition to allowing us to understand other factors that are relevant to communication and can be affected by the ontology use. *Communication Openness* is defined as "the receptiveness of a group member to the communication of others" (Lowry et al., 2009; O'Reilly & Roberts, 1977). *Discussion Efficiency* reflects the extent to which group members are oriented towards results, the effective use of time in interactions, and how thoroughly issues are discussed (Lowry et al., 2009). *Task Discussion Effectiveness* reflects the extent to which group members participate in the discussion, develop discussion content, exchange information, and examine issues and ideas effectively and critically (Lowry et al., 2009). *Communication Clarity* defines to which extent exchanged messages between group members are clear (Kahai & Cooper, 2003; Kayworth & Leidner, 2002).

Based on these definitions, we predict the effect of domain ontology usage on each of these constructs. Recall that domain ontologies facilitate domain understanding of the represented domain (Burton-Jones et al., 2009; Gemino, 2004). Therefore, by having a good understanding of the domain, group members will likely have more confidence to talk about what they understand about the domain in order to solve a particular issue. This increased confidence implies that *Communication Openness* is enhanced. Group members will also likely be more focused on solving the issue rather than trying to further understand the domain. Similarly, they will likely reduce the time spent on interactions explaining the domain and be more willing to further discuss the problem; consequently, *Discussion Efficiency* is enhanced. Furthermore, group members will likely be more participative because they are confident about what they know of the domain. This will likely lead to group members being more open to develop and discuss content, increase the exchange of ideas about domain issues, examine the issues more effectively and critically; thus enhancing *Task Discussion Effectiveness*. Finally, group members are also likely to convey clearer messages about the domain, improving c*ommunication clarity*.

Accordingly, to enhance Communication Quality, group members must thoroughly understand the domain. Moreover, if group members use a source of information that does not allow them to understand the domain clearly, Communication Quality will be compromised. We thus propose the following hypothesis:

> *H2. Group members who use a domain ontology engage in better communication quality in terms of communication openness, discussion efficiency, task discussion effectiveness, and communication clarity than those who do not use a domain ontology.*

3.2.3 Impact of Communication Quality on Shared Understanding Improvement and Cross-Understanding Development

In this section, we assert that Communication Quality (CQ) enhances SU improvement and CU development. We base our arguments on theory related to team communication and shared cognition.

As per our domain ontology usage process, SU and CU can be developed and improved through good team communication (Mathieu et al., 2000; Resnick, 1991; Stein et al., 2011). Based on communication theory (Kahai & Cooper, 2003; Lowry et al., 2009; O'Reilly & Roberts, 1977), we defined CQ in terms of four dimensions – *Communication Openness, Discussion Efficiency, Task-Discussion Effectiveness,* and *Communication Clarity*. Therefore, SU improvement and CU development are a function of the degree to which users have good communication in terms of these four dimensions.

By having better *CQ,* which is improved by domain ontology usage, first, group members will be more open to exchanging information about the domain; second, have a more efficient discussion about the domain; third, have a more effective discussion of tasks in which they are involved; and communicate more clearly with each other. This leads to the exchange of more precise information about the domain between group members, which can subsequently lead to achieving agreement about the said domain among group members and SU improvement (He et al., 2007; Kacmar, 2003; Kayworth & Leidner, 2002; Ko et al., 2005; Lowry et al., 2009). Additionally, this exchange of information allows group members to understand what other group members know or think about the domain, creating CU.

To summarize, with a higher quality communication enabled by domain ontology usage, users can focus on relevant information represented about the domain and are therefore able to better exchange their beliefs and personal knowledge with one another, thus improving SU and leading to the achievement of CU. Contrarily, during a less effective communication, users are distracted and need

to bring to bear prior knowledge to interpret the representation, the focus of the discussion may be disrupted and lead to a low exchange of information about the domain between users. Thus, we hypothesize:

H3. Group members who use a domain ontology have greater shared understanding improvement than those who do not use a domain ontology.

H4. Communication quality in terms of communication openness, discussion efficiency, task discussion effectiveness, and communication clarity mediates the effect of domain ontology usage on the improvement of share understanding.

H5. Group members who use a domain ontology develop greater cross-understanding than those who do not use a domain ontology.

H6. Communication quality in terms of communication openness, discussion efficiency, task-discussion effectiveness, and communication clarity mediates the effect of domain ontology usage on the development of cross-understanding.

CU can be operationalized in two main ways, *viz*. Perceptual Approach and Behavioral Manifestation Approach (Huber & Lewis, 2010). Nevertheless, each approach has some shortcomings. On the one hand, the Perceptual Approach is easy to execute, but is based on the perception of participants. On the other hand, the Behavioral Manifestation Approach is based on the perception of an external observer and is difficult to implement and quantify in terms of levels of understanding. This study adopts the Perceptual Approach because it is less subjective to code for analysis. Accordingly, we operationalize CU by asking each participant their perception of answers that the other participant will give to comprehension questions.

Details of the measurement instruments used to measure our different operationalized variables will be covered in the next chapter on empirical validation.

3.3 CHAPTER SUMMARY

In this chapter, we developed a theoretical model that allows us to understand our research question. To develop the model, we first described a domain ontology usage process to facilitate shared understanding (SU) and cross-understanding (CU). Based on our usage process, we then developed the theoretical model that describes the effect of domain ontology usage on SU and CU. Specifically, our model describes that *communication quality* (CQ) mediates the effect of domain ontology usage on SU improvement and CU development. Our usage process and theoretical model are supported by

literature and theory related to conceptual modelling, multimedia learning, group communication and shared cognition.

4 EMPIRICAL VALIDATION

To the extent of our knowledge, we believe that our study is the first to test the effect of domain ontology on shared understanding (SU) and cross-understanding (CU) in IS research. Therefore, we selected an experimental design to maximize internal validity (Cook & Campbell, 1979; Trochim & Donnelly, 2008). To extend the external validity of our study, we selected an appropriate domain and thus, domain ontology, to simulate a more practical situation necessary to provide SU and CU. This chapter explains details of the selected domain, the used ontology, and the experimental design used in our study.

4.1 COMPLIANCE MANAGEMENT DOMAIN

Compliance management is defined as "a process of meeting or adhering to the organization's obligations, such as those required by laws, industry and organizational standards and codes, principles of good governance and, accepted community and ethical standards" (Standards Australia, 2006, p. 5). Compliance management has been discussed within academia and industry for two main reasons; the high cost of compliance and the economic impact of non-compliance. Firstly, the operational cost of compliance management is very high. For instance, Protiviti (2012, p. 3) in their report of the Sarbanes-Oxley Compliance Survey found that the expenditures for compliance with this legislation in any size of company is between USD 100,000 to USD 500,000 annually. Secondly, the consequences of failing to align with regulations or standards can be drastic. For example, the Australian company Cotton On Kids was required to pay AUD $1 million for non-compliance with a safety standard (Australasian Compliance Institute, 2013b). Thus, compliance management can cause significant economic issues, making it a relevant issue for both industry and academia.

Significant efforts have been made in academic research for ways to improve compliance management in organizations. Some effort has been focused on the mechanisms of compliance by design, that is, to embed the compliance requirements in business processes (Sadiq & Governatori, 2010; Sadiq, Governatori, & Namiri, 2007). Other researchers paid attention to improving the methods of checking compliance in business process (El Kharbili, 2012; Elgammal, Turetken, Heuvel, & Papazoglou, 2011; Ramezani, Fahland, & Aalst, 2012). Additionally, others emphasized establishing new technologies and prescriptive frameworks to achieve organizational compliance (COMPAS, 2011; Foorthuis & Bos, 2011; Schäfer, Fettke, & Loos, 2012), or focused on both extracting and translating the compliance requirements into process rules (Sapkota, Aldea, Younas, Duce, & Banares-Alcantara, 2012). Finally, some studies have concentrated on developing IT tools

or artefacts that help organizations manage and understand compliance knowledge (Boella, Humphreys, Martin, Rossi, & Torre, 2012; Syed Abdullah et al., 2012b). Despite these efforts, more recent studies show that the maturity level of compliance in organizations is still low (Australasian Compliance Institute, 2013a, p. 7).

Many of the IS tools for compliance management that exist in the market have achieved a high level of maturity in the features offered (Gartner, 2012). However, recent industry surveys show that organizations still do not understand the importance of compliance management. For instance, the Australasian Compliance Institute (2013a, p. 7) concluded that organizations do not understand the real value-add of compliance functions to business operations. Eighty-seven per cent of respondents answered that the level of competency and maturity in proficiency and training needs are at a low level. Similarly, the Open Compliance & Ethics Group (2012) reported that in over 50 per cent of companies surveyed, the activities of compliance did not provide a clear view of compliance effectiveness and performance. Indeed, 45.2 percent of respondents indicated that compliance activities are only integrated for business areas of compliance concern, and 26.9 percent of those indicated that compliance activities are not integrated at all. These numbers show that although many organizations are using different tools that help control compliance, there is still a lack of understanding of how compliance management is related to or impacts the organizations operations, in addition to a lack of common understanding of compliance in general within different functions of the same organization.

In summary, compliance management has been an important topic discussed within academia and industry for three main reasons: high-compliance management cost (Protiviti, 2012), drastic consequences of failing to comply (Australasian Compliance Institute, 2013b), and a weak and conflicting understanding of compliance management concepts in organizations (Australasian Compliance Institute, 2013a; Open Compliance & Ethics Group, 2012). Thus, we conclude that compliance management is a suitable setting in which to study the effectiveness of domain ontology in facilitation of SU and CU.

4.2 THE COMPLIANCE MANAGEMENT ONTOLOGY

4.2.1 Description of the Ontology

The *compliance management ontology* (CoMOn) is an informal ontology developed with the specific purpose to facilitate the development of a shared understanding of compliance management (Syed Abdullah et al., 2013). It was constructed based on a five-step approach composed of: identification of purpose, scope and relevant sources, ontology building, ontology evaluation, ontology refinement,

and ontology documentation (Syed Abdullah et al., 2013). CoMOn uses three kinds of sources: scholarly articles, industry experts, and industry practitioners (Syed Abdullah et al., 2013).

The resulting ontology (CoMOn) is composed of 81 concepts, which have varying relationships among them and are structured into four levels of details (Syed Abdullah, Sadiq, & Indulska, 2012a). Figure 4-1 shows a top-level graphical representation of CoMOn.

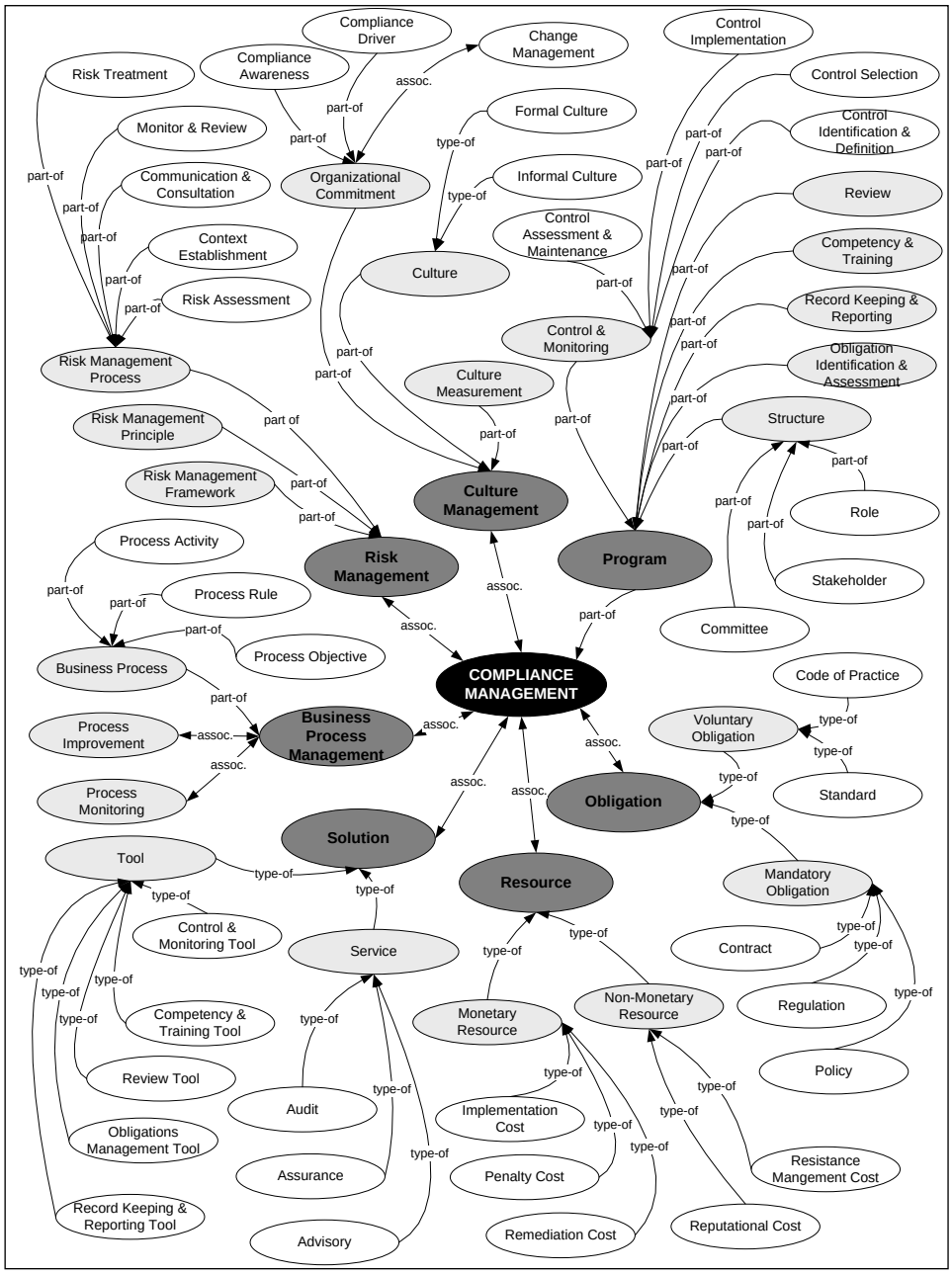

Figure 4-1. Graphical Representation CoMOn (Adapted from Syed Abdullah et al., 2012a)

4.2.2 Quality Evaluation of CoMOn

Although some aspects of CoMOn, such as clarity, interpretability, accuracy, comprehensiveness, and relevance have been evaluated (Syed Abdullah et al. 2013), there are a number of ontology evaluation methodologies that propose additional aspects for evaluation (Delir Haghighi et al. 2012; Sabou and Fernandez 2012; Suárez-Figueroa 2012). To ensure that CoMOn is of a high enough quality for this study, we performed a validation of two additional aspects: coverage of the ontology and completeness of definitions. First, the coverage evaluation allowed us to verify whether all important terms of the relevant domain were incorporated (Delir Haghighi et al. 2012). Even though CoMOn was constructed based on industry reports, industry practitioner input and Australasian and industry standards (Syed Abdullah et al. 2013), the original evaluation did not evaluate the coverage of the ontology. Coverage defines the completeness and coverage of terms and concepts to represent an information domain (Delir Haghighi et al. 2013). Instead the evaluation focused on the quality of concepts and usability of the ontology. Second, the completeness evaluation of definitions allowed us to determine whether the ontology definitions are sufficiently complete to satisfy the requirements for which the ontology was created, that is, to facilitate SU of the compliance management domain (Grüninger and Fox 1995; Yu et al. 2005).

Based on the evaluation approach developed by Delir Haghighi et al. (2012), we evaluated the coverage of the ontology through the use of Leximancer. Coverage is one of the eight evaluation criteria promoted by this approach, namely 1) clarity, 2) consistency/coherence, 3) conciseness, 4) expandability/expandability, 5) correctness, 6) completeness, 7) minimal ontological commitment, and 8) coverage. Accordingly, the sources of data for this evaluation were the Compliance Program Standard and its constituent base of standards. To carry out the evaluation, we considered seven industry standards in addition to the two standards considered during the development of the ontology (See Table 4-1). We did so because CoMOn was developed based on only AS 3806 Compliance Programs and AS/NZS ISO 31000:2009 Risk Management-Principles and Guidelines – see Syed Abdullah et al. (2012b).

The results of content analysis facilitated through Leximancer show that most of the concepts of the 9 standards are included in CoMOn, and those few that are not included are deemed to be not relevant (see Figure 4-2). For example, a relevant term included in CoMOn is “process”. The “process” term is part of the concept of Business Process Management. An example of a term that is not relevant is “form”. Although this term is in the standards, it does not represent an important element in the domain (based on our experience). Thus, we conclude that CoMOn is of high enough quality to be used in our study to investigate the effect of domain ontology on CU and SU.

Table 4-1. Industry Standards for Coverage Evaluation.

Standard Code	Standard Name	Considered During CoMOn Development
AS/NZS ISO 190011:2003	Guidelines for quality and/or environmental management systems auditing	No
AS/NZS 4801:2001	Occupational health and safety management systems	No
AS 8000-2003	Good governance principles	No
AS ISO 10002-2006	Customer satisfaction-guidelines for complaints handling in organizations (ISO 10002:2004, MOD)	No
AS/NZS 14001:2004	Environmental management systems-requirements with guidance for use	No
HB 436:2004	Risk management guidelines. Companion to AS/NZS 4360:2004	No
AS/NZS ISO 31000:2009	Risk Management-Principles and Guidelines	Yes
AS/NZS ISO 9001:2008	Quality Management Systems-Requirements	No
AS 3806-2006	Compliance programs	Yes

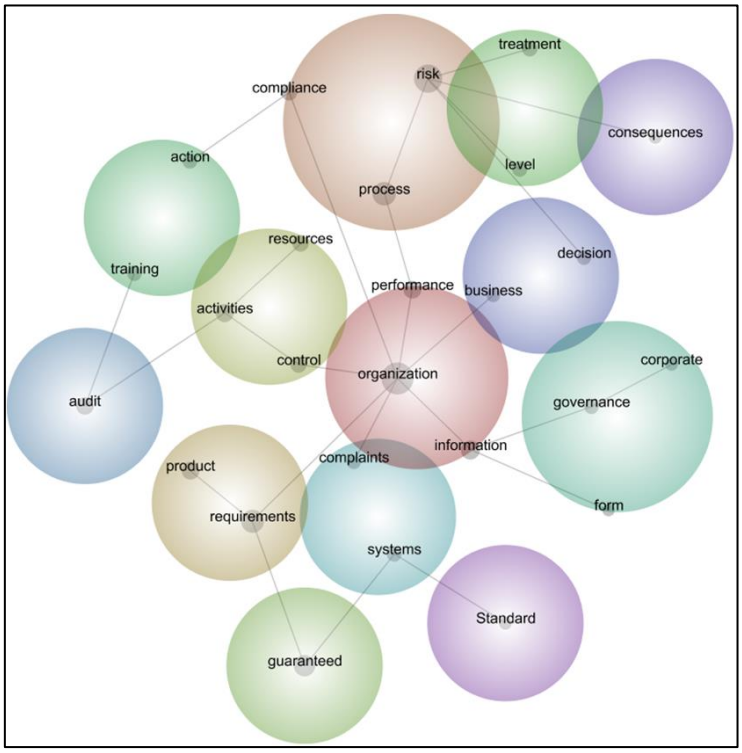

Figure 4-2. Conceptual Map produced by Leximancer

4.3 EXPERIMENTAL DESIGN

Once we had determined a suitable domain ontology to test our hypotheses, we had to establish an appropriate experimental design. We considered a two-group, post-test only, randomized experimental design (Shanks, 2008; Trochim & Donnelly, 2008). Although this design is the simplest design of all experimental designs (Trochim & Donnelly, 2008), it is the most appropriate to determine whether two experimental groups are different. In our theoretical model, we needed to test if a group that used a domain ontology performed differently to one that did not use the ontology.

Accordingly, our treatment group would use CoMOn and our control group would use a portion of the standard ISO 19600:2014 (British Standards Institution, 2014), which provides guidelines for compliance management systems. By using a portion of the standard, we provided more external validity to the experiment design as it is source of information highly used in the industry to achieve compliance. In practice, team members are not able to answer questions or solve a particular problem related to a domain if they do not have a source of information that allows them to first understand the domain (Bera et al., 2011; Burton-Jones & Meso, 2008). More details about the use of CoMOn and the standard are in the subsequent treatment materials section.

Our experiment design has an important novel difference to previous experimental designs in conceptual modelling. Previous studies in conceptual modelling are focused on an individual's domain understanding – procedures and measures and are applied to only one participant e.g. see Vijay Khatri et al. (2006) – whereas our study is focused on group understanding – procedures and measures are applied to groups of two participants. Therefore, in our study, each experiment requires the participation of two-student pairs, as is further described in the measurement and procedure section.

4.4 PARTICIPANTS AND RECRUITMENT PROCESS

In Chapter 3, we mentioned that domain understanding development is important for success in developing SU and CU. When domain ontologies are used to provide domain understanding in group members, such an understanding can be affected by prior knowledge; domain or conceptual modelling (Burton-Jones & Meso, 2008). Specifically, in our study, domain understanding can be affected by either prior compliance management knowledge or the interpretation of conceptual models. In this study, we are interested in users that have zero to low knowledge in both compliance management and conceptual modelling – i.e. novice practitioners. We selected this group of users because the aim of this study is to understand the effect of an ontology on SU and CU. This change in understanding is most important and significant in novice users rather than expert users (Burton-Jones, Clarke, Lazarenko, & Weber, 2012), as aforementioned in section 1.1.

To represent this population of domain ontology users, we chose a student sample. We invited students from a course of database fundamentals offered in the School of Information Technology and Electrical Engineering at the University of Queensland to participate. Students from this course are first-year students from different backgrounds that have a requirement to learn fundamental concepts of relational databases. This cohort of students, who have zero or low level of conceptual modelling and compliance management knowledge helps us to recreate the group of users that we

were targeting. Thus, we believe that our student sample has an acceptable similarity to the target population (Compeau, Marcolin, Kelley, & Higgin, 2012). In fact, previous studies consider that students can be a proxy for novice and junior practitioners if the task is designed properly – i.e. see Burton-Jones and Meso (2008), Bera et al. (2011), Bera et al. (2014), Vijay Khatri et al. (2006). To conclude, we believe that the participants in our study adequately represent novice and practitioners in organizations, which are the target of our research.

Suitable students were invited to participate through an invitation presented at the end of a lecture by the coordinator of the aforementioned course at the beginning of semester 1 2016. Figure A-1 in Appendix A.1 shows the invitation that was presented and distributed among the students. Students who were interested in participating had the option of getting information through a Facebook page or by directly contacting the main researcher. If students decided to participate, they were asked to register in a Doodle[3] poll by providing their name, contact email, and the times when they would be available.

Participants who were willing to participate and had a similar availability were paired randomly and notified by email about their participation. The email contained an appointment which specified the date and time of students' participation (See example on the notification on Figure A-2 in Appendix A.2). The notification also attached a digital copy of the *Participant Information* and *Consent Form* (See Figures in Appendix A.3).

4.5 INTERNAL VALIDITY

Internal Validity is the approximate truth about inferences regarding cause-effect or causal relationships (Trochim & Donnelly, 2008). That is, we have not made internal errors to the design of a research project that might produce false conclusions (Neuman, 2011). There are twelve threats to internal validity that needs to be controlled (Cook & Campbell, 1979; Neuman, 2011). Table 4-2 presents the different internal validity threats, their definitions, and the general controls that we undertook to mitigate such threats. These controls were considered during our experimental design (See section 4.3).

According to Table 4-2, there are 12 likely threats that could impact the internal validity of our experimental design. For each one of these threats we adopted a mitigation strategy to decrease the likely of occurrence of them. To follow we describe these threats and the mitigations adopted:

[3] Doodle is a web tool that facilitates the process of scheduling events: http://doodle.com

Table 4-2. Threats to Internal Validity and their Mitigation (Neuman, 2011)

Threat	Description	Mitigation Measures
1. Selection bias	Experiment has more than one group, which differs or does not differ from equivalent groups.	• Participants were assigned randomly to the control and treatment group.
2. History	An event unrelated to the treatment will occur during the experiment and influence the dependent variable.	• Experimental sessions were short in time (less than 2 hours). No unrelated event was present during each experiment session.
3. Maturation	Result of a threat that a biological, psychological, or emotional process within participants other than the treatment occurs during the experiment and influences the experimental variable.	• Experiments were short in time (less than hours), which decrease the risk of maturation. Also, we considered a control and treatment group, which helped to show similar changes over time.
4. Testing	The effect of a pretest measure in the experiment.	• Our experiment design did not include a pretest.
5. Instrumentation	The instrument or dependent variable measure changes during the experiment.	• Both our instrument and dependent variables did not change during the experiment.
6. Experiment mortality	Some research participants do not continue through the entire experiment.	• Samples in which participants left the experimental session were not considered during the analysis.
7. Statistical regression effect	a) Participants are unusual regarding the dependent variable. b) Measure is such that most people score very high or very low on a variable, random chance alone will produce a change between the pretest and the posttest.	a) Participants had a practice section in the experiment familiarize them with the questions related to the dependent variables. b) Our experiment design did not consider a pretest.
8. Diffusion of treatment or contamination	Participants in different groups will communicate with each other and learn about the other's treatment.	• Each experimental session had a particular schedule. A session included participants from only one group – control group or treatment group.
9. Compensatory behaviour	Something of value is provided to one group of participants but not to other and the difference becomes known.	• Both control group and treatment group received the same economic incentive for their participation.
10. Experimental expectancy	The experimenter indirectly communicates a desired outcome to participants.	• Experimenter involvement during experiments was only to facilitate the experimental session. Experimenter had minimal communication and involvement with participants during the experiment.
11. Demand characteristics	Participants pick up clues about the hypothesis or an experiment's purpose and they modify their behaviors to what they think the research demands of them.	• There were many questions during the experiment, which would had made it difficult for participants to realize our hypothesis.
12. Placebo effect	Some participants receive a placebo, but they respond as if they have received the real treatment.	• We do not used a placebo in our experiment. In fact, participants did not know if they were in a control or treatment group.

1. *Selection bias* threat is the effect produced when an experiment has more than one group, which differ or do not from equivalent groups (Neuman, 2011). To mitigate this threat, participants were assigned randomly to the control and treatment group.

2. *History* threat occurs when an event unrelated to the treatment will occur during the experiment and influence the dependent variable (Neuman, 2011). To avoid this problem, experimental sessions were short in time (less than 2 hours). Also, no unrelated events were present during each experiment session.
3. *Maturation* threat is the result of a threat that a biological, psychological, or emotional process within participants other than the treatment occurs during the experiment and influences the experimental variable (Neuman, 2011). To avoid this problem, experiments were short in time (less than hours), which decreased the risk of maturation. Also, we considered a control and treatment group, which helped to show similar changes over time.
4. *Testing* threat is the effect of a pretest measure in the experiment (Neuman, 2011). To avoid this problem, our experiment design did not include a pretest.
5. *Instrumentation* threat occurs when the instrument or dependent variable measure changes during the experiment (Neuman, 2011). To avoid this problem, both the instrument and dependent variables did not change during the experiment.
6. *Experiment mortality* occurs when some research participants do not continue through the entire experiment (Neuman, 2011). To avoid this threat, samples in which participants left the experimental session were not considered during the analysis.
7. *Statistical regression effect* threat can occur in 2 situations. First, when participants are unusual regarding the dependent variable (Neuman, 2011). It also occurs when measure is such that most people score very high or very low on a variable, random chance alone will produce a change between the pretest and the posttest (Neuman, 2011). To avoid this threat, first, participants had a practice section in the experiment to familiarize themselves with the questions related to the dependent variables. Finally, our experiment design does not consider a pretest.
8. *Diffusion of treatment or contamination* threat occurs when participants in different groups communicate with each other and learn about the other's treatment (Neuman, 2011). To avoid this threat, each experimental session had a particular schedule. Also, an experimental session included participants from only one group – control group or treatment group.
9. *Compensatory behavior* threat occurs when something of value is provided to one group of participants but not to other and the difference becomes known (Neuman, 2011). To avoid this threat, both control group and treatment group received the same economic incentive for their participation.
10. *Experimental expectancy* threat occurs when the experimenter indirectly communicates a desired outcome to participants (Neuman, 2011). To avoid this threat, experimenter involvement during experiments was only to facilitate the experimental session. In fact, the

experimenter only had minimal communication and involvement with participants during the experiment.

11. *Demand characteristics* threat occurs when participants pick up clues about the hypothesis or an experiment's purpose and they modify their behaviors to what they think the research demands of them (Neuman, 2011). To avoid this threat, there was a large set of questions during the experiment, which would had made difficult to participants to determine purpose.
12. *Placebo effect* threat occurs when some participants receive a placebo, but they respond as if they have received the real treatment (Neuman, 2011). To avoid this threat, we do not used a placebo in our experiment. In fact, participants were tested blindly and did not know if they were in a control or treatment group.

4.6 EXTERNAL VALIDITY

External validity is the degree to which the conclusions in a study would hold for other persons in other places and at other times (Trochim & Donnelly, 2008). In experimental research, external validity is concerned with the generalization of the results outside the laboratory. Although experimental research has strong internal validity, it has some limitations in terms of external validity (Trochim & Donnelly, 2008). The following control was undertaken to increase external validity of this study:

1. The participants that we recruited had similar characteristics to our identified requirements i.e. low level of knowledge of the domain and low level of knowledge in conceptual modelling.
2. We selected an appropriate domain and thus, domain ontology, to simulate a more practical situation necessary to provide SU and CU. Specifically, we selected the compliance management domain and CoMOn. Compliance management has been an important topic discussed within academia and industry for three main reasons: high-compliance management cost (Protiviti, 2012), drastic consequences of failing to comply, and a weak and conflicting understanding of compliance management concepts in organizations (Australasian Compliance Institute, 2013a, 2013b; Open Compliance & Ethics Group, 2012). Thus, compliance management is a suitable setting in which to study the effect of domain ontology in facilitation of SU and CU.

4.7 TREATMENT MATERIALS

Recall that our experiment design considers a treatment group (usage of CoMOn) and a control group (usage of ISO 19600:2014 standard). In this section, we provide more details of the materials used during our experiment in each one of these groups.

4.7.1 Treatment Group Materials

The treatment group received a domain ontology (CoMOn) to complete the experimental task. Thus, they were required to be familiar with how to interpret the ontology and how to answer the questions. To make participants familiar with these two issues in the treatment group, we developed a simple practice section before they received CoMOn to complete the experimental task.

We adapted both the materials and questionnaires used by Bera et al. (2011) to develop this practice section. The practice section consisted of a training section and a practice questions section. The training section gave an introduction to the main constructs used to represent CoMOn (See Appendix C.1). To represent the ontology, we used a graphical representation of Web Ontology Language (OWL). OWL is a formal language developed for the semantic web and highly used for the representation of ontologies in general (Bera et al., 2011; Gómez-Pérez et al., 2004). This formal language contains several constructs and some of these constructs (i.e. classes, external properties, and internal properties) can be represented graphically as is the case of the provided visualizations in Protégé, OWLGrEd (Cerans, Liepins, Sprogis, Ovcinnikova, & Barzdins, 2015) or visual ontologies (Bera et al., 2011). We extended upon the study of Bera et al. (2011) in order to understand the effect of graphically-represented ontologies on domain understanding at the group level.

The practice question section consisted of eight questions related to a travel domain (See Appendix C.2), which had to be answered according to information represented in a *travel domain ontology* (See Appendix C.3). The questions included true/false answers and an option “I don’t know” in the case that participants did not know the answer. We implemented this option to check that participants were engaged with the task.

Often, because of the large number of terms and relations involved, ontologies are very large. Thus, if we wanted to use the entire CoMOn ontology in measuring SU and CU, the participants may be subjected to cognitive load, making it difficult to measure the desired variables (D. L. Moody, 2004). Cognitive load refers to the total amount of mental effort being used in the working memory. To avoid this problem, only a subsection of the ontology was used in the experiment. We choose the most representative concepts and relations in order to measure how the knowledge captured in this

ontology can be transferred to the users of the ontology. Also, we only considered concepts and relations that were part of the standard ISO 19600:2014 (British Standards Institution, 2014) used in the control group in order to maintain information equivalence among the materials (Aguirre-Urreta, 2008; Burton-Jones & Meso, 2006; Burton-Jones et al., 2009; Parsons, 2011; Shanks, 2008). Figure 4-3 shows the resulting version of CoMOn that was used during the experiments.

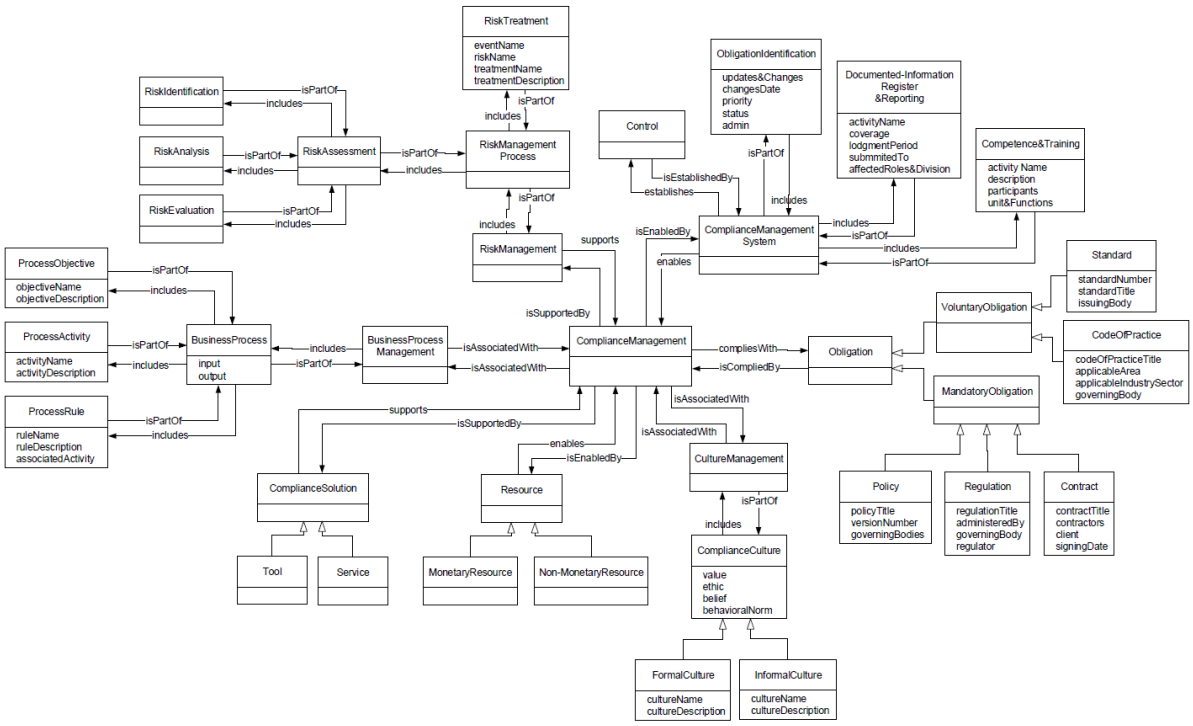

Figure 4-3. Simplified Version of CoMOn

4.7.2 Control Group Materials

Similar to the treatment group, the control group received practice section materials and the final materials necessary to complete the experimental task. Different to the treatment group, the practice section for the control group did not include a training section and only a set of questions were presented. We did so because the control group only received a domain described textually. The practice section consisted of eight questions related to a travel domain (See Appendix C.2), which had to be answered based using the textual description of a travel domain (See Appendix C.4). We adapted both the materials and questionnaires used by Bera et al. (2011) to develop this practice section. Similar to the treatment group, the questions included true/false answers and an option "I don't know" in the case that participants did not know the answer. We implemented this option to check that participants were engaged with the task at hand.

As we mentioned before, we used a simplified version of the ISO 19600:2014 Compliance Management Systems – Guidelines (British Standards Institution, 2014). The simplification was

performed with consideration to two issues. First, the standard is very extensive and we wanted to reduce cognitive load on participants (Sweller, 1988). Secondly, we wanted to maintain information equivalence with the materials used in the treatment group (those using CoMOn) (Aguirre-Urreta, 2008; Burton-Jones & Meso, 2006; Burton-Jones et al., 2009; Parsons, 2011; Shanks, 2008). Table 4-3 shows the sections considered in the resulting simplified version of the standard. For copyright reasons, we have been unable to include a complete copy of the simplified version of the standard.

Table 4-3. Simplified Version of the Standard ISO 19600:2014 Compliance Management Systems – Guidelines

Section	Section Title	Section	Section Title
	Introduction	4.5.2	Maintenance of compliance obligations
3	Terms and definition	4.6	Identification, analysis and evaluation of compliance risks
3.1	Organization	7	Support
3.2	Interested party (preferred term)	7.1	Resources
	Stakeholder (admitted term)	7.2	Competence and training
3.3	Top management	7.2.1	Competence
3.4	Governing body	7.2.2	Training
3.5	Employee	7.3	Awareness
3.6	Compliance function	7.3.1	General
3.7	Management system	7.3.2	Behavior
3.8	Policy	7.5	Documented information
3.9	Objective	7.5.1	General
3.1	Process	7.5.2	Creating and updating
3.11	Risk	7.5.3	Control of documented information
3.12	Compliance risk	8	Operation
3.13	Requirement	8.1	Operational planning and control
3.14	Compliance requirement	8.2	Establishing controls and procedures
3.15	Compliance commitment	8.3	Outsourced processes
3.16	Compliance obligation	9	Performance evaluation
3.17	Compliance	9.1	Monitoring, measurement, analysis and evaluation
3.18	Noncompliance	9.1.1	General
3.19	Compliance culture	9.1.2	Monitoring
3.2	Code	9.1.3	Sources of feedback on compliance performance
3.21	Organizational and industry standards	9.1.4	Methods of information collection
3.22	Regulatory authority	9.1.5	Information analysis and classification
3.23	Competence	9.1.6	Development of indicators
3.24	Documented information	9.1.7	Compliance reporting
3.36	Risk treatment	9.1.8	Content of compliance reports
4.5	Compliance obligations	9.1.9	Record-keeping
4.5.1	Identification of compliance obligations		

4.8 MEASUREMENTS

Most measures that we used to quantify our variables at the individual level were based on existing studies. However, our group level variables, SU and CU, had to be defined after the individual

components were established. Subsequently we describe the different measures used to quantify our dependent and control variables.

4.8.1 Dependent Variables

Based on our theoretical model, there are several dependent variables to be measured: *Shared Understanding Development, Shared Understanding Improvement, Cross-Understanding Development, Communication Openness, Discussion Efficiency, Task Discussion Effectiveness* and *Communication Clarity.*

Recall we defined shared understanding as the extent of common comprehension of a topic among team members (Ko et al., 2005; Mathieu et al., 2000). Therefore, this study establishes SU through comparing the individual understandings of team members (F. B. Tan & Hunter, 2002), and operationalizes SU through establishing the extent of similarity of answers in comprehension questions between team members. Accordingly, to measure SU we developed a set of 14 comprehension questions to evaluate the understanding of the compliance management domain (Shaft & Vessey, 2006; Shanks, 2008), and to allow us to establish the similarity of answers in each group. This set of questions allowed us to measure initial *Shared Understanding Development* i.e. before group members interact with each other during the group task.

To measure *Shared Understanding Improvement*, participants received a re-phrased version of the comprehension questions used to measure *Shared Understanding Development*. We followed this approach to maintain consistency of question complexity. We chose not to use the exact set of question twice because participants may have learnt or memorized the questions. Consequently, participants would be likely to associate the question with a previous one already answered.

The set of questions that we developed were extracted from the domain information represented in CoMOn and the ISO 19600:2014 standard. From such development, the questions are able to be answered by an understanding of the ontology (CoMOn) or the standard (ISO 19600:2014). Also, to ensure that we could rule out potentially conflicting explanations, we asked participants to identify "Which part of the documentation or what information allowed you to come to your answer". Table 4-4 shows the questions used to measure SU development and SU improvement.

To quantify SU, both development and improvement, this study considered the answers of the two participants in each group and uses the following rules to score points in the measure:

- When group members have the same answer, the measure receives a value of "1".
- When group members have a different answer, the measure receives a value of "0".

- When a group member does not know the answer to a question, the measure receives a value of "0".

Table 4-4. Compliance Management Questions to Measure Share Understanding

No	Shared Understanding Development Questions	Improved Shared Understanding Questions
1.	Organizations implement a compliance management system to enable compliance management.	To enable compliance management, organizations implement a compliance management system.
2.	Organizations engage in compliance management to aid risk management.	To aid risk management, organizations engage in compliance management.
3.	Organizations need to provide sufficient resources to enable compliance management.	To enable compliance management, organizations need to provide sufficient resources.
4.	Organizations engage in compliance management to ensure they comply with obligations.	To ensure organizations comply with obligations, they engage in compliance management.
5.	A compliance requirement (or mandatory obligation) of an organization is an example of an obligation type.	An example of an obligation type is a compliance requirement (or mandatory requirement).
6.	A compliance commitment (or voluntary obligation) of an organization is an example of an obligation type.	An example of an obligation type is a compliance commitment (or voluntary obligation).
7.	Organizations should identify, analyze and evaluate risks to perform a risk assessment.	To perform a risk assessment, organizations should identify, analyze and evaluate risks.
8.	Monetary resources (or financial resources) and human resources (non-monetary resources) are required for compliance management in organizations.	Compliance management in organizations requires monetary resources (or financial resources) and human resources (non-monetary resources).
9.	Organizations through their compliance management systems ensure the competency and training of organization staff.	The competency and training of employees are ensured by the organization through their compliance management systems.
10.	Compliance management systems register and report documented information of organizations.	Documented information of organizations is registered and reported by compliance management systems.
11.	Compliance management systems establish all controls necessary to check compliance in organizations.	To check compliance in organizations, compliance management systems establish all the necessary controls.
12.	A process (or business process) has related risks.	A process (or business process) includes related risks.
13.	The compliance culture of an organization specifies behavioral norms.	The compliance culture of an organization describes behavioral norms.
14.	The treatment of a risk does not include a description of the applied treatment nor the risk.	The treatment of a risk does not consider a description of the applied treatment nor the risk.

Cross-understanding is defined as "the extent to which group members have an accurate understanding of another's mental model" (Huber & Lewis, 2010, p. 7). Accordingly, to measure CU development, we asked each participant their perception of answers that the other participant will give to the comprehension questions. The accuracy of those perceptions was then evaluated to establish CU. Table 4-5 shows the additional question that we added to each part in the second set of comprehension questions to help evaluate CU.

To quantify CU, this study considered the answers of the two participants in each group and used the following rules to score points in the measure:

- When a team member correctly recognizes the answer of the other team member, the question receives a value of "1". In this category, we also include the occurrence of one participant correctly answering that other person does not know the answer to a particular question.
- When a team member incorrectly recognizes the answer of the other team member, the question receives a value of "0".
- When a team member does not know what the other would respond, the measure receives a value of "0".

Table 4-5. Additional Question to Measure Cross-Understanding Development

Question Statement	What do you think would be the answer of your partner?
Possible Answers	My partner would answer "True" My partner would answer "False" My partner wouldn't know the answer I don't know what my partner would answer

Recall *Communication Openness* is defined as the receptiveness of a group member to the communication of others (Lowry et al., 2009; O'Reilly & Roberts, 1977). Therefore, we adapted the measurement developed by Lowry et al. (2009) to measure this dependent variable. We re-stated questions 1 and 3 from Lowry et al. (2009)'s instrument in such a way that these questions make reference to a group of 2 people rather than larger groups. We did not consider question 5 from the original instrument because the communication was one-to-one instead of through a computer mediated communication (CMC). Table 4-6 shows our resulting measurement instrument for *Communication Openness*. Each question in the instrument was quantified using a seven-point Likert scale.

Table 4-6. Communication Openness Measurement Instrument

Question Statement
It was easy to communicate openly with my partner.
Communication in this group was very open.
When we communicated with each other in this group, there was a great deal of understanding.
It was easy to ask advice from my partner.

Recall that *Discussion Efficiency* reflects to what extent group members are oriented towards results, the effective use of time on interactions, and how thoroughly the issues are discussed (Lowry et al., 2009). We used the similar reflective measurement used in the studies of Lowry et al. (2009) and Davison (1997) to measure *Discussion Efficiency.* Table 4-7 shows the resulting measurement instrument for *Discussion Efficiency*. Each question in the instrument was quantified using a seven-point Likert scale.

Table 4-7. Discussion Efficiency Measurement Instrument

Question Statement
To what extent would you agree that this group discussion was result oriented?
The time spent in the group discussion was efficiently used.
Issues raised in the group interaction were discussed thoroughly.

Task Discussion Effectiveness reflects to what extent group members participate in the discussion, develop discussion content, exchange information, and examine issues and ideas effectively and critically (Lowry et al., 2009). We modified slightly the formative measure used by Lowry et al. (2009) in order to make the questions clearer to the reader. Table 4-8 shows our resulting measurement instrument for *Task Discussion Effectiveness.* Similar to *Discussion Efficiency*, each question in the instrument was quantified using a seven-point Likert scale.

Table 4-8. Task Discussion Effectiveness Measurement Instrument

Question Statement
The discussions were effective.
The context of the discussions was carefully developed.
Issues were not examined effectively (reverse coded).
Participation in the discussions was consistently distributed.
Ideas in the discussions were critically examined.
The amount of information exchanged was sufficient.

Communication Clarity defines to what extent exchanged messages between group members are clear (Kahai & Cooper, 2003; Kayworth & Leidner, 2002). We adapted the reflective measurement used by Kahai and Cooper (2003) in order to make the questions clearer to the reader. Table 4-9 shows our resulting measurement instrument for Communication Clarity. Again, each question in the instrument was quantified using a seven-point Likert scale.

Table 4-9. Communication Clarity Measurement Instrument

Question Statement
How clear were the messages of your partner?
How often were the messages of your partner unclear?

4.8.2 Control Variables

Our study includes a number of control variables for two main purposes. First, to check that our groups are formed homogenously, we obtained data on several control variables: *participant age, participant gender, type of student, area of study, year of study in current degree,* and *native language.* These variables were measured through multiple choice questions and is not able to be used to identify any specific participants. Table 4-10 shows the questions used to measure these variables.

Finally, to provide additional evidence that differences between groups stemmed from our treatment rather than from confounding factors (Bera et al., 2011), we obtained additional data on prior

conceptual modelling knowledge, and *compliance management knowledge*. Prior knowledge is used as a control variable because participants might try to use their prior knowledge to perform the task rather than using the provided information (Bera et al., 2011). Also, we considered these control variables because we wanted to check that our participants match those required in our experimental design; i.e. participants with a low level of compliance management and conceptual modelling. To measure *conceptual modelling knowledge*, we adapted the measurement instrument used by Bera et al. (2011) (See Table 4-11). *Conceptual modelling knowledge* was quantified using a seven-point Likert scale. To measure *compliance management knowledge*, we expanded the measurement instrument used by Bera et al. (2011) in order to ask more specific questions related to the compliance management domain (See Table 4-12). Similarly, each question in the instruments was quantified using a seven-point Likert scale.

Table 4-10. Control Variables to Check Homogeneity of Groups

	Possible Answers
Participant age	16 – 24 25 – 35 Above 35
Participant gender	Male Female
Type of student	Undergraduate Coursework postgraduate Research postgraduate
Area of study	Agribusiness, Agriculture, Environment and Science Business, Economics and Law Engineering, Architecture and Planning, and Information Technology, Health Humanities, Education, Psychology and Music
Year of study in current degree	First year Second year Third year Fourth year Fifth year
Native language	English Other

Table 4-11. Conceptual Modelling Knowledge Measurement Instrument

Question Statement
What is the extent of your knowledge of data modelling concepts such as entities, classes, relationships, and properties?
Over the last two years, to what extent do you have experience in using data modelling concepts such as entities, classes, relationships, and properties?

Table 4-12. Compliance Management Knowledge Measurement Instrument

Question Statement
What is the extent of your knowledge in compliance management concepts?
Over the last two years, to what extent do you have experience with applying compliance management concepts?
What is the extent of your knowledge of risk management concepts?
Over the last two years, to what extent do you have experience with applying risk management concepts?
What is the extent of your knowledge of Business Process Management concepts?
Over the last two years, to what extent do you have experience with applying Business Process Management concepts?

4.8.3 Construct Validity

Construct validity refers to the degree to which inferences can legitimately be made from the operationalizations in a study to the theoretical constructs on which those operationalizations were based (Trochim & Donnelly, 2008). Moreover, construct validity refers to generalizing from our measures to the concept of our measures (Trochim & Donnelly, 2008). Table 4-13 presents the threats to construct validity, their description and summarizes the mitigation measures that we undertook to prevent or reduce such threats.

Table 4-13. Threats to Construct Validity and Their Mitigation (Trochim & Donnelly, 2008)

	Threats	Description	Mitigation
1.	Inadequate preoperational explication of constructs	Inadequate operational definition of the construct.	• We defined and operationalized all the latent constructs precisely – i.e. SU, CU, communication openness, discussion efficiency, task discussion effectiveness, communication clarity – including the specificity, nature, and the measurement scale of the constructs.
2.	Mono-operation bias	Using a single version of a treatment in a single place at a single point in time.	• We used two treatments: a control group and a treatment group.
3.	Mono-method bias	Bias produced by measures or observations.	• We implemented multiple measures of our constructs. Also, our pilot tests showed that measures we used behaved as we theoretically expect them to.
4.	Interaction of testing and treatment	Testing or measurement itself make the groups more sensitive or receptive to the treatment.	• We had a control group and treatment group to reduce this threat. If there is such effect, both groups will be affected.
5.	Restricted generalizability across constructs	It occurs when observed effects (treatment X is effective) are generalized to other outcomes. Some negative outcomes could not be anticipated.	• We did not generalize our results further than the definition of our constructs.
6.	Construct confounding and levels of constructs	The proposed construct does not represent the intended construct.	• Communication quality constructs were adopted from prior studies. • SU and CU are based on comprehension questions. This measurement instrument is commonly used in previous studies to measure understanding. • Statistical analysis was conducted to examine whether the latent constructs achieve an adequate level of validity and reliability.

According to Table 4-13, there are 6 likely threats that could impact the construct validity of our experimental design. For each one of these threats we adopted a particular strategy to decrease the likely of occurrence of them. To follow we describe these threats and the mitigations adopted:

1. *Inadequate preoperational explication of constructs* threat occurs by an inadequate operational definition of the construct (Trochim & Donnelly, 2008). To avoid this threat, we defined and operationalized all the latent constructs precisely – i.e. SU, CU, communication

openness, discussion efficiency, task discussion effectiveness, communication clarity – including the specificity, nature, and the measurement scale of the constructs.

2. *Mono-operation bias* threat occurs for using a single version of a treatment in a single place at a single point in time (Trochim & Donnelly, 2008). To avoid this threat, we used two treatments: a control group and a treatment group.
3. *Mono-method bias* threat is produced by measures or observations. To avoid this threat, we implemented multiple measures of our constructs (Trochim & Donnelly, 2008). Also, our pilot studies showed that the measures we used behaved as we theoretically expect them to.
4. *Interaction of testing and treatment* threat occurs by testing or measurement itself making the groups more sensitive or receptive to the treatment (Trochim & Donnelly, 2008). To avoid this threat, we had a control group and treatment group. If there is such effect, both groups will be affected.
5. *Restricted generalizability across constructs* threat occurs when observed effects (treatment X is effective) are generalized to other outcomes; hence some negative outcomes could not be anticipated (Trochim & Donnelly, 2008). To avoid this threat, we did not generalize our results further than the definition of our constructs.
6. *Construct confounding and levels of constructs* threat occurs when the proposed construct does not represent the intended construct (Trochim & Donnelly, 2008). To avoid this threat, *communication quality* constructs were adopted from prior studies. Also, SU and CU are based on comprehension questions. This measurement instrument is commonly used in previous studies to measure understanding. Additionally, a statistical analysis was conducted to examine whether the latent constructs achieved an adequate level of validity and reliability.

4.9 PROCEDURES

The different experimental sessions were conducted in a quiet computer lab in the School of Information and Electrical Engineering. We used a computer lab because our experimental materials and measurement instrument were implemented using Qualtrics application software[4] (Appendix D shows print screens of the data collection instrument that we used). Accordingly, this software allows us to collect and store the data more easily compared to collection using physical documents. Also, it is important to mention that the computers we used had 21-inch screens to facilitate adequate visualization for participants.

[4] Qualtrics is a web-based research application that allows users to design online surveys and experiments: https://www.qualtrics.com

Before the experiment began, the moderator asked participants to read the participation information sheet, and sign the consent form (to confirm willingness to participate) (See Appendix A.2). All the participants that attended the scheduled experiments signed the consent form without any hesitation. Once participants signed the consent form, the moderator provided a brief explanation of how the experiment is performed – this information was also provided on the participation information sheet. Then, unbeknownst to the participants the moderator assigned both to either the control or both to the treatment group, and allowed participants o access Qualtrics.

The experiment included five stages, namely *Control Variables, Training, Individual Task, Group Task, and Final Individual Task* (see Figure 4-4). First, during the *Demographic Data Collection*, participants had to answer a set of questions to measure the control variables described in the previous section.

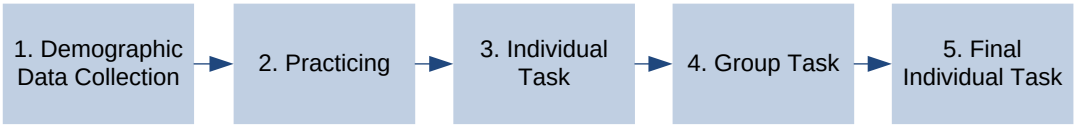

Figure 4-4. Experiment Stages

In the second stage (Figure 4-5), *Practicing*, participants had a simple practice activity to familiarize themselves with the types of questions they had to answer later. We adapted both the materials and questionnaires used by Bera et al. (2011) to develop this practicing section. However, procedures were a little different for each treatment group. In the treatment group, participants had access to a training section that allowed them to understand the graphical representation of ontologies (See Appendix C.1). Then, participants received a travel domain ontology (See Appendix C.3) to facilitate the answering of the practice questions (See Appendix C.2). On the other hand, in the control group, participants did not have access to the training section. Participants received a textual description of the travel domain (See Appendix C.4) to facilitate the answering of the practice questions (See Appendix C.2). Appendix D.1 and D.2 show the data collection instruments used in the treatment group and control group respectively.

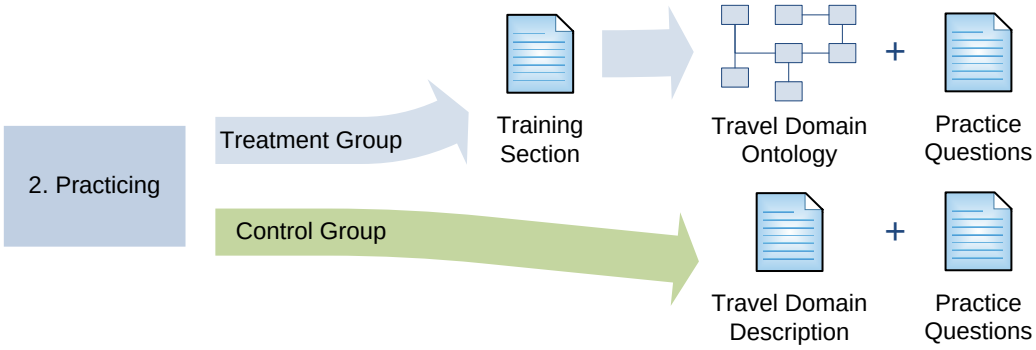

Figure 4-5. Practicing Stage

In the third stage (Figure 4-6), *Individual Task*, procedures for the treatment group and control group were the same, but each group received different materials. In the treatment group, participants received a digital and physical copy of the graphical representation of CoMOn. On the other hand, in the control group, participants received a digital and physical copy of the simplified version of the standard ISO 19600:2014. The hard copy was supplied to make it easier for the participant to refer back to the provided information. Then, participants in both the treatment and control group, were quizzed on their domain understanding through a set of questions defined in the section 4.6.1. All the questions were managed through Qualtrics. Appendix D.1 and D.2 show the data collection instruments used in the treatment group and control group respectively.

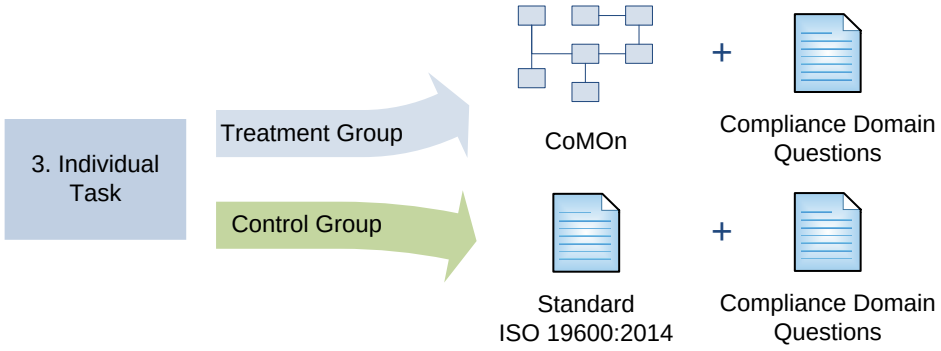

Figure 4-6. Individual Task Stage

In the fourth stage, *Group Task*, participants were asked to collaborate with their partner to perform a group task. As with the individual questions, the treatment group had the use of the ontology as a tool to aid their task progression, whilst the control group only had the standard of compliance management systems. The discussion process was audio recorded with permission for further analysis in the future. We designed a group task that allowed participants to maximize the exchange of information. As previously mentioned, in order to enhance group understanding constructs, it is necessary to improve the exchange of valuable information (Mathieu et al., 2000; Resnick, 1991; Stein et al., 2011). Therefore, we adapted our group task to suit the *MindMerger* process to improve this exchange of information between team members. The *MindMerger* process is a collaborative process that helps individuals in teams to develop SU (Bittner & Leimeister, 2014). Accordingly, during the group task, participants had to initially solve the problem individually using a source of information (the ontology or the simplified ISO 19600:2014 standard) and then they showed their partner their answers. During this process, participants had to see if there was any disagreement and discuss the disagreement in order to achieve an agreement. Appendix C.5 shows the instruction used during the group task. The information collected in this task was not formally measured or considered in our final variables; however, it will be used for future research.

In the final stage, *Final Individual Task*, participants were quizzed again, but this time questions about their partner's perception of the problem and solution were added. As with the individual questions, the treatment group had the use of the ontology as a tool to aid their task progression, whilst the control group only had the simplified standard of compliance management systems. The purpose of this approach is to gauge the participant's perception of the task from their own and from their partner's point of view to measure SU improvement and CU.

The required time for the whole experimental session was around 1.5 hours. At the end of the session each participant received AUD 50 in exchange for their participation.

4.10 ETHICAL CLEARANCE

This study includes human behavior as data to assess our theoretical model and our hypotheses. Most of the instrumental measures that we used considered self-reported measures. For example, questions related to what participants understand about compliance management (domain understanding) or the perceptions that participants have with regards to the understanding of other participants (CU) are associated with human behavior. Therefore, our study requires a risk and ethical assessment before any data collection is performed (Saunders, Lewis, & Thornhill, 2009). Additionally, ethical clearance is required to ensure our study complies with the University of Queensland's Ethical Conduct guidelines, including the characteristics of the required participants, experimental procedures, and data management.

Prior to conducting any data collection, including the pilot tests and main test, this study complied with the ethical guidelines of the University of Queensland. Ethical clearance was assessed and approved by the Ethical Committee of the School of Information Technology and Electrical Engineering on 26/08/2014. This ethical clearance was amended on 24/07/2015 and on 01/03/2016 to include some changes in recruitment process (See Appendix B to see the different approvals). We also had to increase the participation incentives to gain more participants.

Our study poses no feasible risk, and no risk that would exceed that which people experience as part of everyday life. Once participants read the study information sheet and agreed to participate, they had to sign the provided consent form before the experiment began. Participants, as noted in the information sheet, may withdraw at any time from the experiment without any consequence. Data was anonymously collected and the unidentified data can only be accessed by the research team. Any personal data relative to participants in this study is not disclosed in or relevant to the results of the study.

4.11 PILOT STUDIES

Prior to conducting the experiment, we conducted 4 pilots to test our experimental procedure, materials, required time for the experiment, and results on the dependent variables. In the first pilot, we recruited a sample of 10 undergraduate and postgraduate university students from a course of database fundamental offered in the School of Information Technology and Electrical Engineering at the University of Queensland. Participants were distributed in two different treatment groups. Each treatment evaluated a different representation of CoMOn, i.e. high quality representation and low quality representation. One group had 3 pairs of participants and the other group had 2 pairs of participants. We proceeded in this way because in the early stages of this research, we also wanted to explore the influence that representation quality has on SU and CU. This pilot specifically helped us to analyze the comprehension questions that we developed to test the understanding of the compliance management domain. Similarly, the pilot helped as to test our experimental procedures. As one of the results of this pilot, we noticed that our initial interaction procedure did not work at all. Thus, we needed to improve this procedure.

The second pilot allowed us to test a new set of questions and a new experimental procedure on the group task. For this pilot, we recruited 10 participants distributed randomly: 2 pair of participants for control group and 3 pairs of participants for the treatment group. Participants were also students from a course of database fundamental offered in the School of Information Technology and Electrical Engineering at the University of Queensland. The results of this pilot allow us to improve the quality of the experimental procedure and the group task. However, at this stage we decided not to analyze the effect of representation quality on SU and CU. We had to leave this analysis for future research because of time restrictions.

The third pilot that we ran, allowed us to test our new control group. We recruited 4 pairs of people: 2 pairs for the control group and 2 pairs for the treatment group. Participants were also students from a course of database fundamental offered in the School of Information Technology and Electrical Engineering at the University of Queensland. The results of this experiment allowed us to confirm that the control group had a good design. Also, we observed the main differences among the scores of the different variables between the control and the treatment, which showed good treatment manipulation.

On the fourth pilot, we only recruited 2 pair of people: one pair for the treatment and one pair for the control. The objective of this pilot was to evaluate whether written or verbalized responses are more appropriate to collect qualitative data regarding comprehension questions. We could observe that verbalization was very difficult to transcribed because not all participants had English as their first language. Thus, we decided only to consider the written responses.

At the end of the four pilots, we tuned our experimental design and procedures to the final ones.

4.12 CHAPTER SUMMARY

In this chapter, we explained the details of our research design used to address our research questions and to test our proposed hypotheses. To achieve this, first, we introduced and justified the use of the compliance management domain in our study. Secondly, we provided details of the ontology of the compliance management domain used during the experiments and its respective evaluation to guarantee its eligibility. Thirdly, we provided details and justification of the experimental design that were used in this study. Then, we specified the participants considered for the experiment and how they were recruited. After that, we detailed the different treatment materials that were used during the experiment. Once we defined our experimental settings, we provided details of the measurement instruments to measure dependent and control variables, and we explained how the experiment was performed. Finally, we provided details of the ethical clearances that were required before our study was conducted.

5 ANALYSIS OF RESULTS

In this chapter, we present the analysis of the results of the hypothesis testing. Accordingly, we perform a data screening of our results, we analyze the reliability of the measures, we test our hypotheses and discuss the results. Finally, we present an analysis of conclusion validity.

5.1 DATA SCREENING

Once we fine-tuned our experimental design, materials, and procedures, we performed our final data collection. For our final experiment, we recruited 39 participants. All the participants were paired before the experiment with the exception of our first participant, whose assigned partner did not arrive. Consequently, 19 groups were formed and tested. Assignment of participants to the treatment and control group was performed randomly based on availability the participants provided during the study recruitment process. Accordingly, we had eight pairs of participants in the control group and ten pairs of participants in the treatment group.

In addition to the one excluded participant we had to exclude data from a further two groups from the study. They were excluded for the following reasons; participants being unable to complete the task within the allocated time, lack of adherence to the designed tasks, and working individually rather than collaborating on the group tasks. Therefore, at the end of the experiments, we took into account data from 16 groups (8 for control and 8 for treatment), totaling 32 participant samples.

Before we tested our hypotheses, we checked that our data complied with the assumptions required to perform independent-sample t-test and linear regression analyses. This included checking for existence of outliers, normality, and linearity. First, we checked that our data did not have any significant outliers. We proceeded in this way because our sample is small and outliers may have affected our results in the independent-sample t-tests. Figure E-1 in Appendix E, shows the results of our outlier analysis. According to the results, there are two outliers in the scores of *Developed Shared Understanding* belonging to the treatment group. As we can observe on the boxplot of *Developed Shared Understanding*, those outliers are more than 1.5 box-lengths away from the edge of their box. Thus, we proceeded to eliminate those samples to avoid influences in our results. Therefore, our resulting data was 30 samples, 16 samples for no ontology use and 14 for ontology use.

Our second check was normality or normal distribution of the data. To check normality, we conducted a Shapiro-Wilk test (see Table F-1 in Appendix F). According to the results of the Shapiro-Wilk's test (Table E-1), *Communication Openness*, *Discussion Efficiency*, *Task Discussion Effectiveness* and

Communication Clarity were normally distributed for both non-ontology usage and ontology usage ($p > 0.05$). Contrarily, D*eveloped Shared Understanding*, *Improved Shared Understanding*, and *Developed Cross-Understanding* were not normally distributed in some of the experimental treatments. To determine if we still can consider this data without any normalization procedures, we analyzed the skewness and kurtosis of the data. We chose to further examine the skewness and kurtosis of the data as the data did not have scores close to zero, which could affect normality, and because the data may still be valid if the skewness and kurtosis is acceptable (Hayes, 2013). Table F-2 on Appendix F shows the results of the Z-scores for skewness and kurtosis. According to the data presented in Table E-2, all the dependent variables can be considered to be normally distributed for non-ontology and ontology groups (Z-scores were inside the range of - 2.58 to 2.58).

Finally, we performed a linearity check on our data. One of the requirements of linear regression is the existence of a linear relationship between the dependent and independent variable. To check this assumption, we visually inspected a scatterplot of the dependent variable plotted against the independent variable to see if a linear relationship exists. The scatterplots of the dependent variables used in this study are shown on Appendix E.2 and appear to meet the requirements for linearity.

After we verified that our data met the basic assumptions for our planned statistical tests, we collated our results. Table 5-1 presents the descriptive statistics for our control variables. According to Table 5-1, in terms of *age*, the control group (non-ontology use) had 12 participants with an age from 16 to 24 years old, and 4 participants with an age from 25 to 35 years old. While the treatment group had 13 participants with an age from 16 to 24 years old, and 1 participant with an age from 25 to 35 years old. Thus, both the control group and treatment group were homogenous in terms of *age*.

In terms of *gender* of participants, Table 5-1 shows that the control group had 10 male participants and 6 female participants. While the treatment group had 8 male participants and 6 female participants. Thus, both the control group and the treatment group were homogenous in terms of *participant gender* of participants.

In terms of *type of study* of participants, Table 5-1 shows that most participants were undergraduate students with 10 participants in the control group and 11 participants in the treatment group. The rest of participants were coursework postgraduate students: 6 participants for the control group and 3 participants for the treatment group. Thus, both the control group and the treatment group were homogenous in terms of *type of study* of participants.

Table 5-1. Descriptive Statistics for the Control Variables

		Non-ontology Usage			Ontology Usage		
	Scale	N	Mean	Std. Dev	N	Mean	Std. Dev.
Age	1 (16 – 24)	12	1.25	0.45	13	1.07	0.27
	2 (25 – 35)	4			1		
	3 (Above 35)	0			0		
Gender	1 (Male)	10	1.38	0.5	8	1.43	0.51
	2 (Female)	6			6		
Type of Study	1 (Undergraduate)	10	1.38	0.5	11	1.21	0.43
	2 (Coursework postgraduate)	6			3		
	3 (Research postgraduate)	0			0		
Area of Study	1 (Agribusiness, Agriculture, Environment and Science)	4	2.56	1.09	4	2.43	1.02
	2 (Business, Economics and Law)	1			1		
	3 (Engineering, Architecture and Planning, and Information Technology)	10			8		
	4 (Health)	0			1		
	5 (Humanities, Education, Psychology and Music)	1			0		
Year of Study	1 (First year)	14	1.13	0.34	12	1.43	1.16
	2 (Second year)	2			0		
	3 (Third year)	0			1		
	4 (Fourth year)	0			0		
	5 (Fifth year)	0			1		
Native Language	1 (English)	8	1.5	0.52	9	1.36	0.5
	2 (Other)	8			5		
Conceptual Model Knowledge	1 – 7		2.59	0.84		3.32	0.91
Compliance Management Knowledge	1 – 7		2.48	1.15		2.32	0.91

In terms of *area of study* of participants, Table 5-1 shows that most of the students were enrolled in the *Engineering, Architecture and Planning, and Information Technology* faculty. Specifically, 10 students were allocated in the control group and eight students were allocated in the treatment group. From the faculty of *Agribusiness, Agriculture, Environment and Science,* we had 4 students for both the control and the treatment group. We also had one student from the Business, Economics and Law faculty in the control group and one in the treatment group. Finally, we had one participant from the *Health* faculty for the treatment group. Thus, both the control group and the treatment group were homogenous in terms of *area of study* of participants.

In terms of *year of study* of participants, most participants were first year students. Fourteen participants were for the control group and 12 participants were for the treatment group. A group of two participants (second year) were part of the control group. While for the treatment group, we had

one participant in the third year and one participant in the fifth year. Thus, both the control group and the treatment group were homogenous in terms of *years of study* of participants.

In terms of *conceptual model knowledge* of participants, Table 5-1 shows that both the control group and the treatment group had similar means, 2.59 and 3.32 respectively. This knowledge was measured in a scale from 1 to 7. Thus, both the control group and the treatment group were homogenous in terms of *conceptual model knowledge* of participants.

In terms of *compliance management knowledge* of participants, Table 5-1 shows that both the control group and the treatment group had similar means, 2.48 and 2.32 respectively. This knowledge was measured in a scale from 1 to 7. Thus, both the control group and the treatment group were homogenous in their *compliance management knowledge*.

In summary, according to Table 5-1, scores for each of the control variables do not vary substantially between the experimental groups. This suggests that our randomization was effective and both groups are homogenous. In other words, we have similar groups for both experimental groups.

Table 5-2 presents the descriptive statistics for dependent variables. According to Table 5-2, means and scores for each of the dependent variables vary substantially between the experimental groups. Moreover, we see better results in the treatment group (ontology usage) than the control group (non-ontology usage). For example, the means for *developed shared understanding* for the control group and treatment group were 6.63 and 9.57 respectively on a scale from 0 to 14. The means for *improved shared understanding* for the control group and treatment group were 8.13 and 12 respectively on a scale from 0 to 14. The means for *developed cross-understanding* for the control group and treatment group were 7.94 and 10.64 respectively on a scale from 0 to 14. Also, the means for *communication openness* were 4.88 and 5.43 for the control group and the treatment group respectively on a scale from 1 to 7. For *discussion efficiency*, the means were 4.58 and 5.48 for the control group and treatment group respectively on a scale from 1 to 7. Similarly, the means for *communication clarity* were 4.88 and 5.71 on a scale from 1 to 7. For *task discussion effectiveness*, the means were 4.31 and 5.04 for the control group and treatment group respectively on a scale from 1 to 7. Similarly, the means for communication clarity were 4.88 and 5.71 on a scale from 1 to 7. Finally, for shared understanding improvement, the means were 1.50 and 2.43 for the control group and treatment group respectively on a scale from 1 to 7.

In summary, considering that the control variable scores do not vary substantially (See Table 5-1), but the dependent variables do (See Table 5-2), we can preliminarily consider that manipulation of

the ontology use was successful. Also, means in the treatment group were higher than means in the control group, which is at least partly in line with our hypothesis.

Table 5-2. Descriptive Statistics for the Dependent Variables

		Non-Ontology Usage		Ontology Usage	
	Scale	Mean	Std. Dev	Mean	Std. Dev
Developed Shared Understanding	0 – 14	6.63	3.42	9.57	1.65
Improved Shared Understanding	0 – 14	8.13	2.99	12.00	1.36
Developed Cross-Understanding	0 – 14	7.94	3.43	10.64	2.21
Communication Openness	1 – 7	4.88	1.06	5.43	1.13
Discussion Efficiency	1 – 7	4.58	1.05	5.48	1.17
Task Discussion Effectiveness	1 – 7	4.31	1.12	5.04	1.17
Communication Clarity	1 – 7	4.88	0.94	5.71	1.09
Shared Understanding Improvement	0 – 14	1.50	1.93	2.43	1.65

Table 5-3 presents our correlation matrix. There are some important points to note in this table. First, *Developed Shared Understanding*, *Developed Cross-Understanding*, *Discussion Efficiency*, and *Communication Clarity* are correlated significantly with the *Domain-Ontology Usage*, as per our predictions. However, we can see that *Shared Understanding Improvement, Communication Openness* and *Task Discussion Effectiveness* are not correlated significantly with the *Domain-Ontology Usage*, contrary to our predictions. Finally, we also note that *Shared Understanding Improvement* is correlated with most of the Communication Quality factors with exception of *Communication Clarity*; and *Developed Cross-Understanding* is correlated significantly with all the Communication Quality factors. This also is at least partly in line with our hypotheses. We examine these results further below.

Table 5-3. Constructs Correlations

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Domain Ontology Usage	1																
2	Age	-0.24	1															
3	Gender	0.05	0	1														
4	Type of Study	-0.17	**0.49****	0.06	1													
5	Area of Study	-0.07	-0.22	0.13	-0.25	1												
6	Year of Study	0.19	-0.15	-0.02	-0.13	-0.2	1											
7	Native Language	-0.14	-0.03	0.11	**0.46***	0.16	-0.04	1										
8	Conceptual Model Knowledge	**0.39***	-0.16	0.24	-0.07	0.23	0.05	-0.01	1									
9	Compliance Management Knowledge	-0.08	**0.37***	0.03	0.04	**0.45***	-0.29	-0.22	0.3	1								
10	Developed Shared Understanding	**0.48****	-0.27	-0.02	**-0.58****	0	-0.12	**-0.60****	0.14	0.13	1							
11	Improved Shared Understanding	**0.64****	-0.14	0.02	**-0.47****	-0.08	0.01	**-0.47****	0.27	0.06	**0.82****	1						
12	Shared Understanding Improvement	0.26	0.21	0.07	0.19	-0.13	0.22	0.22	0.21	-0.12	-0.32	0.28	1					
13	Developed Cross-Understanding	**0.43***	0.11	-0.16	-0.23	-0.12	-0.1	**-0.42***	0.21	0.11	**0.53****	**0.76****	**0.37***	1				
14	Communication Openness	0.25	0.11	0.18	0.25	0	0.13	0.06	0.32	0.14	0.07	0.32	**0.42***	**0.49****	1			
15	Discussion Efficiency	**0.38***	0.03	0.27	0.25	-0.01	0.21	0.02	**0.42***	0.09	0.08	0.36	**0.46***	**0.45***	**0.87****	1		
16	Task Discussion Effectiveness	0.31	-0.11	0.27	0.21	-0.22	0.12	0.11	0.28	-0.14	0.11	**0.40***	**0.48****	**0.52****	**0.82****	**0.85****	1	
17	Communication Clarity	**0.39***	-0.24	0.18	-0.06	-0.12	0.11	-0.03	0.17	-0.22	0.17	0.34	0.28	**0.38***	**0.59****	**0.58****	**0.64****	1

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

5.2 RELIABILITY OF MEASURES

As we mentioned before, the pilots that we performed allowed us to validate the procedures and to observe whether *shared understanding* (SU) and *cross-understanding* (CU) can be achieved and measured appropriately. However, because of the changes made to the experimental design resulting from the first pilot studies, we re-worded the set of comprehension questions to measure domain understanding in our final pilot study. We proceeded in this way to collect both 'True/False' answers and qualitative answers instead of just qualitative answers as our previous designs. The modifications of these statements in the comprehension question could introduce problems of understanding during question reading in our domain understanding measurement instrument. Unfortunately, the low number of participants in our last pilot (4 participants) did not allow us to unequivocally check the reliability of our instrument.

The rest of measurement instruments were taken from previous studies (Davison, 1997; Kahai & Cooper, 2003; Lowry et al., 2009), in which reliability and validity were already evaluated. Nevertheless, we analyzed if the reliability is retained for this study.

We examined average Cronbach's alpha values for all the multi-item constructs used in the experiment to assess their reliability. Table 5-4 show our results. According to Table 5-4, all the measures are over 0.7, which are regarded as satisfactory (Bland & Altman, 1997). We therefore concluded that the instruments are reliable and began testing our hypothesis.

Table 5-4. Reliability of Dependent Variables

	Cronbach's Alpha	No of Items
Domain Understanding	0.76	14
Improved Domain Understanding	0.71	14
Communication Openness	0.85	4
Discussion Efficiency	0.74	3
Task Discussion Effectiveness	0.89	6
Communication Clarity	0.76	2

5.3 HYPOTHESES TESTING

In the following sub-sections, we present the tests that we performed to test each of the dependent variables and discuss how the results support or refute our hypotheses. Figure 5-1 re-iterates our theoretical model and the hypotheses to be tested.

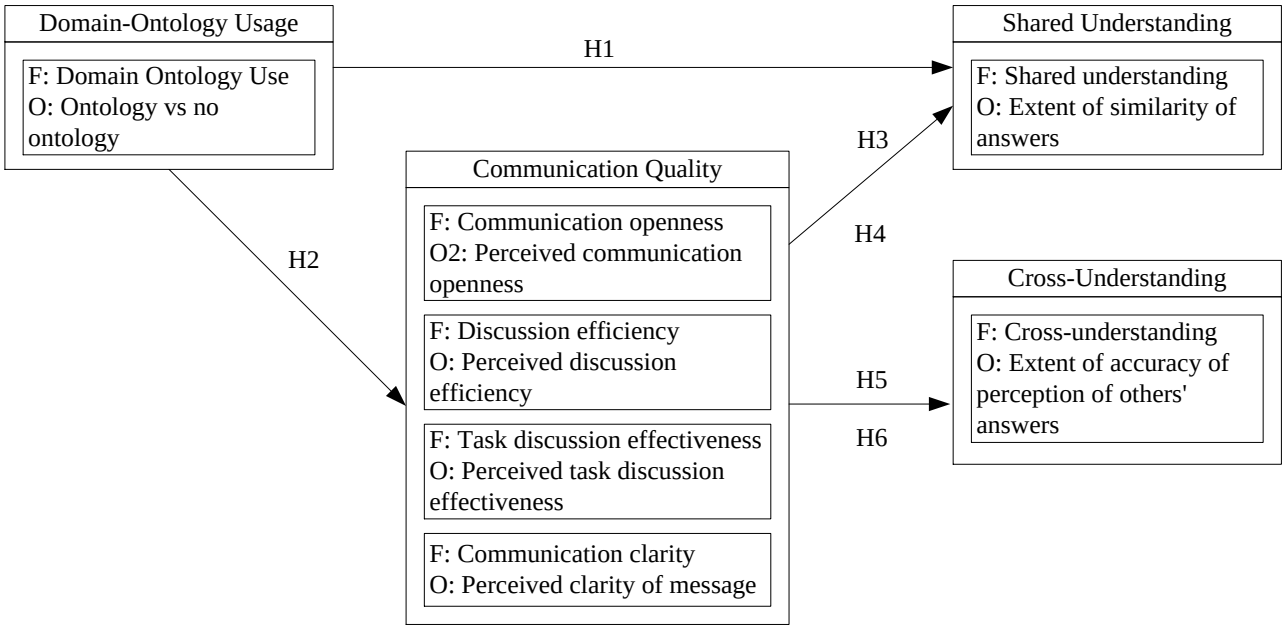

Figure 5-1. Domain-Ontology Usage Effect Model (F: Theoretical factor; O: Operationalization of factor)

5.3.1 Test of Developed Shared Understanding

Recall our first hypothesis is related to the impact of domain ontology use on developed shared understanding:

> *H1. Group members who use a domain ontology develop higher levels of shared understanding than those who do not use a domain ontology.*

Accordingly, the aim of our first test is to examine if team members who use a domain ontology develop higher levels of SU than those who do not use a domain ontology. To test this, we conducted an independent-samples t-test with *Developed Shared Understanding* as the dependent measure and *Domain-Ontology Usage* as independent variable. Table 5-5 shows the mean scores (*M*), the number of samples (N), and the standard errors (*SE*) for *Developed Shared Understanding*. Table 5-6 shows the results of the independent-samples t-test for this variable.

Table 5-5. Descriptive Statistics for Developed Shared Understanding

Experimental Group		N	M	Std. Error Mean
Developed Shared Understanding	Ontology	14	9.57	0.44
	Non-Ontology	16	6.63	0.86

Table 5-6. Independent-Samples t-test Results for Developed Shared Understanding

	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Developed Shared Understanding	3.06	22.22	0.01	2.95	0.96	0.95	4.94

According to the results on Table 5-5 and Table 5-6, on average, participants given a domain ontology developed a better *shared understanding* (M = 9.57, SE = 0.44), than those not given a domain ontology (M = 6.63, SE= 0.86). This difference of 0.96 (95% CI, 0.95 to 4.94), was significant t (22.2) = 3.06, p = 0.01. According to this result, H1 is supported fully and participants who used a domain ontology developed higher level of *shared understanding* than those who did not. In other words, we can use a domain ontology – providing it has acceptable quality – to facilitate the development of shared understanding among group members before they have an interaction or communication between them. As we theorized, this effect is produced because conceptual models facilitate the development of domain understanding (Bera et al., 2011; Burton-Jones & Meso, 2008). Thus, when the same domain ontology is used as an information tool by group members without interaction, they are likely to gain a similar level of domain understanding, which leads to SU development.

5.3.2 Test of Communication Quality

Our second hypothesis is related to the impact of domain-ontology usage on communication quality:

> *H2. Group members who use a domain ontology engage in better communication quality in terms of communication openness, discussion efficiency, task discussion effectiveness, and communication clarity than those who do not use a domain ontology.*

Accordingly, the objective of this test is to measure whether the use of a domain ontology facilitates better *Communication Quality* in terms of *Communication Openness, Discussion Efficiency, Task Discussion Effectiveness,* and *Communication Clarity* as compared to situations in which a domain ontology in not used. To test this, we conducted an independent-samples t-test having *Communication Openness, Discussion Efficiency, Task Discussion Effectiveness, and Communication Clarity* as dependent measures and *Domain-Ontology Usage* as independent variable. Table 5-7 shows the mean scores (M), the number of samples, and the standard errors (SE) for the dependent variables. Table 5-8 shows the results of the independent-samples t-test for these variables.

Table 5-7. Descriptive Statistics for Communication Quality Factors

	Experimental Group	N	Mean	Std. Error Mean
Communication Openness	Ontology	14	5.43	0.30
	Non-Ontology	16	4.88	0.26
Discussion Efficiency	Ontology	14	5.48	0.31
	Non-Ontology	16	4.58	0.26
Task Discussion Effectiveness	Ontology	14	5.04	0.31
	Non-Ontology	16	4.31	0.28
Communication Clarity	Ontology	14	5.71	0.29
	Non-Ontology	16	4.88	0.23

Table 5-8. Independent-Samples t-test Results for Communication Quality Factors

						95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Communication Openness	1.39	26.89	0.18	0.55	0.40	-0.26	1.37
Discussion Efficiency	2.21	26.44	0.04	0.89	0.40	0.06	1.72
Task Discussion Effectiveness	1.73	27.14	0.10	0.72	0.42	-0.13	1.58
Communication Clarity	2.27	25.95	0.03	0.84	0.37	0.08	1.60

According to the results in Table 5-7 and Table 5-8, on average, participants given a domain ontology developed better *Communication Openness* (M = 5.43, SE = 0.30), than those not given a domain ontology (M = 4.88, SE= 0.26) however this difference, 0.55 (95% CI, -0.26 to 1.37), was not statistically significant t (26.89) = 1.39, p = 0.18. This result means that the use of a domain ontology does not enhance *Communication Openness* during the communication between group members. In other words, group members are not more open in exchanging information or more receptive to the communication of others purely by using a domain ontology during their task and communication.

Second, on average, participants given a domain ontology developed better *Discussion Efficiency* (M = 5.48, SE = 0.31), than those not given a domain ontology (M = 4.58, SE= 0.26). This difference, 0.89 (95% CI, 0.06 to 1.72), was statistically significant t (26.44) = 2.21, p = 0.04. This means that the use of a domain ontology enhances the *Discussion Efficiency* during communication between group members, as we theorized. In other words, when using a domain ontology during the communication, group members are more results-oriented, they spend time on interactions effectively, their interactions are more meaningful, and they discuss issues thoroughly.

Third, on average, participants given a domain ontology developed better *Task Discussion Effectiveness* (M = 5.04, SE = 0.31), than those not given a domain ontology (M = 4.31, SE= 0.28). This difference, 0.72 (95% CI, -0.13 to 1.58), was not statistically significant t (27.14) = 1.73, p = 0.10. This means that the use of a domain ontology does not enhance *Task Discussion Effectiveness* during communication between group members. In other words, by using a domain ontology during a group task, team members do not participate more in the discussion, do not develop better discussion

content, do not exchange more information, and do not examine issues and ideas more effectively or clearly.

Finally, on average, participants given a domain ontology developed better *Communication Clarity* (M = 5.71, SE = 0.29), than those not given a domain ontology (M = 4.88, SE= 0.23). This difference, 0.84 (95% CI, 0.08 to 1.60), was statistically significant t (25.95) = 2.27, p = 0.03. This means that the use of a domain ontology enhances *Communication Clarity* during communication between group members, as we theorized. That is, by using a doming ontology during communication between group members, the exchanged messages between them are more clear.

In summary, our results support partially hypothesis H2. Moreover, the use of a domain ontology significantly facilitates better *Discussion Efficiency* and *Communication Clarity*. However, contrary to our view, *Communication Openness* and *Task Discussion Effectiveness* are not facilitated significantly through the use of a domain ontology. These results are to be considered in the analysis of *Shared Understanding Improvement* and *Developed Cross-Understanding* to follow.

5.3.3 Testing of Shared Understanding Improvement

Recall our third and fourth hypotheses are related to shared understanding improvement:

> *H3. Group members who use a domain ontology have greater shared understanding improvement than those who do not use a domain ontology.*
>
> *H4. Communication quality in terms of communication openness, discussion efficiency, task discussion effectiveness, and communication clarity mediates the effect of domain ontology usage on the improvement of shared understanding.*

Accordingly, for *Shared Understanding Improvement*, we performed two tests to assess H3 and H4. First, to test H3, we measured whether there is a significant difference in *Shared Understanding Improvement* between participants who use a domain ontology and those who do not use a domain ontology. Table 5-9 shows the mean scores (M), the number of samples, and the standard errors (SE) for *Shared Understanding Improvement*. Whilst, Table 5-10 shows the results of the independent-samples t-test.

Table 5-9. Descriptive Statistics for Shared Understanding Improvement

	Experimental Group	N	Mean	Std. Error Mean
Shared Understanding Improvement	Ontology	14	2.43	0.44
	Non-Ontology	16	1.50	0.48

Table 5-10. Independent-Samples t-test Results for SU Improvement

	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Shared Understanding Improvement	1.40	28	0.17	0.93	0.66	-0.43	2.28

According to the results in Table 5-9 and Table 5-10, on average, participants given a domain ontology had a greater *Shared Understanding Improvement* (M = 2.43, SE = 0.44), than those not given a domain ontology (M = 1.50, SE= 0.48). This difference, 0.93 (95% CI, -0.43 to 2.28), was not statistically significant t (28) = 1.40, p = 0.17; however, it did represent a medium-size effect, d = 0.62 (Cohen, 1992). According to this result, our H3 is not supported. This means that the use of a domain ontology does not improve shared understanding significantly during the group task. However, the results are still important in practice when shared understanding is required to be improved because of the medium-size effect (Cohen, 1992). Considering that the interaction group task was limited in time in our experimental setting, perhaps a longer activity or more interactions would be required in order to get a significant effect – e.g. see the work of He et al. (2007). Our fourth hypothesis, H4, deals with communication quality in terms of *Communication Openness*, *Discussion Efficiency*, *Task-discussion Effectiveness*, and *Communication Clarity* mediating the improvement of *shared understanding*. To test this hypothesis, we will use mediation analysis.

Mediation refers to a situation in which the relationship between a predictor variable and an outcome variable can be explained by their relationship with a third variable, the mediator (Field, 2013). Explicitly, our predictor variable is *Domain Ontology Usage*, our outcome variable is *Shared Understanding Improvement*, and our mediator is *Communication Quality*. In our case, *Communication Quality* – through the four different factors – mediates the effect of *Domain Ontology Usage* on *Shared Understanding Improvement*. To facilitate the analysis of mediation, we used the PROCESS[5] (Hayes, 2013) custom dialog box. To estimate mediation, PROCESS computes the indirect effect and its significance or the confidence intervals for the indirect effect using bootstraps methods – see the schematic of a mediation model in Figure 5-2 (Field, 2013).

[5] PROCESS is an add-on for SPSS and SAS for statistical mediation, moderation, and conditional process analysis: http://processmacro.org/

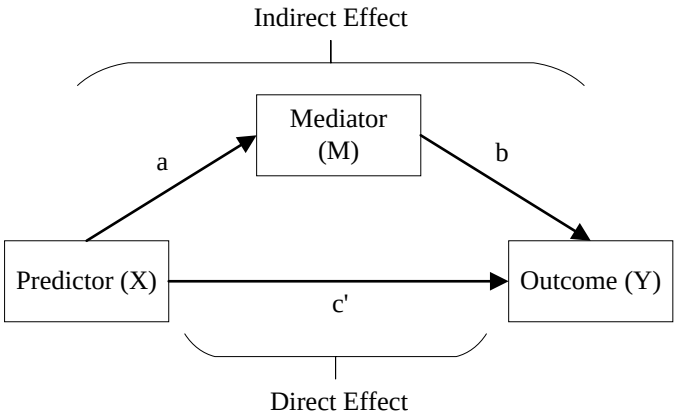

Figure 5-2. Diagram of a Mediation Model (Field, 2013)

We ran mediation analysis with PROCESS on SPSS considering *Domain Ontology Usage* as the predictor variable, the four factors of communication quality as mediators, and *Shared Understanding Improvement* as the outcome. The complete results of the analysis can be observed in Appendix G.1.

Table 5-11 summarizes the total, direct and indirect effects of *Domain Ontology Usage* on *Shared Understanding Improvement* presented in Appendix G.1. According to Table 5-11, *Communication Quality* – through the four different factors – does not significantly mediate the effect of *Domain Ontology Usage* on *Share Understanding Improvement*. First, there was not a significant effect of *Domain Ontology Usage* on *Shared Understanding Improvement* as mediated by *Communication Openness*, b = 0.00, 95% BCa CI (-1.12 to 0.77). Nor was there a significant effect via *Discussion Efficiency*, b = 0.22, 95% BCa CI (-1.06 to 1.94), *Task Discussion Effectiveness*, b = 0.41, 95% BCa Ci (-0.81 to 1.69), or *Communication Clarity*, b = 0.13, 95% BCa Ci (-1.81 to 0.33). Thus, we then analyzed if any of the factors added a negative effect to our results.

Table 5-11. Total, Direct and Indirect Effect on Shared Understanding Improvement (Four Factors)

Total effect of X on Y						
Effect		SE	t	p	LLCI	ULCI
	0.93	0.68	1.37	0.18	-0.46	2.32
Direct effect of X on Y						
Effect		SE	t	p	LLCI	ULCI
	0.43	0.88	0.49	0.63	-1.39	2.25

Indirect effect of X on Y	Effect	Boot SE	BootLLCI	BootULCI
Total	0.50	0.59	-0.53	1.90
Communication Openness (CO)	0.00	0.44	-1.12	0.77
Discussion Efficiency (DE)	0.22	0.72	-1.06	1.94
Task Discussion Effectiveness (TDE)	0.41	0.68	-0.81	1.69
Communication Clarity (CC)	-0.13	0.46	-1.81	0.33

From the previous analysis of Communication Quality (See section 5.3.2), we confirmed that *Communication Openness* and *Task Discussion Effectiveness* are not significantly facilitated through the use of a domain ontology. Thus, we only considered *Discussion Efficiency* and *Communication Clarity* as *Communication Quality* factors for the mediation analysis. The full results of the analysis can be observed in Appendix G.2.

Table 5-12 summarizes the total, direct and indirect effects of *domain ontology usage* on *Shared Understanding Improvement* with respect to *Discussion Efficiency* and *Communication Clarity*. According to these results, there was a significant indirect effect of *Domain Ontology Usage* on *Shared Understanding Improvement* through *Discussion Efficiency, b* = 0.60, 95% BCa Ci (0.22 to 1.67). However, there was not a significant indirect effect of *Domain Ontology Usage* on *Shared Understanding Improvement* through *Communication Clarity, b* = -0.01, 95% BCa Ci (-1.05 to 0.51). In other words, when a *domain ontology* is used by group members as an information tool during communication to improve *shared understanding*, this improvement is mediated by the extent of *Discussion Efficiency* of the group.

Table 5-12. Total, Direct and Indirect Effect on Shared Understanding Improvement (Two Factors)

Total effect of X on Y					
Effect	SE	t	p	LLCI	ULCI
0.93	0.68	1.37	0.18	-0.46	2.32
Direct effect of X on Y					
Effect	SE	t	p	LLCI	ULCI
0.34	0.82	0.42	0.68	-1.34	2.03
Indirect effect of X on Y					
	Effect	Boot SE	BootLLCI	BootULCI	
Total	0.59	0.49	-0.17	1.85	
DE	0.60	0.41	**0.22**	**1.67**	
CC	-0.01	0.37	-1.05	0.51	

Consequently, we consider H4 to be partially supported in that *Discussion Efficiency* significantly mediates the improvement of *shared understanding* but the remaining three *Communication Quality* factors do not.

5.3.4 Test of Cross-Understanding

Similarly, to the previous analysis, we performed two tests to assess H5 and H6*:*

> *H5. Group members who use a domain ontology develop greater cross-understanding than those who do not use a domain ontology.*

H6. Communication quality in terms of communication openness, discussion efficiency, task-discussion effectiveness, and communication clarity mediates the effect of domain ontology usage on the development of cross-understanding.

Accordingly, to test hypothesis H5, we measured whether there is a significant difference in *Developed Cross-Understanding* between participants who use a domain ontology and those who do not. Table 5-13 shows the mean scores (*M*), the number of samples (N), and the standard errors (*SE*) for *Developed Cross-Understanding*. Table 5-14 shows the results of the independent-samples t-test.

Table 5-13. Descriptive Statistics for Developed Cross-Understanding

	Experimental Group	N	Mean	Std. Error Mean
Developed Cross-Understanding	Ontology	14	10.64	0.59
	Non-Ontology	16	7.94	0.86

Table 5-14. Independent-Samples t-test Results for Developed Cross-Understanding

	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Developed Cross-Understanding	2.60	25.84	0.02	2.71	1.04	0.56	4.85

According to the results in Table 5-13 and Table 5-14, on average, participants given a domain ontology had a greater *Developed Cross-Understanding* (*M* = 10.64, SE = 0.59), than those not given a domain ontology (*M* = 7.94, SE= 0.86). This difference, 2.71 (95% CI, 0.56 to 4.85), was statistically significant *t* (25.84) = 2.60, *p* = 0.02. Based on this result, H5 is fully supported. This means that the use of a domain ontology enhances the development of *cross-understanding* after team members communicate with each other. In other words, the ontology use leads to the exchange of more precise information about the domain, which allows group members to understand what the other group members know or think about the domain.

To test hypothesis H6, we ran a mediation analysis with PROCESS on SPSS considering *Domain-Ontology Usage* as the predictor, the four factors of *Communication Quality* as mediators, and *Developed Cross-Understanding* as the outcome. The complete results of the analysis are provided in Appendix G.3.

Table 5-15 summarizes the total, direct and indirect effects of *Domain Ontology Usage* on *Shared Understanding Improvement* presented in Appendix G.3. According to Table 5-15, *Communication Quality* – through the four different factors – does not mediate the effect of *Domain Ontology Usage* on *Developed Cross-Understanding*. There was no significant effect of *Domain Ontology Usage* on *Developed Cross-Understanding* through *Communication Openness*, *b* = 0.62, 95% BCa CI (-0.40 to 3.85), nor through *Discussion Efficiency*, *b* = -0.84, 95% BCa CI (-3.81 to 0.60), *Task Discussion Effectiveness*, *b* = 0.81, 95% BCa Ci (-0.67 to 4.17) or through *Communication Clarity*, *b* = -0.13,

95% BCa Ci (-2.39 to 1.38). Thus, we analyzed if any of the factors added a negative effect to our results as explained in the following.

Table 5-15. Total, Direct and Indirect Effect on Developed Cross-Understanding

Total effect of X on Y						
Effect		SE	t	p	LLCI	ULCI
	2.71	1.08	2.51	0.02	0.50	4.91
Direct effect of X on Y						
Effect		SE	T	p	LLCI	ULCI
	2.42	1.34	1.67	0.11	-0.52	5.00
Indirect effect of X on Y						
		Effect	Boot SE	BootLLCI	BootULCI	
Total		0.46	0.90	-1.15	2.56	
Communication Openness (CO)		0.62	1.02	-0.40	3.85	
Discussion Efficiency (DE)		-0.84	1.09	-3.81	0.60	
Task Discussion Effectiveness (TDE)		0.81	1.16	-0.67	4.17	
Communication Clarity (CC)		-0.13	0.88	-2.39	1.38	

Performing a similar subsequent analysis as we did for *Shared Understanding Improvement*, we only considered the *Communication Quality* factors that were improved through the use of a domain ontology – i.e. *Discussion Efficiency* and *Communication Clarity*. Therefore, we performed the second mediation analysis only considering *Discussion Efficiency* and *Communication Clarity*. The complete results of this analysis are provided in Appendix G.4.

Table 5-16 summarizes the total, direct and indirect effects of D*omain Ontology Usage* on *Developed Cross-Understanding*. According to these results, there was a significant indirect effect of *Domain Ontology Usage* on *Developed Cross-Understanding* through *Discussion Efficiency, b* = 0.69, 95% BCa Ci (0.02 to 2.58). However, there was no significant indirect effect of *Domain Ontology Usage* on *Developed Cross-Understanding* through *Communication Clarity, b* = 0.25, 95% BCa Ci (-0.69 to 2.11). Consequently, H6 is partially supported in that *Discussion Efficiency* significantly mediates the development of *cross-understanding* but the remaining three *Communication Quality* factors do not. In other words, when a domain ontology is used by group members as an information tool during communication between them to develop *cross-understanding*, this development is mediated by the extent of *Discussion Efficiency* of the group.

Table 5-16. Total, Direct and Indirect Effect on Developed Cross-Understanding

Total effect of X on Y					
Effect	SE	t	p	LLCI	ULCI
2.71	1.08	2.51	0.02	0.5	4.91
Direct effect of X on Y					
Effect	SE	t	p	LLCI	ULCI
1.76	1.18	1.49	0.15	-0.67	4.19
Indirect effect of X on Y					
	Effect	Boot SE	BootLLCI	BootULCI	
Total	0.94	0.69	0.00	2.84	
DE	0.69	0.55	**0.02**	**2.58**	
CC	0.25	0.65	-0.69	2.11	

To summarize, we now present a synopsis of the outcomes of hypotheses testing in Table 5-17.

Table 5-17. Summary of Hypothesis Testing Results

Hypothesis	Support
H1. Group members who use a domain ontology develop higher levels of shared understanding than those who do not use a domain ontology.	Full
H2. Group members who use a domain ontology engage in better Communication Quality in terms of Communication Openness, Discussion Efficiency, Task Discussion Effectiveness, and Communication Clarity than those who do not use a domain ontology.	Partially, only Discussion Efficiency and Communication Clarity
H3. Group members who use a domain ontology have greater shared understanding improvement than those who do not use a domain ontology.	No
H4. Communication Quality in terms of Communication Openness, Discussion Efficiency, Task-Discussion Effectiveness, and Communication Clarity mediates the effect of domain ontology usage on the improvement of share understanding.	Partially, only Discussion Efficiency
H5. Group members who use a domain ontology develop greater cross-understanding that those who do not use a domain ontology.	Full
H6. Communication quality in terms of Communication Openness, Discussion Efficiency, Task-Discussion Effectiveness, and Communication Clarity mediates the effect of domain ontology usage on the development of cross-understanding.	Partially, only Discussion Efficiency

5.4 CONCLUSION VALIDITY

Conclusion validity is the degree to which conclusions we reach about relationships in the data are reasonable (Trochim & Donnelly, 2008). Conclusion validity differs from internal validity (see Section 4.3.2) in that it is only concerned with whether there is a relationship and whether that relationship is a reasonable one or not, given the data (Trochim & Donnelly, 2008). Conversely, internal validity is the approximate truth about inferences regarding cause-effect or causal relationship (Trochim & Donnelly, 2008). Table 5-18 presents several threats to conclusion validity, their description, and the controls that we undertook to mitigate such threats.

Table 5-18. Threats to Conclusion Validity and their Mitigation (Trochim & Donnelly, 2008)

	Threats	Description	Mitigation in This Study
1.	Low reliability of measures	Measures are not consistent or cannot be repeated.	• We measured reliability of variables.
2.	Poor reliability of treatment implementation	Lack of standardized treatments in an experiment can lead to erroneous conclusions.	• Four pilot studies were performed to check our treatments were standardized.
3.	Low Statistical Power	Conclusions drawn from a study are based on insufficient statistical power.	• Sample sizes were very similar in the two treatments. • Participants were assigned randomly. • We implemented control variables.
4.	Violated Assumptions of Statistical Tests	Violation of assumptions required by particular statistical techniques.	• We ensured statistical assumptions held for the t-test and linear regression.
5.	Fishing and the Error Rate Problem	Undertaking repeated testing for significant relationships.	• No repeated tests were taken.
6.	Restriction of Range	Lack of standardized treatments in an experiment can lead to erroneous conclusions.	• The used treatments have equivalence of information.
7.	Extraneous Variance in the Experimental Setting	Extraneous variance (distractions, noise) affecting participants in experiments may cause inaccuracy of statistical conclusions.	• We used a computer lab, which was free of external interruptions, to reduce this threat.
8.	Random Heterogeneity of respondents	Error increases due to participants' heterogeneity.	• We used students in a database course. Their heterogeneity was measured and controlled by our control variables.

As per Table 5-18, there are 8 likely threats that could impact the conclusion validity of our experimental results. For each one of these threats we adopted strategies to decrease their likely occurrence. In the following, we describe these threats and the mitigations adopted:

1. *Low reliability of measures* occurs when measures are not consistent or cannot be repeated (Trochim & Donnelly, 2008). To avoid this treat, we measured reliability of variables and ensured repeatability of the experiment.
2. *Poor reliability of treatment implementation* occurs when a lack of standardized treatments in an experiment leads to erroneous conclusions (Trochim & Donnelly, 2008). To avoid this threat, four pilots were performed to ensure that our treatment and control are standardized.
3. *Low Statistical Power* occurs when conclusions drawn from a study are based on insufficient statistical power (Trochim & Donnelly, 2008). To avoid this treat, sample sizes were similar in the treatment and the control. Also, participants were assigned randomly. Finally, we implemented control variables.
4. *Violated Assumptions of Statistical Tests* occurs by the violation of assumptions required by particular statistical techniques (Trochim & Donnelly, 2008). To avoid this threat, we ensured statistical assumptions held for the t-test and linear regression.
5. *Fishing and the Error Rate Problem* occurs when repeated testing for significant relationships is undertaken (Trochim & Donnelly, 2008). To avoid this threat, no repeated tests were carried out.

6. *Restriction of Range* occurs when a lack of standardized treatments in an experiment can lead to erroneous conclusions (Trochim & Donnelly, 2008). To avoid this threat, we used treatments that have equivalence of information.
7. *Extraneous Variance in the Experimental Setting* occurs when extraneous variance (distractions, noise) affecting participants in experiments may cause inaccuracy of statistical conclusions (Trochim & Donnelly, 2008). To reduce this threat, we used a computer lab, which was free of external interruptions.
8. *Random Heterogeneity of respondents* occurs when error increases due to participants' heterogeneity (Trochim & Donnelly, 2008). To avoid this threat, we used students in a database course. Their heterogeneity was measured and controlled by our control variables.

5.5 CHAPTER SUMMARY

This chapter provided the results of the empirical study performed to test our theoretical model of the effect of *Domain-Ontology Usage* on s*hared understanding* (SU) and *cross-understanding* (CU). To achieve this objective, first, we screened the data to establish that the data is adequate for our statistical tests. Second, we ensured the reliability of our measurement instruments. Then we tested our six hypotheses through independent-samples t-tests and mediation analysis. The results of our tests allow us to fully or partially confirm all but one of our hypotheses. Finally, we analyzed the conclusion validity of our results and found our results to be satisfactory. In the next chapter, we will provide more insights into the meaning and importance of our findings.

6 CONCLUSIONS

This chapter concludes the thesis. First, we present an overview of the findings, which were the result of the empirical evaluation of our theoretical model. Second, we present the potential theoretical and practical contributions resulting from our findings. Third, we recognize the limitations of our study. Fourth, based on our limitations, we proposed new research opportunities that can be undertaken in the future. Finally, we present the overarching conclusions.

6.1 OVERVIEW OF FINDINGS

As evidenced in the literature review, many domain ontologies have been developed to facilitate the development of *shared understanding* (SU), however there is a lack of empirical evidence to support such claims. Accordingly, to address this gap in the body of knowledge in IS, the aim of this research was to theoretically and empirically investigate the effect of a domain ontology on *shared understanding* (SU) and *cross-understanding* (CU) in groups. Specifically, our main research question in this study was "*what is the effect of using a domain ontology on shared understanding and cross-understanding?"* In this study, we developed a theoretical model theorizing the effect of domain ontology usage on SU and CU. We then tested the model through experimental research. The findings from our empirical evaluation are described in Table 6-1.

Table 6-1. Summary of Results of Thesis

	Results
1.	Group members who use a domain ontology develop significantly higher levels of shared understanding than those who do not use a domain ontology.
2.	a) Group members who use a domain ontology have significantly better communication quality in terms of discussion efficiency and communication clarity than those who do not use a domain ontology. b) There is no significant difference in communication openness and task discussion effectiveness among group members who use a domain ontology and those who do not use a domain ontology.
3.	There is no significant improvement in shared understanding between group members who use a domain ontology and those who do not use a domain ontology.
4.	a) Discussion efficiency significantly mediates the effect of domain ontology usage on the improvement of shared understanding. b) Communication openness, communication clarity and task discussion effectiveness do not significantly mediate the effect of domain ontology usage on the improvement of shared understanding.
5.	Group members who use a domain ontology develop a significantly greater cross-understanding than those who do not use a domain ontology.
6.	a) Communication quality in terms of discussion efficiency significantly mediates the effect of domain ontology usage on the development of cross-understanding. b) Communication openness, communication clarity and task discussion effectiveness do not significantly mediate the effect of domain ontology usage on the development of cross-understanding.

As per Table 6-1, the group members who used a domain ontology developed significantly higher levels of *shared understanding* than those who did not use a domain ontology. This implies that if group members are provided a (good quality) domain ontology, it is possible to achieve a significantly

higher level of *shared understanding* development between group members before they interact with each other as compared to group members who do not have access to a domain ontology.

Second, group members who use a domain ontology have significantly better *Communication Quality* in terms of *Discussion Efficiency* and *Communication Clarity* than those who do not use a domain ontology. In other words, our results show that through the use of a good quality ontology it is possible to increase the efficiency and clarity of communication between group members. However, communication openness and task discussion effectiveness are not increased significantly through the use of an ontology. Hence, we consider that these factors are more affected by both group and task characteristics, and therefore, more research is necessary to clarify this issue.

Third, there is no significant improvement in shared understanding between team members who use a domain ontology and those who do not use a domain ontology. According to this result, the use of the ontology in a group interaction task is not enough to produce a significant improvement in shared understanding. However, the results are important in practice when shared understanding needs to be improved because of the medium-size effect (Cohen, 1992). Indeed, considering that the interaction group task was limited in time in our experimental setting, a longer activity or more interactions may be required to get a significant effect – e.g. see (He et al., 2007).

Fourth, *Discussion Efficiency* significantly mediates the effect of *Domain Ontology Usage* on the improvement of *shared understanding*. That is, although the use of a domain ontology improves *shared understanding*, this improvement also depends on how efficient the discussion between group members is. Contrarily to our hypotheses, other communication quality factors such as *Communication Openness, Communication Clarity and Task Discussion Effectiveness* did not mediate the effect of Domain Ontology on shared understanding. In other words, some communication quality factors are less relevant during shared understanding improvement. Thus, we consider that further research is required to understand what other quality factors mediate the effect of *Domain Ontology Usage* on the improvement of *shared understanding*.

Fifth, group members who used a domain ontology developed a significantly greater *cross-understanding* than those who did not use a domain ontology. This is an important finding because it indicates that the effect of *Domain Ontology Use* extends beyond just improving *shared understanding*. Although we recognize that further research is required to better understand how *cross-understanding* is developed, our results are significant in terms of practical applications. That is, the use of a domain ontology during an interaction task will lead to better development of *cross-*

understanding of the said domain among group members as compared to a group not using the domain ontology.

Finally, communication quality in terms of *Discussion Efficiency* significantly mediates the effect of domain ontology usage on the development of *cross-understanding*. That is, the development of *cross-understanding* is not only affected by the use of the domain ontology, but is also mediated by how efficient the communication is. Contrary to our hypotheses, *Communication Openness*, *Communication Clarity* and *Task Discussion Effectiveness* did not significantly mediate the effect of *Domain Ontology Usage* on the development of *cross-understanding.* Further research is required to understand what other communication quality factors may mediate the effect of *Domain Ontology Usage* on improvement of *cross-understanding.*

In summary, our results show that a domain ontology can be beneficial for *shared understanding* and *cross-understanding* in groups. First, domain ontology usage has an important effect on the *Development of Shared Understanding* and *Development of Cross-Understanding* but not *Shared Understanding Improvement*. Also, our results show that *communication quality* factors, specifically *Discussion Efficiency* and *Communication Clarity*, are improved through the use of a domain ontology. Finally, *Discussion Efficiency* is also important in mediating the effect of a domain ontology in *Shared Understanding Improvement* and *Cross-Understanding Development.*

6.2 CONTRIBUTIONS AND IMPLICATIONS

We argue that the results of this study contribute to both theory and practice. In the following sub-sections, we present the theoretical and practical contributions based on the findings of this study.

6.2.1 Theoretical Contributions

6.2.1.1 Theory of Domain Ontology Effect on Shared Understanding and Cross-Understanding

In IS and related fields, one of the often-cited benefits of conceptual models, e.g. domain ontologies, is that they facilitate *shared understanding* (SU) (Al-Debei & Fitzgerald, 2010; Innab et al., 2012; Lin et al., 2004; Uschold et al., 1998). However, such claims have lacked theoretical and empirical validation.

Through this study, we contribute to the theory of conceptual modelling by presenting a model of the effect of domain ontology usage on SU and *cross-understanding* (CU) in groups (Figure 6-1). To the best of our knowledge, this is the first theory of domain ontology usage in the body of knowledge of IS that considers the effect of a domain ontology on the group level. According to the results of our

model, domain ontology usage affects the development of SU. The model also shows that domain ontology usage affects communication quality and CU development. Furthermore, it shows that SU improvement and CU development are mediated by the communication quality factor *discussion efficiency*.

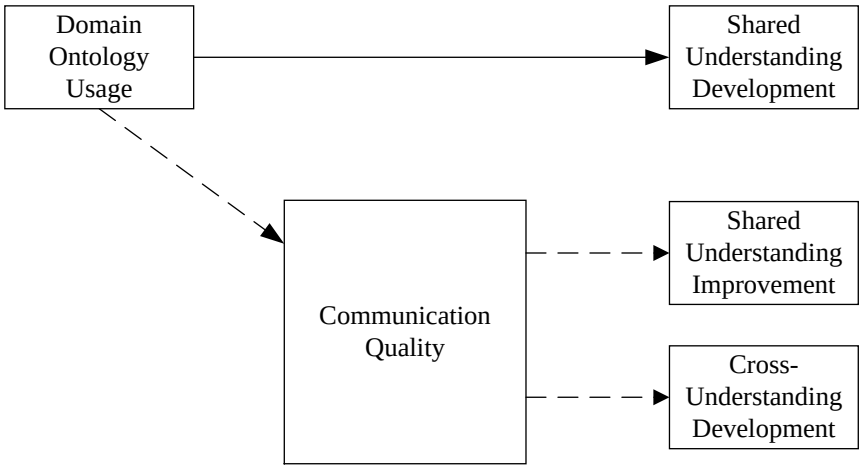

Figure 6-1. Theory of Domain Ontology Usage on Shared Understanding and Cross-Understanding

Another important contribution to theory is that at the group level, *communication quality* is a key construct on enabling SU and CU. Further, this construct can also be improved through the use of a domain ontology. As we mentioned before, communication quality is an important enabler of performance in groups in organizations (Bittner & Leimeister, 2014; Briggs, 2014; Field, 2013; Huber & Lewis, 2010; Salas et al., 2008). Thus, domain ontologies can also contribute to group performance by supporting SU and CU.

In this study, we also contribute to the theory by providing the first empirical evaluation of our theoretical model. As we mentioned in the previous chapter, our findings support fully H1 and H5, and partially H2, H4, and H6, which open a new spectrum of research opportunities that will be exposed later in this chapter in Section 6.4.

6.2.1.2 Operationalization and Empirical Testing of Cross-Understanding

Cross-understanding is a recent construct introduced by Huber and Lewis (2010) to explain contradictory results in empirical validations of team performance. Because of its recent introduction, to the best of our knowledge, this construct has not been operationalized and tested empirically. Although Huber and Lewis (2010) recommend two approaches, perceptual and behavioral, to operationalize CU, there are no specific or detailed instructions of how to perform such operationalization. In this study, we adopted the perceptual recommendation and through a coding process that considers the answers of two participants in a group, we estimate CU (See section 4.8.1).

The coding process shows that CU in each team member can be determined through comparing team members' answers on comprehension questions.

6.2.2 Practical Contributions

We consider that the most important contribution to practice is the enhanced understanding of the role that domain ontologies can play as information tools in novice groups. Previous studies show that visual ontologies can be useful for knowledge identification (a particular result of domain understanding at the individual level), e.g. Bera et al. (2011). However, as we mentioned in our literature review, there is a lack of evidence to support the benefits that domain ontologies provide in enabling SU, even less for CU. Thus, we consider that our study is the first to provide evidence of how domain ontologies can be used to support domain understanding at the group level, specifically on SU and CU. Indeed, our study shows that the use of domain ontologies as information tools during group tasks can enable SU and CU.

Our empirical validation shows how, through the use of the compliance management domain ontology CoMOn, team members can achieve a good understanding of the compliance management domain and also enhanced their SU and CU of the domain. The compliance management domain is a very complex domain that suffers from conflicting understanding of compliance management in organizations (Australasian Compliance Institute, 2013a; Open Compliance & Ethics Group, 2012) and hence it is difficult to achieve a shared understanding of it in group members. Moreover, although many organizations are using different tools that help control compliance, there is still a lack of understanding of how compliance management is related to, or impacts the organization's operations, in addition to a lack of common understanding of compliance in general within different functions of the same organization.

Thus, the introduction of CoMOn as an information tool within an organization can potentially assist in overcoming the differences and establish a common understanding. Domain ontologies such as CoMOn can be introduced in a variety of formats that engage employees in a group task, including but not limited to use in employee induction and training workshops and as a reference source for policy and process documentations.

6.3 LIMITATIONS

Although we believe our study makes a significant contribution, it also has limitations that are necessary to explain. The limitations of our study can be understood with reference to the traditional criteria for validity (Bera et al., 2011). Below we describe the main limitations of our study.

In terms of *internal validity*, a challenge could be raised in terms of the treatments that we used in our experiments. Specifically, we use a graphical domain ontology in our treatment group and a text based description of the domain in the control group. As these are two different presentation types of information, this could have created a difference in the results across groups that may not have been due to our treatment. While this might have been possible, we do not consider it to be a major concern for the following reason: we ensured that all the comprehension questions could be answered irrespective of the type of the treatment used and the information provided to each group was equivalent. Thus, we believe that general conclusions can be drawn safely from the experiments.

In terms of *construct validity*, we operationalized each construct in our study in a limited way. It would be ideal to manipulate each treatment in multiple ways (e.g. different domains, different representations of the ontology) to measure variables in various ways, and to study the effects of our treatments on our dependent variables in different tasks (Burton-Jones & Meso, 2008). However, we could not proceed in that way due to limitations of time and resources. Thus, our results are limited to the characteristics of our experimental design, and readers should be cautious in over-generalizing from our results (Bera et al., 2011; Burton-Jones & Meso, 2008).

In terms of *external validity*, our study could be challenged because we used laboratory experiments with a sample of university students rather than a sample of real practitioners or users. However, this practice is typical in the early stages of research (Trochim & Donnelly, 2008), and we maintained some realism by using a domain and an ontology that complied with our study necessities, while satisfying the need to have novice participants. That is, we believe that the students who participated in our experiments were very similar to the target population, in that they are individuals of a diverse background who are not very familiar with a domain and were learning from conceptual models.

Finally, in terms of *statistical conclusion validity*, the limited statistical power because of the modest sample size in the present study (N = 30) may have played a role in constraining the significance of the statistical comparisons conducted. Although a post hoc power analysis for t-tests shows the used sample size is sufficient, this not the case for the mediation analysis. First, the post hoc power analysis for t-tests revealed that on the basis of the mean, between-groups comparison effect size observed in the present study (d = 2.02), approximately 12 samples would have been sufficient to obtain statistical power at the recommended 0.80 level (Cohen, 1992). To the contrary, a study of the required sample size to detect a mediation effect to achieve statistical power of 0.80 level shows that at least 385 samples are needed when we consider our observed effects of the dependent variable on the mediators ($a < 0.10$) and the effect of the mediator on the independent variable ($b < 0.59$) (Fritz & MacKinnon, 2007).

6.4 FUTURE RESEARCH

In this study, we have taken the first step to study domain understanding of conceptual models at the group level. However, we consider that there are still aspects of the study that can be extended. First, our theoretical model considered only 4 factors of communication quality. We know that the communication process between human beings can be very complex (Dennis, Fuller, & Valacich, 2008), Thus it is important to know what other factors may be affecting communication processes and how they affect *shared understanding* (SU) and *cross-understanding* (CU).

Second, our results show that SU improvement was not significantly different with the use of the domain ontology to without. It is important to understand if such improvement can be improved over the time. Our group task was designed for only one short meeting between participants. Despite this, participants achieved a representative improvement on SU with the use of the domain ontology. We consider that SU improvement could be more significant through more team interactions over a longer period of time.

Third, we used an experiment in a lab setting to test our hypothesis. Although we can obtain high internal validity, external validity still remains low (Trochim & Donnelly, 2008). Through other types of studies, such as case studies, our findings can be contrasted and further developed. Thus, we encourage researchers to consider further research on this topic.

Finally, the theory of ontology effects on SU and CU is a foundation on which to understand domain understanding at the group level. Indeed. there are plenty of opportunities that need to be explored. For example, it would be important to know how SU and CU might be affected by both external and internal factors to the ontology. As we explained in Section 2.3, there are many factors that affect the individual understanding of group members, and hence SU and CU. However, we do not yet know how drastic the impact of those factors is on these shared cognition constructs. By determining the impact of these factors, it will be possible make recommendations of ontology design and development to get better results on SU and CU.

6.5 CONCLUDING REMARKS

In this study, we considered the importance that *shared understanding* (SU) and *cross-understanding* (CU) have on task performance in teams. Our literature review shows that there is a lack of mechanisms to improve such constructs in groups. Indeed, our literature review shows that domain ontologies might facilitate SU, but there is a lack of theoretical and empirical evidence to support such claims. Thus, we considered as an artifact of study domain ontologies as enabler of SU and CU.

Indeed, our study examined the effect of domain ontology usage on shared understanding and cross-understanding in novice teams.

To achieve this aim, first, we developed a theoretical model that describes such effect. According to our theoretical model, domain ontology usage affects the development of *shared understanding*; as well as the development of *cross-understanding*. However, the effect of domain ontology usage on improvement of *shared understanding* and development of *cross-understanding* is mediated by *communication quality* (CQ) factors.

To test our theoretical model, we considered a specific domain and a particular kind of representation of a domain ontology. That is, we selected the compliance management domain and a graphical ontology of this domain (CoMOn). On the one hand, compliance management has been an important topic discussed within academia and industry for three main reasons: high-compliance management cost (Protiviti, 2012), drastic consequences of failing to comply (Australasian Compliance Institute, 2013b), and a weak and conflicting understanding of compliance management concepts in organizations (Australasian Compliance Institute, 2013a; Open Compliance & Ethics Group, 2012). Thus, we conclude that compliance management is a suitable setting in which to study the effectiveness of domain ontology in facilitating SU and CU. On the other hand, the compliance management ontology (CoMOn) is an informal ontology developed with the specific purpose to facilitate the development of a SU of compliance management (Syed Abdullah et al., 2013), and thus presents an ideal basis on which to conduct our test.

We tested our hypotheses through an experimental research design. We considered a two-group, post-test only, randomized experimental design (Shanks, 2008; Trochim & Donnelly, 2008). Accordingly, our treatment group used CoMOn and our control group used a portion of the standard ISO 19600:2014 (British Standards Institution, 2014), which provides guidelines for compliance management systems. Also, we considered as participants for our experiment students from a course of database fundamental offered in the School of Information Technology and Electrical Engineering at the University of Queensland. These students have zero or low level of conceptual modeling knowledge and compliance management, which helped us to recreate similar users to those we targeted – i.e., novice users.

Our results show that, first, group members who use a domain ontology develop significant higher levels of *shared understanding* than those who do not use a domain ontology. Second, group members who use a domain ontology have significantly better *communication quality* in terms of *Discussion Efficiency* and *Communication Clarity* than those who do not use a domain ontology. Third,

communication quality in terms of *Discussion Efficiency* significantly mediates the effect of *Domain Ontology Usage* on the improvement of *shared understanding*. Fourth, group members who use a domain ontology develop a significantly greater *cross-understanding* than those who do not use a domain ontology. Finally, *communication quality* in terms of discussion efficiency significantly mediates the effect of domain ontology usage on the development of *cross-understanding*.

Our theoretical model and the findings of its evaluation contribute to both theory and the practice of IS. Firstly, by expanding the body of knowledge of conceptual modelling at the group level by introducing the study of *shared understanding* and *cross-understanding*. Secondly, by presenting how domain ontologies can be used in practice to enhance *shared understanding* and *cross-understanding*, and consequently improve performance in groups. As we mentioned before, improving performance in groups is one of the most challenging tasks in organizations (Bittner & Leimeister, 2014).

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APPENDIX A. RECRUITMENT MATERIALS

A.1 RECRUITMENT SLIDE AND LEAFLET

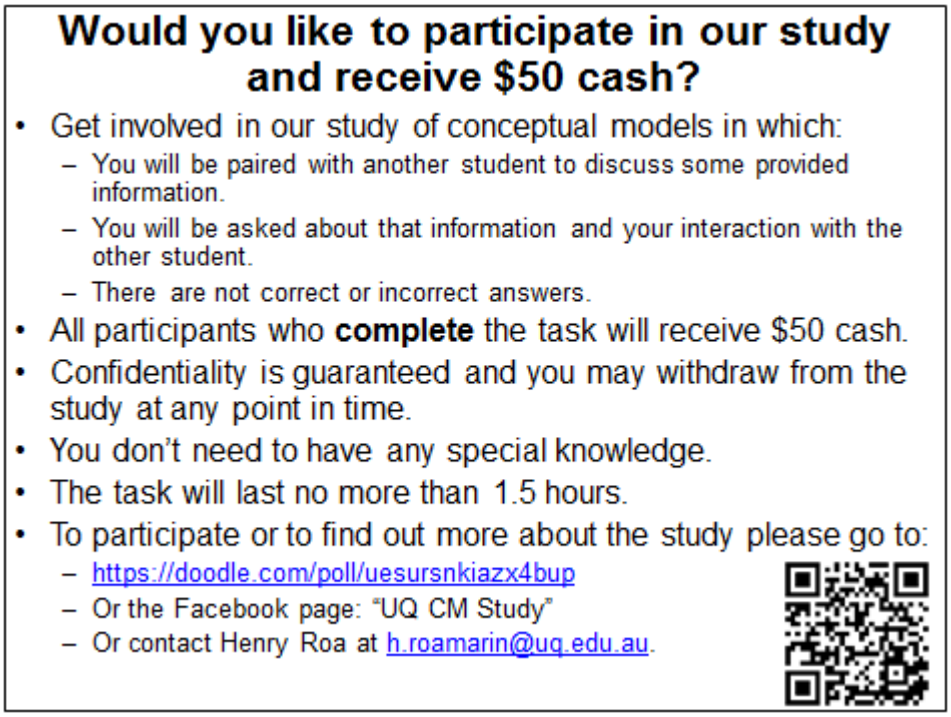


Figure A-1. Recruitment Slide

A.2 APPOINTMENT MAIL EXAMPLE

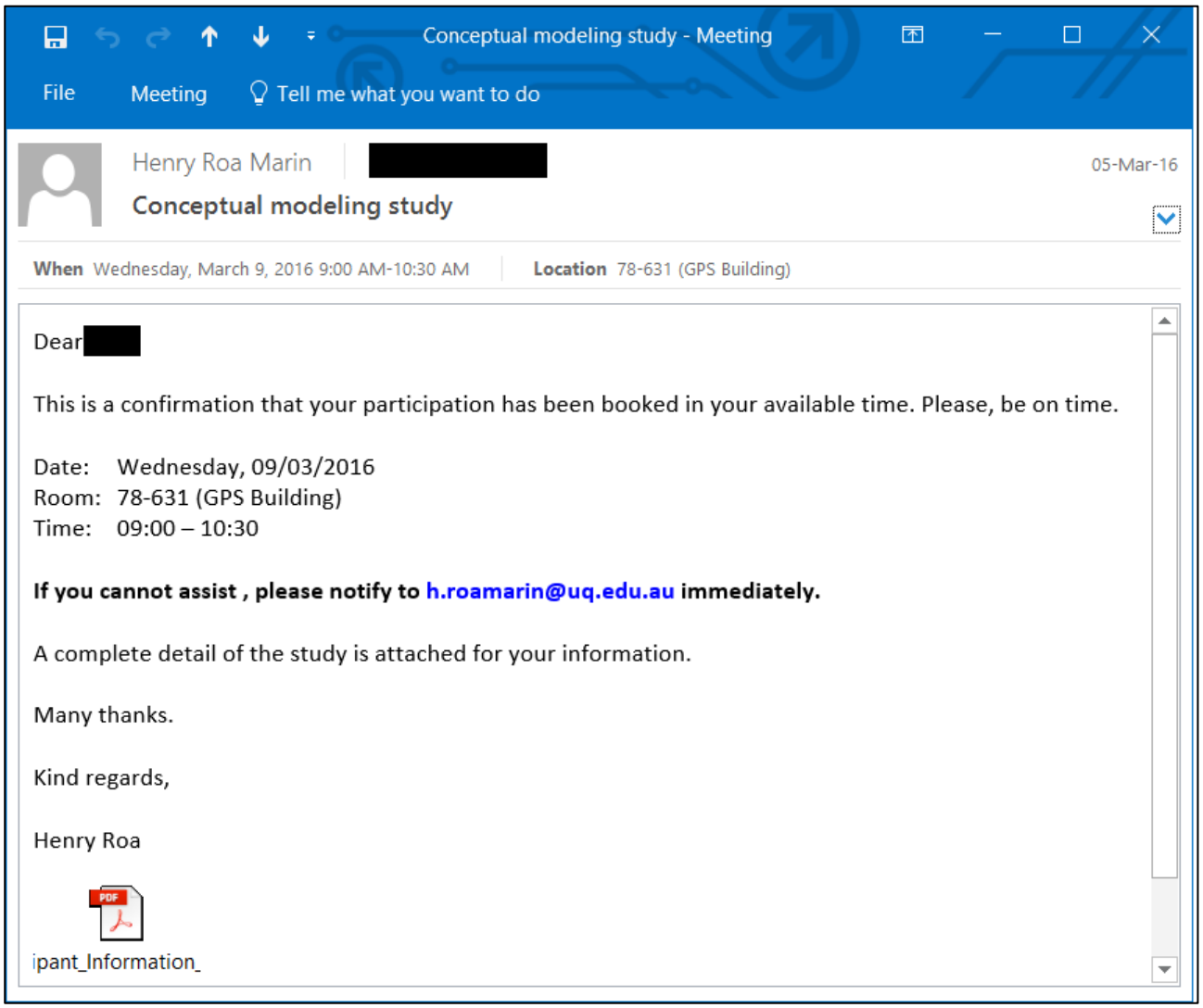
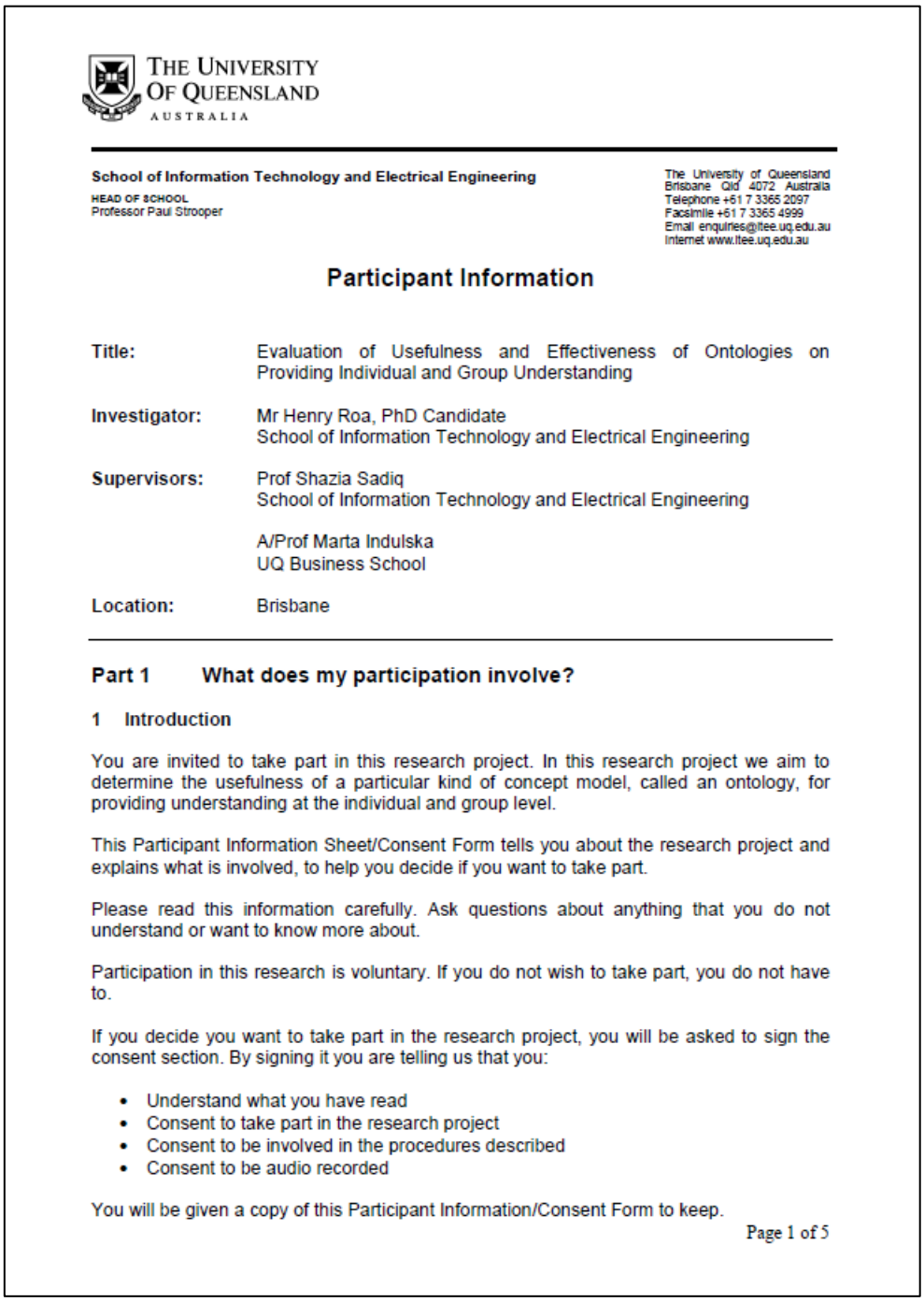


Figure A-2. Appointment Mail Example

A.3 PARTICIPANT INFORMATION AND CONSENT FORM



THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

School of Information Technology and Electrical Engineering
HEAD OF SCHOOL
Professor Paul Strooper

The University of Queensland
Brisbane Qld 4072 Australia
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Email enquiries@itee.uq.edu.au
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Participant Information

Title: Evaluation of Usefulness and Effectiveness of Ontologies on Providing Individual and Group Understanding

Investigator: Mr Henry Roa, PhD Candidate
School of Information Technology and Electrical Engineering

Supervisors: Prof Shazia Sadiq
School of Information Technology and Electrical Engineering

A/Prof Marta Indulska
UQ Business School

Location: Brisbane

Part 1 What does my participation involve?

1 Introduction

You are invited to take part in this research project. In this research project we aim to determine the usefulness of a particular kind of concept model, called an ontology, for providing understanding at the individual and group level.

This Participant Information Sheet/Consent Form tells you about the research project and explains what is involved, to help you decide if you want to take part.

Please read this information carefully. Ask questions about anything that you do not understand or want to know more about.

Participation in this research is voluntary. If you do not wish to take part, you do not have to.

If you decide you want to take part in the research project, you will be asked to sign the consent section. By signing it you are telling us that you:

- Understand what you have read
- Consent to take part in the research project
- Consent to be involved in the procedures described
- Consent to be audio recorded

You will be given a copy of this Participant Information/Consent Form to keep.

Figure A-3. Participant Information and Consent form 1-5

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AUSTRALIA

2 What is the purpose of this research project?

The purpose of this research project is to understand the usefulness and effectiveness of ontologies on providing understanding, at the individual and group level. Ontologies are a particular kind of conceptual models that represent a portion of specific domain through concepts and relations. We are looking for the main characteristics which allow these conceptual models to transfer knowledge about a particular domain effectively.

3 What does participation in this research project involve?

A short introduction into the research will be conducted in lay terms. This will involve a basic introduction into what ontologies are and how they are used.

The study will take place at The University of Queensland at a quiet, neutral, private location (such as a conference room) where you will not be distracted. You will be paired with another student participant in order to discuss a particular topic related with a particular domain, through the use of the ontology as a tool of discussion.

Parts of the study will be audio recorded through the use of an iPad so the full value of your comments can be used. You will be notified when this takes place. Other data will be collected through some questionnaires.

Your involvement in the study will not exceed two hours of your time, and will occur at an agreed upon time at your convenience.

4 What are the possible benefits to you?

You will receive $50 cash as thanks for your participation and reimbursement of your time. You may also learn about the results of the study (More information regarding this option is available in section 7).

If you withdraw from the experiment, you will be paid at a pro-rata rate for your participation (e.g. if you decide to withdraw after 1 hour, you will receive $25).

5 What are the possible risks?

There are no risks foreseen beyond those of normal living. In the unlikely event that you become upset or distressed as a result of your participation in the research, please refer to the last paragraph for contact details to speak with an officer of the University. You have the right to stop any time you wish during the session, simply by informing either the researcher or his supervisor. You do not need to give any reasons for not participating or withdrawing from the study and your data will be excluded from the research.

6 Do I have to take part in this research project?

Participation in any research project is voluntary. If you do not wish to take part, you do not have to. If you decide to take part and later change your mind, you are free to withdraw from the project at a later stage.

Figure A-4. Participant Information and Consent form 2-5

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AUSTRALIA

If you decide to withdraw, please notify the researcher as soon as possible.

Your decision whether to take part or not, or to take part and then withdraw, will not affect your relationship with the researchers, your studies, or with The University of Queensland.

7 How will I be informed of the final results of this research project?

If you are interested, we can send you a copy of the final outcomes of this research project. We expect to start producing peer-reviewed papers in about a year from now. Please check the box in the signature section and provide an email address if you are interested in receiving a write-up of the results.

Part 2 How is the research project being conducted?

8 What will happen to information about me?

When information is collected from you, it will be collected with a Participant ID code, rather than with your name. No personal information is stored which links the Participant ID code to the participant.

Audio recording of this study has the potential to identify you by voice. This information, and any other information obtained in connection with this research project that can identify you, will remain confidential, and will only be used for the purpose of this research project. Additionally, the information will be kept on UQ password protected computers and any hard copies will be stored in locked filing cabinets in the researcher's office.

The only people who will see the raw data will be the study researchers. The raw data will be used for the present study alone with analyzed data being used in subsequent publications/presentations.

In any subsequent publication and/or presentation, information will be provided in such a way that you cannot be identified.

9 Can I access research information kept about me?

In accordance with relevant Australian and/or Queensland privacy laws, and other relevant laws, you have the right to access the information collected and stored by the researchers about you. Please contact one of the researchers named at the end of this document if you would like to access your information.

Please note, however, that the information collected about you will not be identifiable as after the participant ID has been assigned. The participant ID will be assigned upon the commencement of the experimental tasks. Access to information about your specific contributions after this point will not be possible.

10 Is this research project approved?

The ethical aspects of this research project have been approved by the Ethics Committee of the School of ITEE, which operates under the auspices of the Human Research Ethics Committee of The University of Queensland.

Figure A-5. Participant Information and Consent form 3-5

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AUSTRALIA

11 Who can I contact?

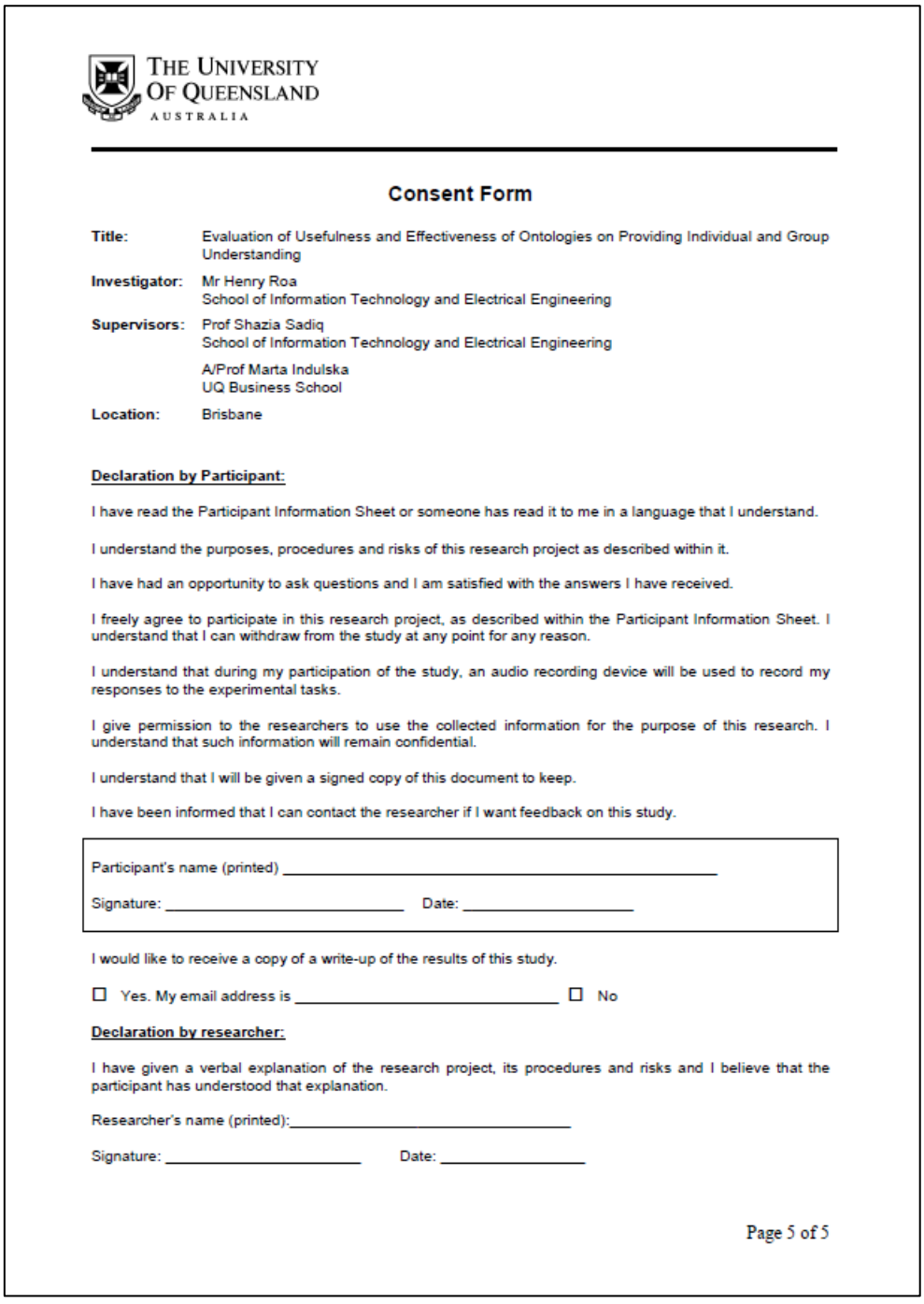
If you want any further information concerning this project or if you have any problems which may be related to your involvement in the project (for example, feelings of distress), you can contact the principal researcher, Henry Roa, on: 3365 1186 or at: h.roamarin@uq.edu.au. You will also be invited to offer feedback to the research team members, either verbally or in writing, at the end of the study and you are welcome to offer feedback at any time later.

Professor Shazia Sadiq
School of Information Technology and Electrical Engineering
shazia@itee.uq.edu.au
3365 1999

A/Prof. Marta Indulska
UQ Business School
m.indulska@business.uq.edu.au
3346 8034

This study adheres to the Guidelines of the ethical review process of The University of Queensland and the National Statement on Ethical Conduct in Human Research. Whilst you are free to discuss your participation in this study with project staff (contactable on: 336 51186 or at: h.roamarin@uq.edu.au), if you would like to speak to an officer of the University not involved in the study, you may contact the Ethics Coordinator on 3365 3924.

Figure A-6. Participant Information and Consent form 4-5



THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Consent Form

Title: Evaluation of Usefulness and Effectiveness of Ontologies on Providing Individual and Group Understanding

Investigator: Mr Henry Roa
School of Information Technology and Electrical Engineering

Supervisors: Prof Shazia Sadiq
School of Information Technology and Electrical Engineering

A/Prof Marta Indulska
UQ Business School

Location: Brisbane

Declaration by Participant:

I have read the Participant Information Sheet or someone has read it to me in a language that I understand.

I understand the purposes, procedures and risks of this research project as described within it.

I have had an opportunity to ask questions and I am satisfied with the answers I have received.

I freely agree to participate in this research project, as described within the Participant Information Sheet. I understand that I can withdraw from the study at any point for any reason.

I understand that during my participation of the study, an audio recording device will be used to record my responses to the experimental tasks.

I give permission to the researchers to use the collected information for the purpose of this research. I understand that such information will remain confidential.

I understand that I will be given a signed copy of this document to keep.

I have been informed that I can contact the researcher if I want feedback on this study.

Participant's name (printed) _____

Signature: _____ Date: _____

I would like to receive a copy of a write-up of the results of this study.

☐ Yes. My email address is _____ ☐ No

Declaration by researcher:

I have given a verbal explanation of the research project, its procedures and risks and I believe that the participant has understood that explanation.

Researcher's name (printed):_____

Signature: _____ Date: _____

Page 5 of 5

Figure A-7. Participant Information and Consent form 5-5

APPENDIX B. ETHICAL CLEARANCE DOCUMENTS

SCHOOL OF INFORMATION TECHNOLOGY AND ELECTRICAL ENGINEERING

ETHICS COMMITTEE

OUTCOME OF REVIEW

APPLICATION DETAILS:

Reference:	EC201406ROA
Name:	Henry N Roa
Student Number:	43008254
Project Title:	Evaluation of Usefulness and Effectiveness of Ontologies on Providing Individual and Group Understanding
Principal Advisor:	Prof Shazia Sadiq, A/Prof Marta Indulska

Date Received:	
Expedited Review:	No
Date Reviewed:	26 August 2014

OUTCOME OF REVIEW:

☑ Approved (subject to filing of minor amendments)	(Approval is for 12 Months)	Approved From: 26/8/2014	Approved To: 25/8/2014
☐ Request Amendment			
☐ Require Submission to BSSERC/MREC			

COMMENTS:

My apologies for the delay on finalising processing of this application –I am on SSP and Emma's messages fell between the cracks.

There are just a few relatively small things to amend, which I have outlined in the attached documents.

1. Need more information on how you approach participants. (1) Need lecturer "gatekeeper" approval (keep documentation of that) and (2) lecturer should not provide you with students' email addresses, but lecturer can forward an email from you to the students, and students should be given your email address so they can reply to you.
2. Just need a few small changes because your audio data makes your participants potentially identifiable. However your protections of the audio data are acceptable.
3. See also a few further small nits in the application form and on the information and consent sheet.

Please make the changes (or accept the changes I have indicated in the two documents) and return the documents to Emma for our records. Then we will send you an unconditionally approved version of this outcome document.

Penny Sanderson

Signature: **Date:** 26 August 2014

Chair, ITEE Ethics Committee

Figure B-1. Approved Ethical Clearance

SCHOOL OF INFORMATION TECHNOLOGY AND ELECTRICAL ENGINEERING

ETHICS COMMITTEE

OUTCOME OF REVIEW

APPLICATION DETAILS:

Reference:	EC201406ROA
Name:	Henry N Roa
Student Number:	43008254
Project Title:	Evaluation of Usefulness and Effectiveness of Ontologies on Providing Individual and Group Understanding
Principal Advisor:	Prof Shazia Sadiq, A/Prof Marta Indulska

Date Received:	
Expedited Review:	No
Date Reviewed:	26 August 2014

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COMMENTS:

My apologies for the delay on finalising processing of this application –I am on SSP and Emma's messages fell between the cracks.

There are just a few relatively small things to amend, which I have outlined in the attached documents.

1. Need more information on how you approach participants. (1) Need lecturer "gatekeeper" approval (keep documentation of that) and (2) lecturer should not provide you with students' email addresses, but lecturer can forward an email from you to the students, and students should be given your email address so they can reply to you.
2. Just need a few small changes because your audio data makes your participants potentially identifiable. However your protections of the audio data are acceptable.
3. See also a few further small nits in the application form and on the information and consent sheet.

Please make the changes (or accept the changes I have indicated in the two documents) and return the documents to Emma for our records. Then we will send you an unconditionally approved version of this outcome document.

Penny Sanderson

Signature: _____ **Date:** 26 August 2014

Chair, ITEE Ethics Committee

Figure B-2. Approval of Ethical Clearance Amendment

SCHOOL OF INFORMATION TECHNOLOGY AND ELECTRICAL ENGINEERING

ETHICS COMMITTEE

OUTCOME OF REVIEW

APPLICATION DETAILS:

Reference:	EC201509ROA_B
Name:	Henry Roa
Student Number:	43008254
Project Title:	Evaluation of Usefulness and Effectiveness of Ontologies on Providing Individual and Group Understanding
Principal Advisor:	Prof Shazia Sadiq A/Prof Marta Indulska

Date Received:	08-02-2016
Expedited Review:	No
Date Reviewed:	17-02-2016

OUTCOME OF REVIEW:

X Approved	(Approval is for 12 Months)	Approved From: 01-03-2016	Approved To: 23-01-2017
X Request Amendment			
☐ Require Submission to BSSERC/MREC			

COMMENTS:

Your ethics application #EC201509ROA_B has been approved, provided the following changes are made:

- Include wording in your Participant Information sheet and at items 3 and 5 in the amendment form to explain that if a participant withdraws from the study, they will be paid at a pro-rata rate for their participation (e.g. if they decide to withdraw after 1 hour, they will receive $25)

Please submit final versions of the forms to ITEE ethics office – rao@itee.uq.edu.au

Approval is for the duration
From: 01-03-2016
To: 23-01-2017

Prof Penelope Sanderson

Signature: **Date:** 29/02/2016

Chair, ITEE Ethics Committee

Figure B-3. Approval of Ethical Clearance Amendment

APPENDIX C. EXPERIMENTAL TRAINING MATERIALS

C.1 TRAINING SECTION FOR TREATMENT GROUP

In this task, you will be introduced to a particular approach for representing information about a domain or topic. The key concepts used in the approach are described below.

A class (represented by a rectangle) is the name of a concept in a particular domain. For example, *Student*, *University* and *Course*, are classes of the Student Registration domain. Figure 1 shows the representation of the *Student* class.

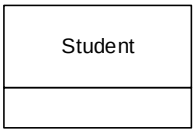


Figure C-1. Example of Student class

A class is described by attributes called properties that describe the class itself. These properties are mentioned within the class. For example, *studentName* and *dateOfBirth* are the properties of the class *Student* – see Figure 2.

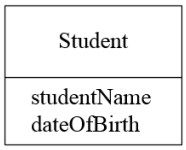


Figure C-2. Properties that describe the student class

Relationships relate one class to another class and are represented through arrows, for example the relationship *takes* connects the *Student* class with the *Course* class – see Figure 3. Figure 3 also shows another relationship, *isTakenBy*, which expresses that 'Course is taken by Student'.

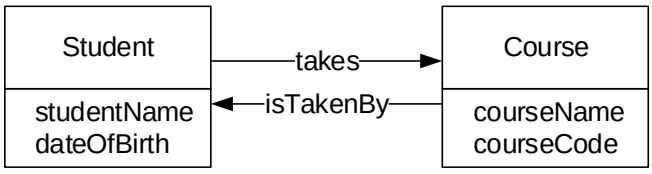


Figure C-3. Relationships

A subclass describes a specialization of the concept of class. A white arrowhead indicates the subclass belongs to its parent class. The arrow originates from the subclass and points towards its parent class. For example, in Figure 4, *Student* is a subclass of *Person*.

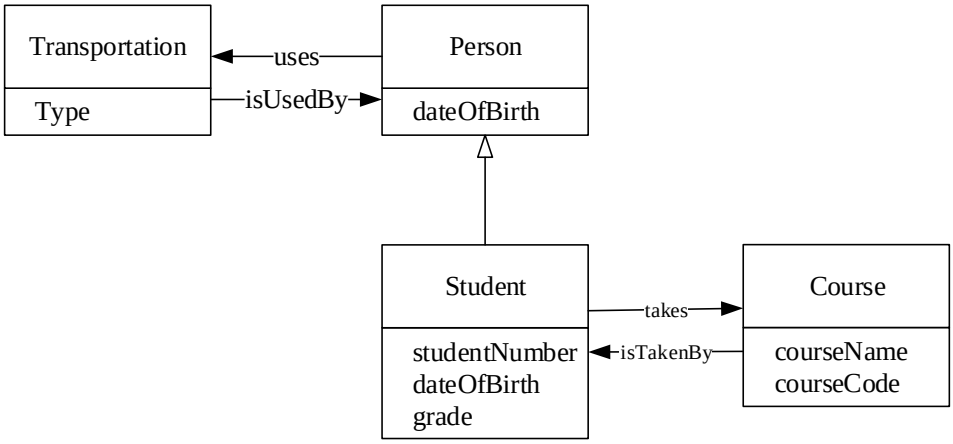


Figure C-4. Student Subclass

The properties of a class are inherited by its subclass. For example, in Figure 4, *Student* inherits the *dateOfBirth* property belonging to *Person*.

The relationships of a class are also inherited by its subclass, but not explicitly represented on the model. For example, in Figure 4 a *person* uses *transportation*, thus a *student* also uses *transportation* because *Student* is a subclass of *Person*.

To demonstrate how information of a domain is represented using the above approach, we will use a specific example. Consider the situation that a student holds a library membership (Figure 5). *Student*, *Membership*, and *Library* are shown as three classes and their relationships are indicated by arrows between these classes. A student can borrow books; thus the *Student* class is related to the *Book* class by a relationship *borrows*. Also, a book can be borrowed by students, thus the *Book* class is related to the *Student* class by a relationship *isBorrowedBy*.

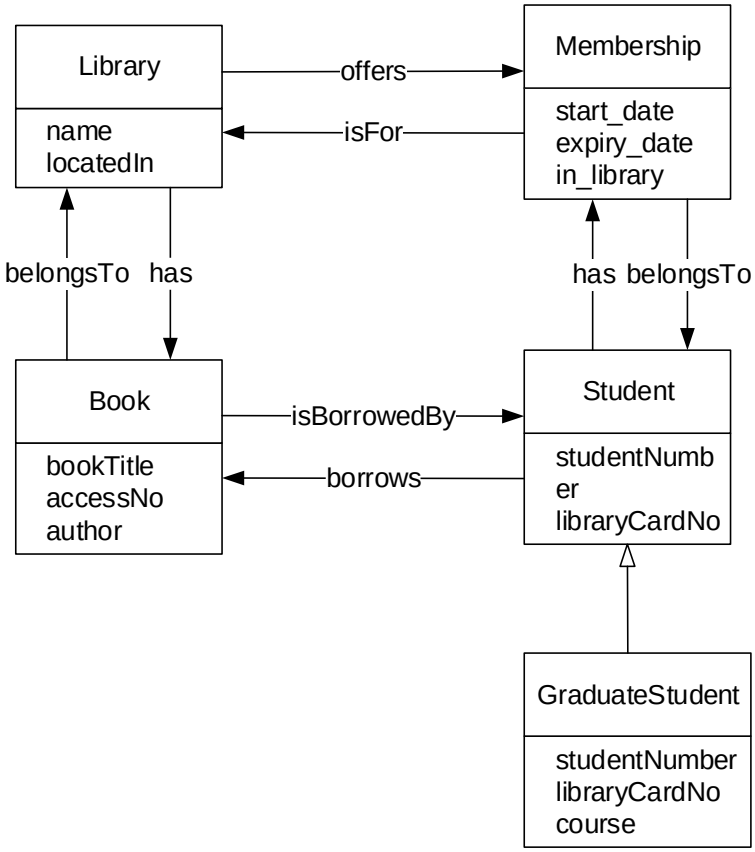


Figure C-5. Library subscription domain

All the classes have internal properties. For example, a library has a name and is located in a particular address. Another example is that a book has its own title, access number, and author.

A graduate student is a student who has taken some graduate courses. Thus, *Graduate Student* is a subclass of the *Student* class. Because it is a subclass, all the properties of the *Student* class are inherited by the *Graduate Student* class as shown on Figure 5. Similarly, all the relationships belonging to the *Student* class are inherited by the *Graduate Student* subclass. For example, a graduate student borrows book in the same way that a student borrows book.

C.2 PRACTICE QUESTIONS

In this experiment, you will be asked to answer true/false statements and provide an explanation of your answer by viewing some diagrams. These are practice statements to follow to familiarize you with the type of questions.
Using the information provided answer the following statements and write your answers on the form.

1. Every final itinerary has a reservation.

☐ True
☐ False
☐ I don’t know

Which part of the documentation or what information allowed you to come to your answer:

2. A service provider is involved in preparing initial itineraries.

☐ True
☐ False
☐ I don’t know

Which part of the documentation or what information allowed you to come to your answer:

3. Any person can make a reservation.

☐ True

☐ False

☐ I don’t know

Which part of the documentation or what information allowed you to come to your answer:

4. Preparing final itineraries involves a service provider.

☐ True

☐ False

☐ I don’t know

Which part of the documentation or what information allowed you to come to your answer:

5. Preparing final itineraries involves a travel agent.

☐ True

☐ False

☐ I don’t know

Which part of the documentation or what information allowed you to come to your answer:

6. Every initial itinerary has a reservation.

☐ True

☐ False

☐ I don’t know

Which part of the documentation or what information allowed you to come to your answer:

7. Every itinerary has a departure date and return date.

☐ True

☐ False

☐ I don’t know

Which part of the documentation or what information allowed you to come to your answer:

8. Customers can participate in the elaboration of the initial itinerary.

☐ True

☐ False

☐ I don’t know

Which part of the documentation or what information allowed you to come to your answer:

C.3 TRAVEL DOMAIN ONTOLOGY

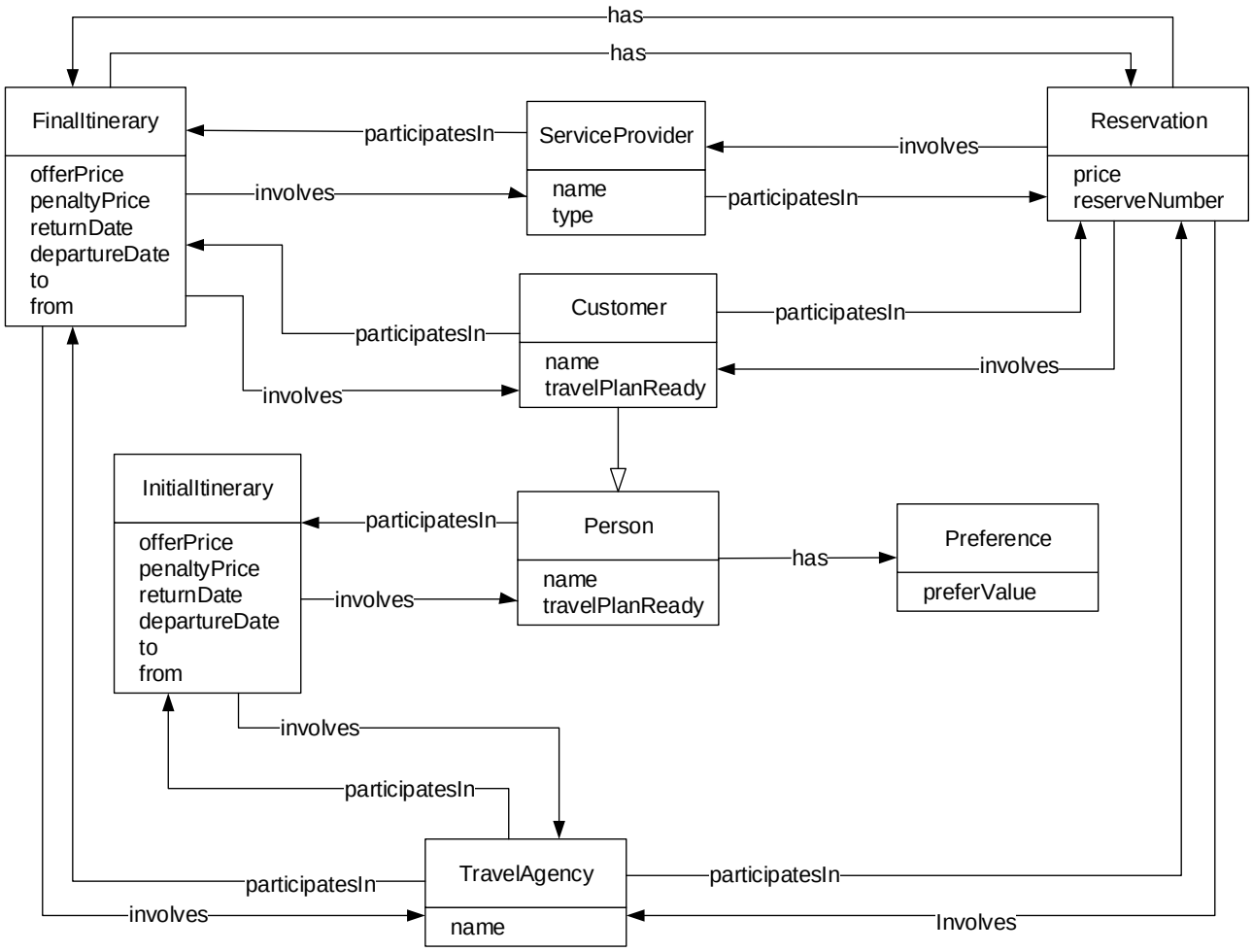


Figure C-6. Travel Domain Ontology

C.4 TRAVEL DOMAIN DESCRIPTION

"A travel agent helps customers to organize travel plans. Travel agents organize hotel bookings, airline tickets and entertainment tickets. A customer has travel preferences including departure time and return date. A travel agent proposes a travel itinerary to a person. Such itinerary is called initial itinerary. A travel itinerary is complete when the reservation is made. Such itinerary is called final itinerary. The reservation is a contract between the customer and the service provider. The travel agent does reservations when the final itinerary is complete and the customer is satisfied with the itinerary. The customer's preference is composed of the preference values for hotel, airline and entertainment."

C.5 GROUP TASK SECTION

In this section, first, you will complete a task individually and then, you will interact with your partner. Your interaction will be audio recorded to help with analysis. Please complete the following tasks.

1. Imagine you work as a compliance management expert in an organization. Your manager wants to have an idea of what issues, tasks or activities the company should consider in order to improve compliance management. Based on the information that you have, list six of the most important issues that you think the organization should consider in order to improve compliance management. Write your answers in the following table along with an explanation of your answers.

Issue to consider	Explanation
A.	
B.	
C.	
D.	
E.	
F.	

2. Participant A reads and explains his/her answer to his/her partner. Participant B completes the following table. If there is any disagreement on the answers, participants discuss the disagreement and write down any agreement on the table.

Partner's issue	Do you agree with your partner's issue?	Do you agree with your partner's explanation?	What was the agreement after the discussion?
1.	Yes ☐ No ☐	Yes ☐ No ☐ Partially ☐	
2.	Yes ☐ No ☐	Yes ☐ No ☐ Partially ☐	
3.	Yes ☐ No ☐	Yes ☐ No ☐ Partially ☐	
4.	Yes ☐ No ☐	Yes ☐ No ☐ Partially ☐	
5.	Yes ☐ No ☐	Yes ☐ No ☐ Partially ☐	
6.	Yes ☐ No ☐	Yes ☐ No ☐ Partially ☐	

3. Change the roles and complete the previous activity.
4. Return this sheet to the moderator.

APPENDIX D. DATA COLLECTION INSTRUMENT

D.1 INSTRUMENT FOR THE TREATMENT GROUP

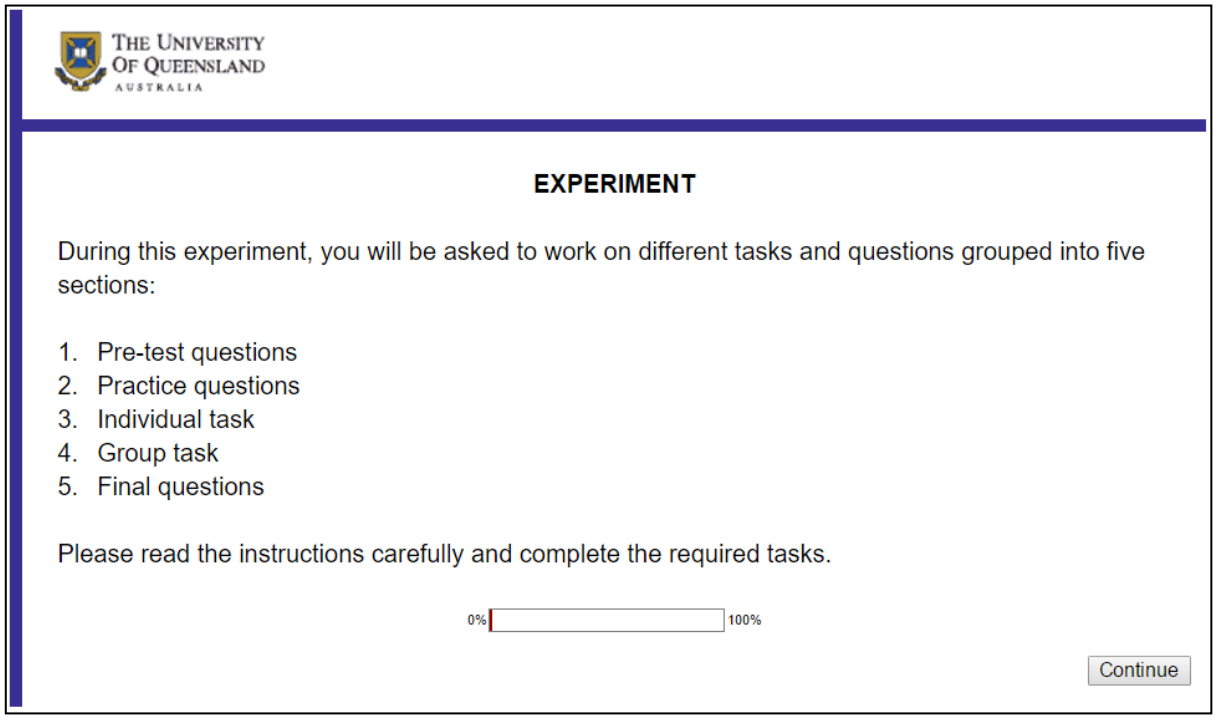


Figure D-1. Screenshot of the Experiment Introduction

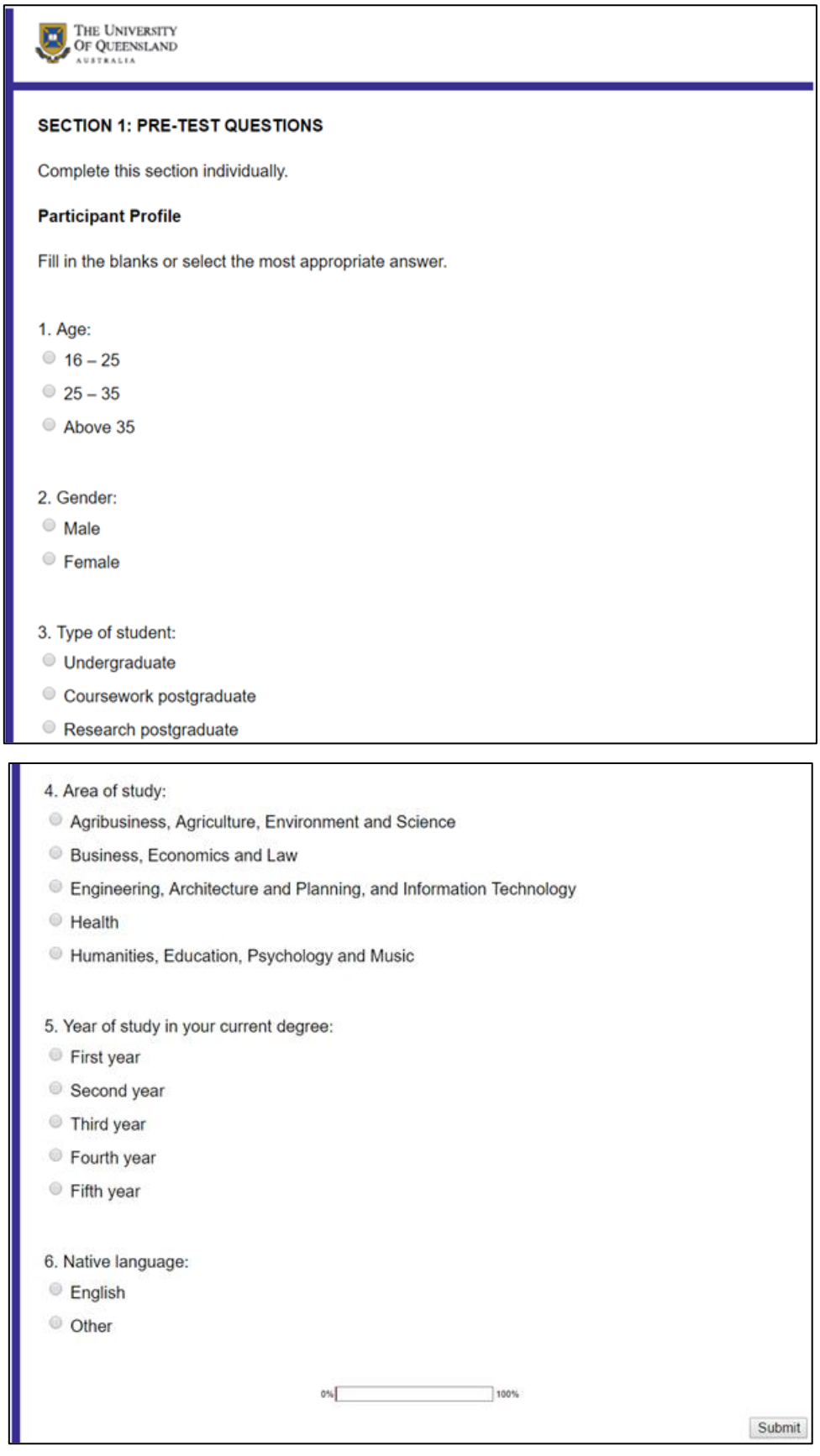


Figure D-2. Screenshots of the Pre-Test Questions

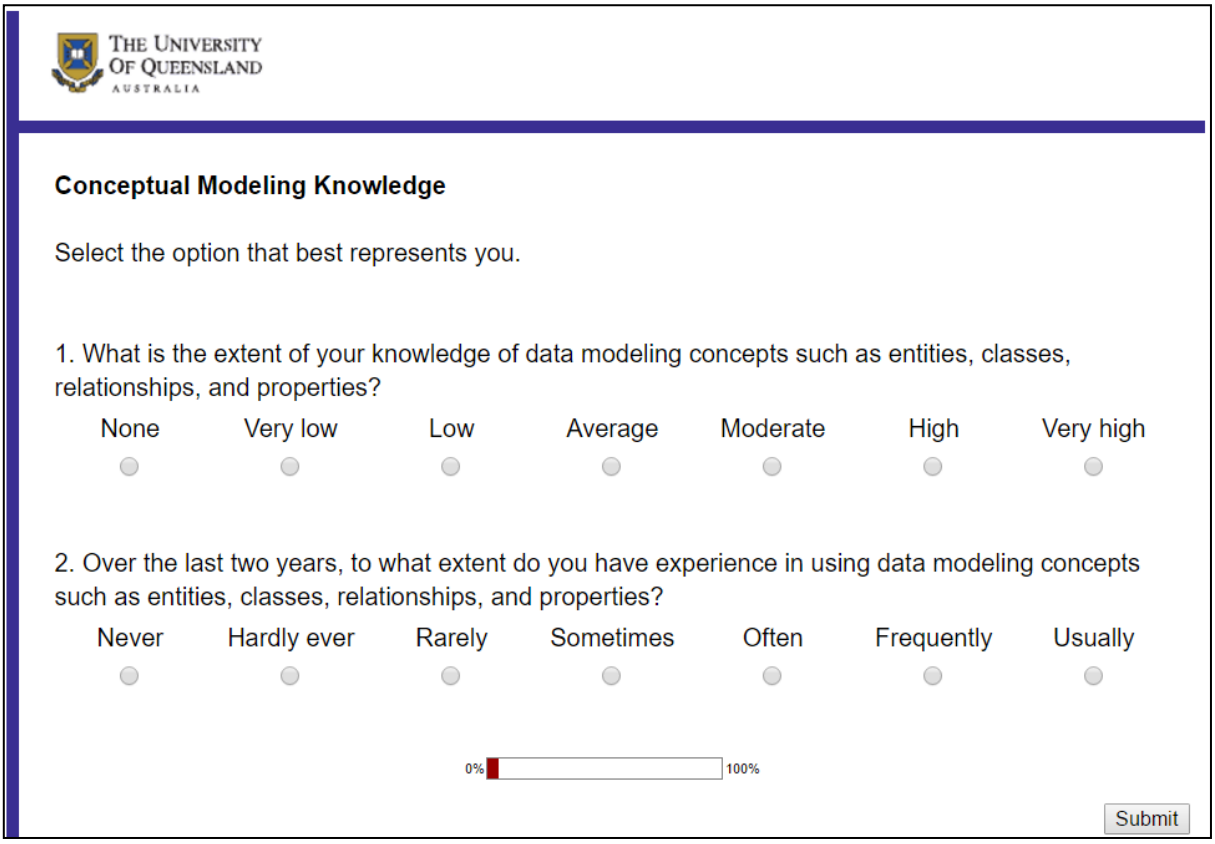


Figure D-3. Screenshot of the Conceptual Modeling Knowledge Questions

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

SECTION 2: PRACTICE QUESTIONS

1. TRAINING

In this task, you will be introduced to a particular approach for representing information about a domain or topic. The key concepts used in the approach are described below.

1. A **class** (represented by a rectangle) is the name of a concept in a particular domain. For example, *Student*, *University* and *Course*, are classes of the Student Registration domain. Figure 1 shows the representation of the *Student* class.

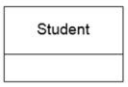


Figure 1. Example of Student class

2. A class is described by attributes called **properties** that describe the class itself. These properties are mentioned within the class. For example, *studentName* and *dateOfBirth* are the properties of the class *Student* – see Figure 2.

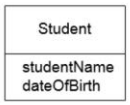


Figure 2. Properties that describe the student class

3. **Relationships** relate one class to another class and are represented through arrows, for example the relationship *takes* connects the *Student* class with the *Course* class – see Figure 3. Figure 3 also shows another relationship, *isTakenBy*, which expresses that 'Course is taken by Student'.

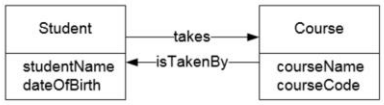


Figure 3. Relationships

4. A **subclass** describes a specialization of the concept of class. A white arrowhead indicates the subclass belongs to its parent class. The arrow originates from the subclass and points towards its parent class. For example, in Figure 4, *Student* is a subclass of *Person*.

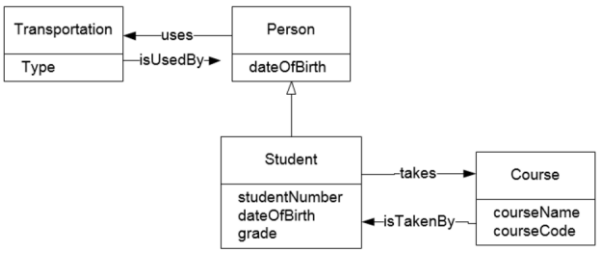


Figure 4. Student Subclass

5. The properties of a class are inherited by its subclass. For example, in Figure 4, *Student* inherits the *dateOfBirth* property belonging to *Person*.

6. The relationships of a class are also inherited by its subclass, but not explicitly represented on the model. For example, in Figure 4 a *person* uses *transportation*, thus a *student* also uses *transportation* because *Student* is a subclass of *Person*.

To demonstrate how information of a domain is represented using the above approach, we will use a specific example. Consider the situation that a student holds a library membership (Figure 5). *Student*, *Membership*, and *Library* are shown as three classes and their relationships are indicated by arrows between these classes. A student can borrow books, thus the *Student* class is related to the *Book* class by a relationship *borrows*. Also, a book can be borrowed by students, thus the *Book* class is related to the *Student* class by a relationship *isBorrowedBy*.

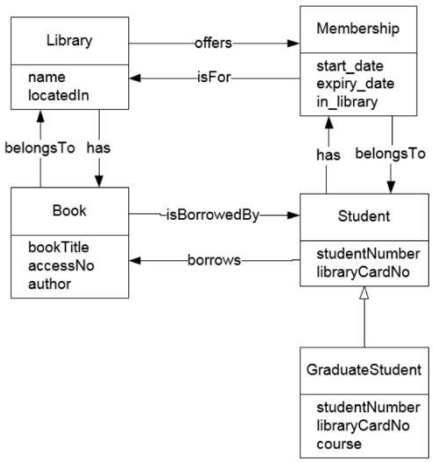


Figure 5. Library subscription domain

All the classes have internal properties. For example, a library has a name and is located in a particular address. Another example is that a book has its own title, access number, and author.
A graduate student is a student who has taken some graduate courses. Thus, *Graduate Student* is a subclass of the *Student* class. Because it is a subclass, all the properties of the *Student* class are inherited by the *Graduate Student* class as shown on Figure 5. Similarly, all the relationships belonging to the *Student* class are inherited by the *Graduate Student* subclass. For example, a graduate student borrows book in the same way that a student borrows book.

0% 100%

Continue

Figure D-4. Screenshot of the Training Section

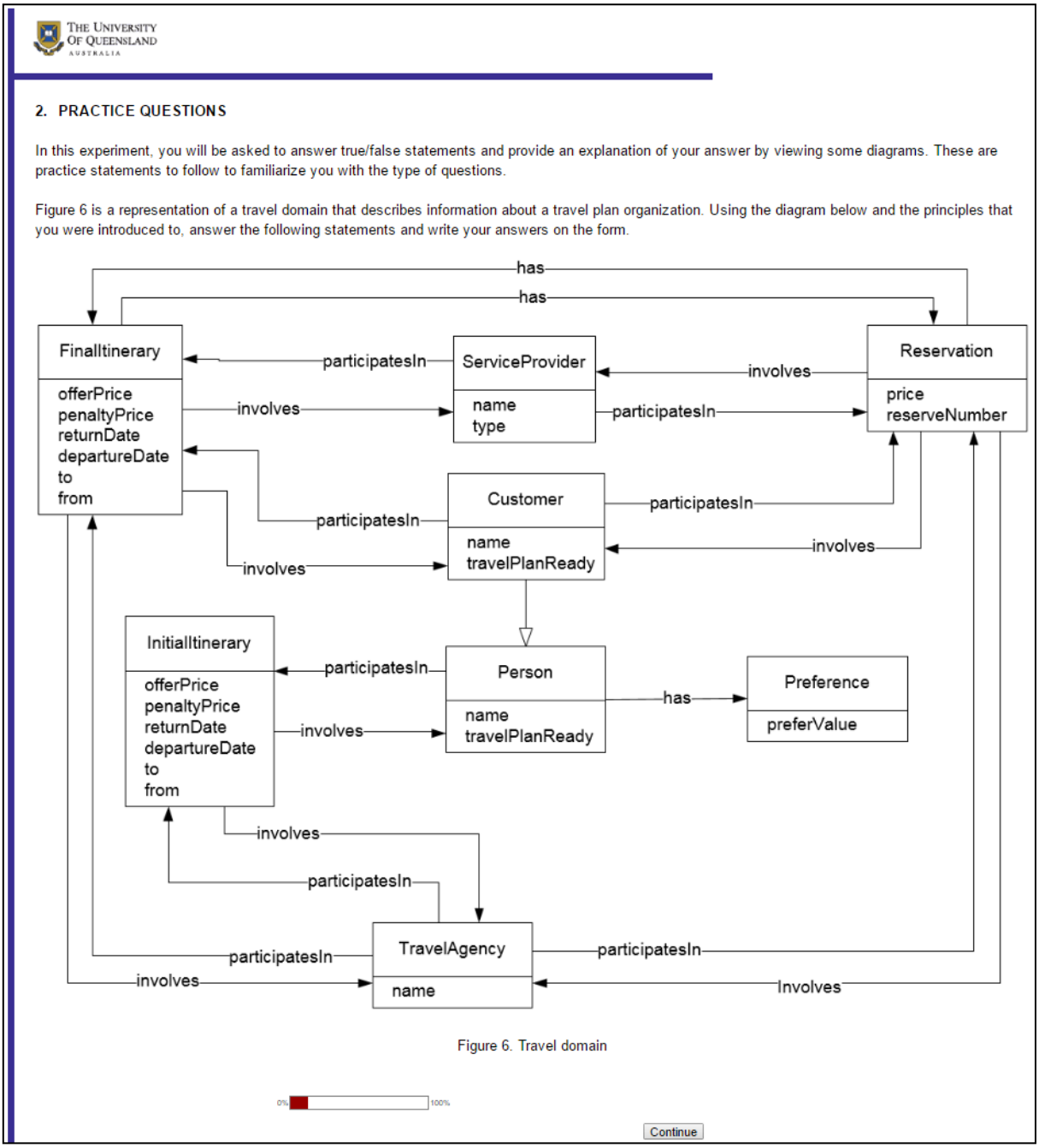


Figure D-5. Screenshot of the Practice Questions Section

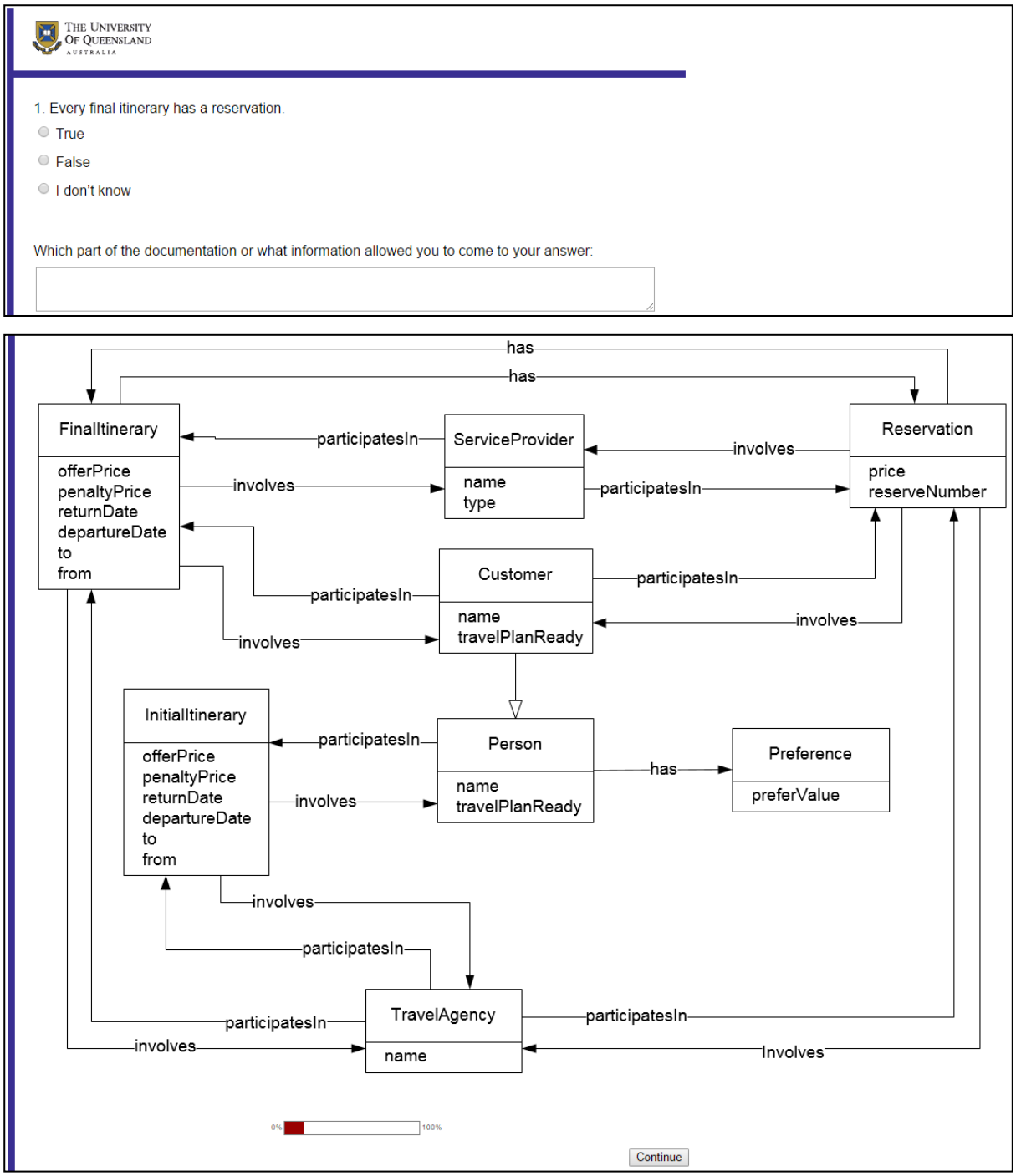


Figure D-6. Screenshot of the Practice Question 1

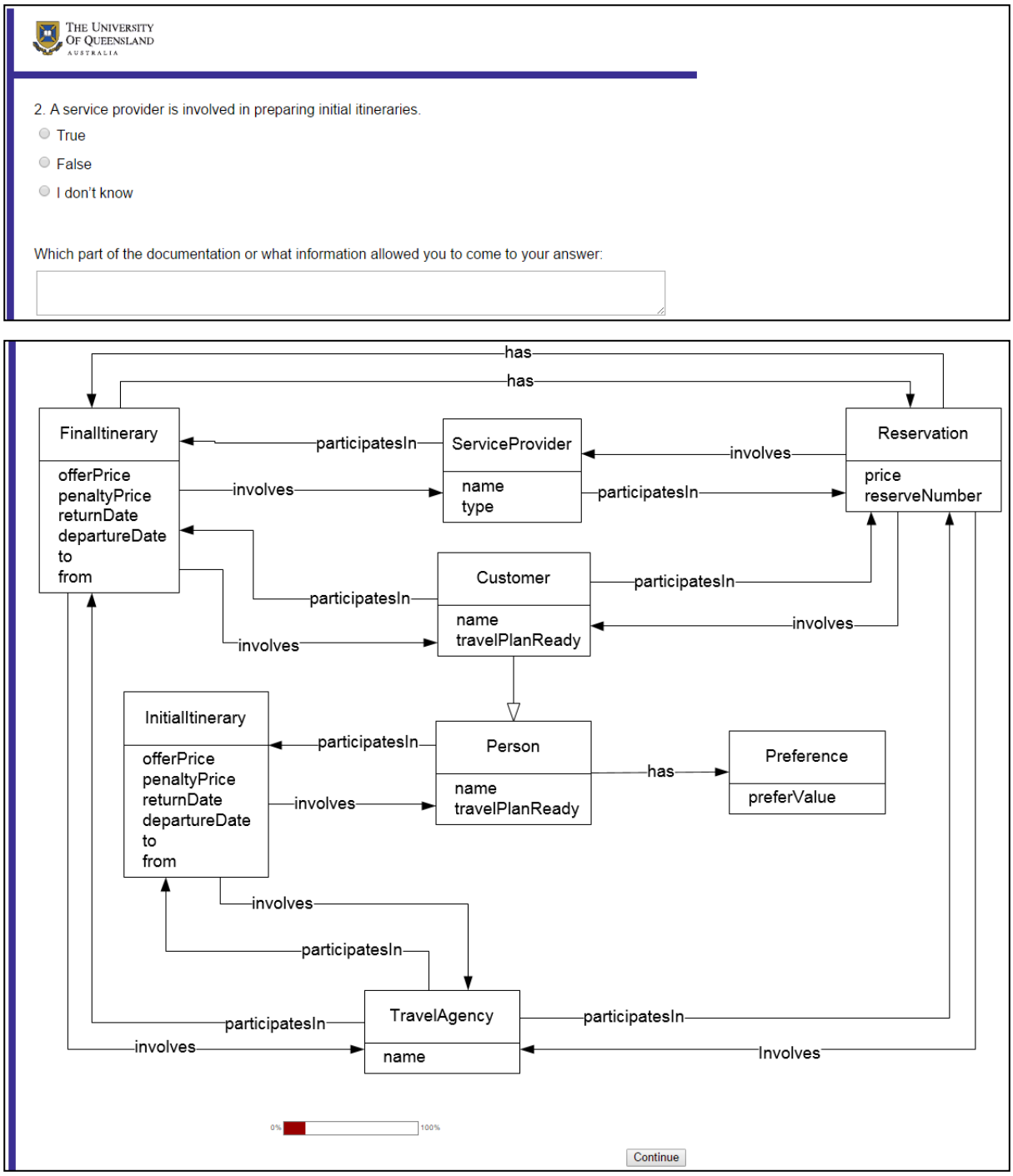


Figure D-7. Screenshot of the Practice Question 2

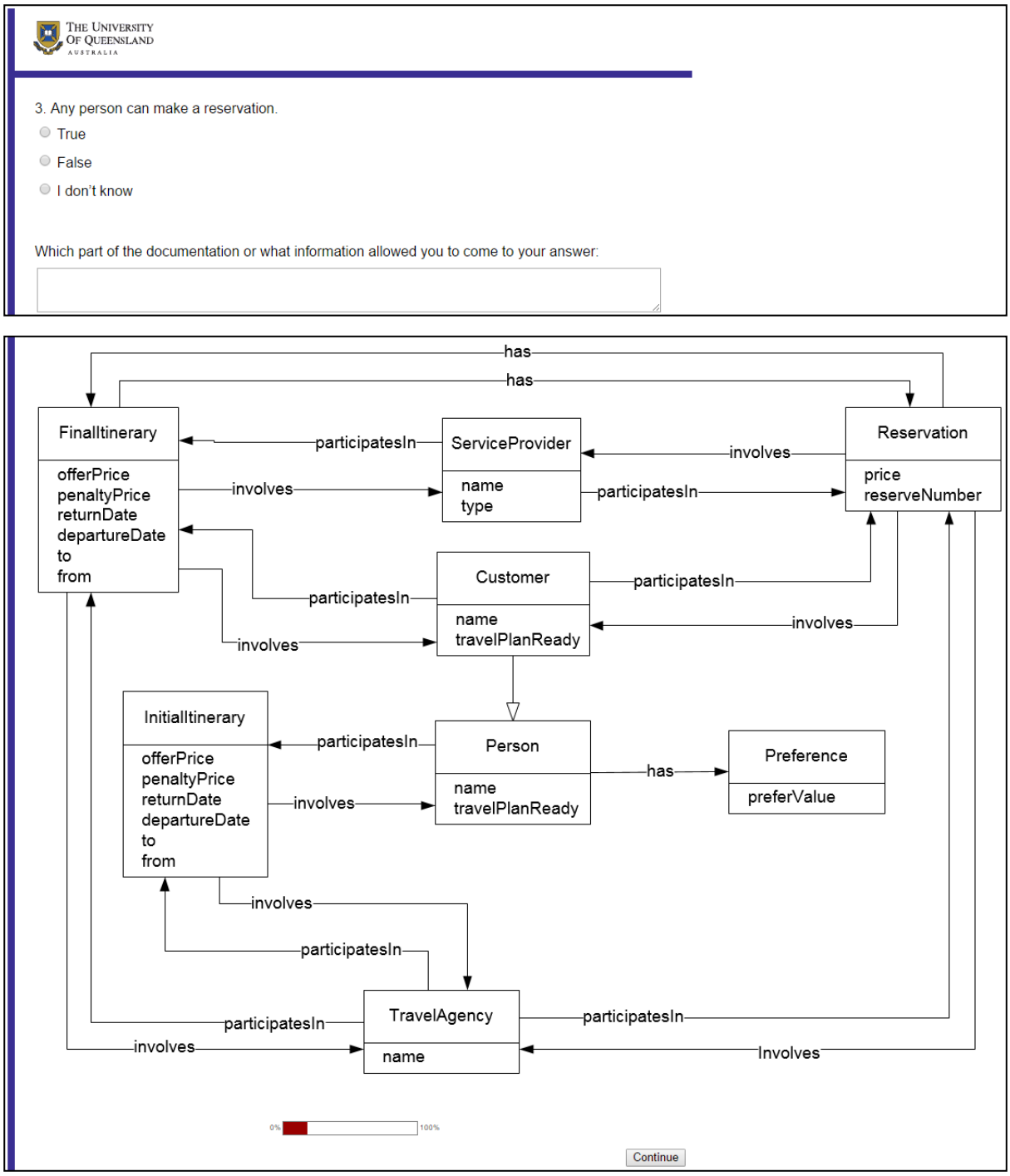


Figure D-8. Screenshot of the Practice Question 3

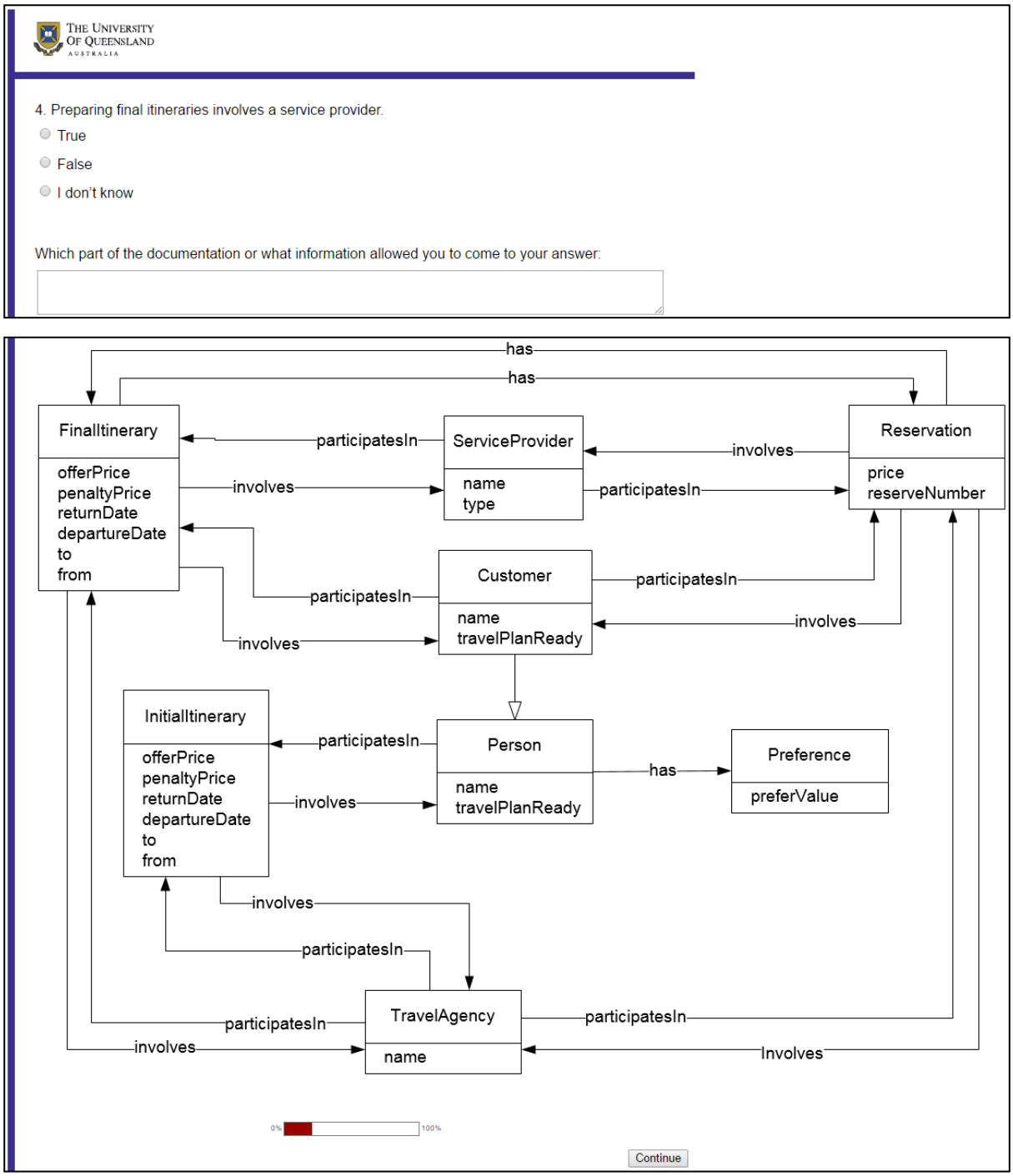


Figure D-9. Screenshot of the Practice Question 4

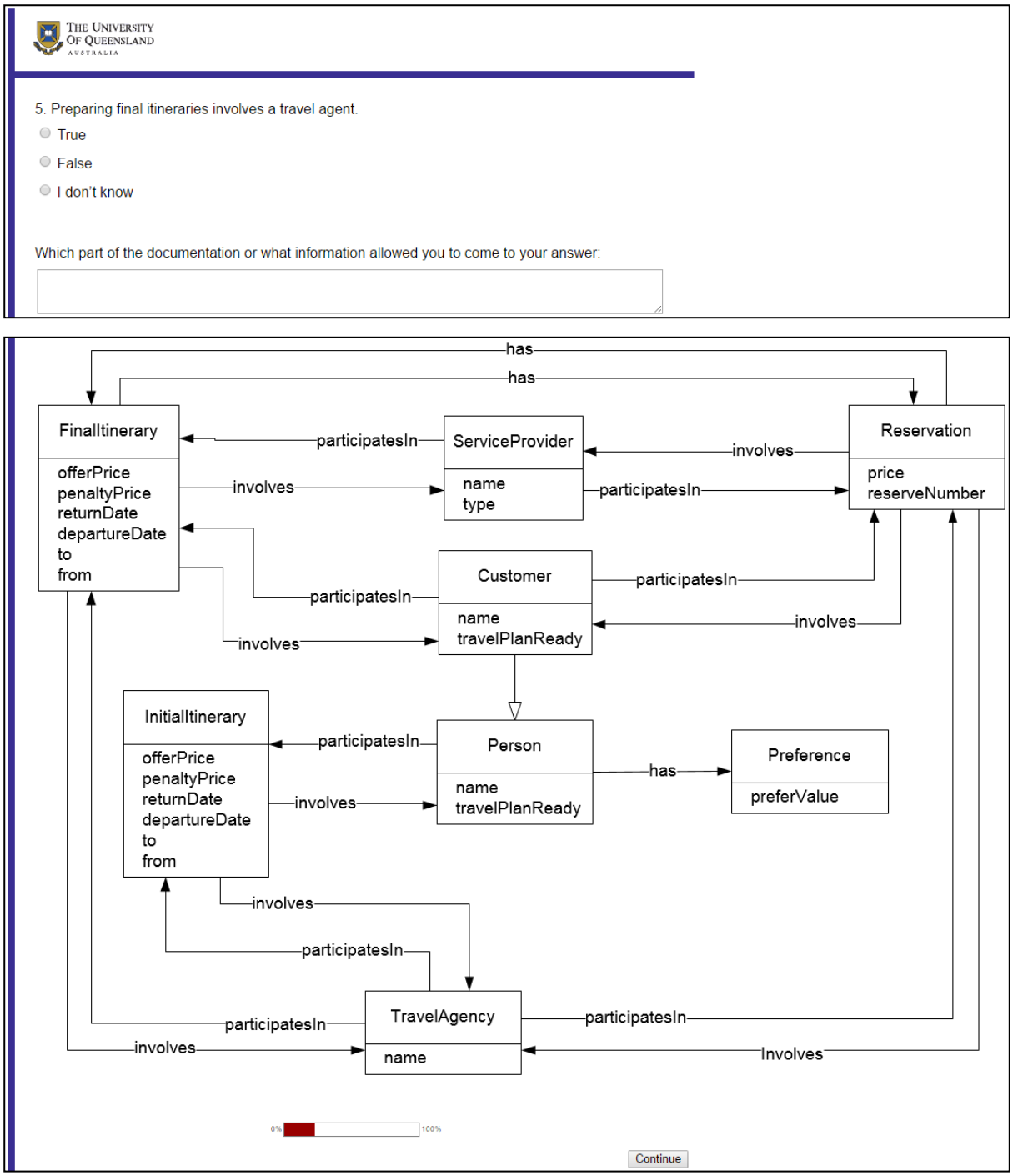


Figure D-10. Screenshot of the Practice Question 5

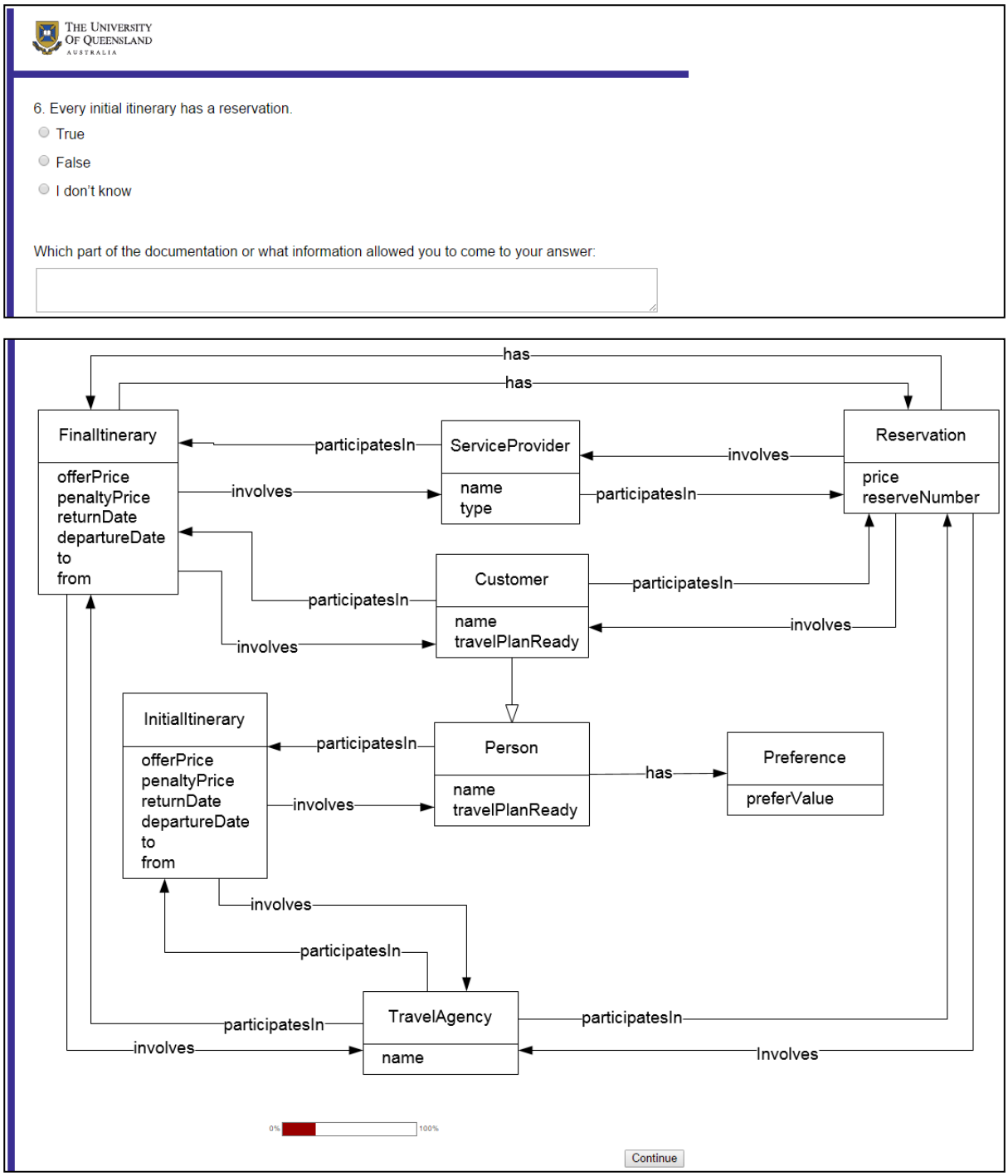


Figure D-11. Screenshot of the Practice Question 6

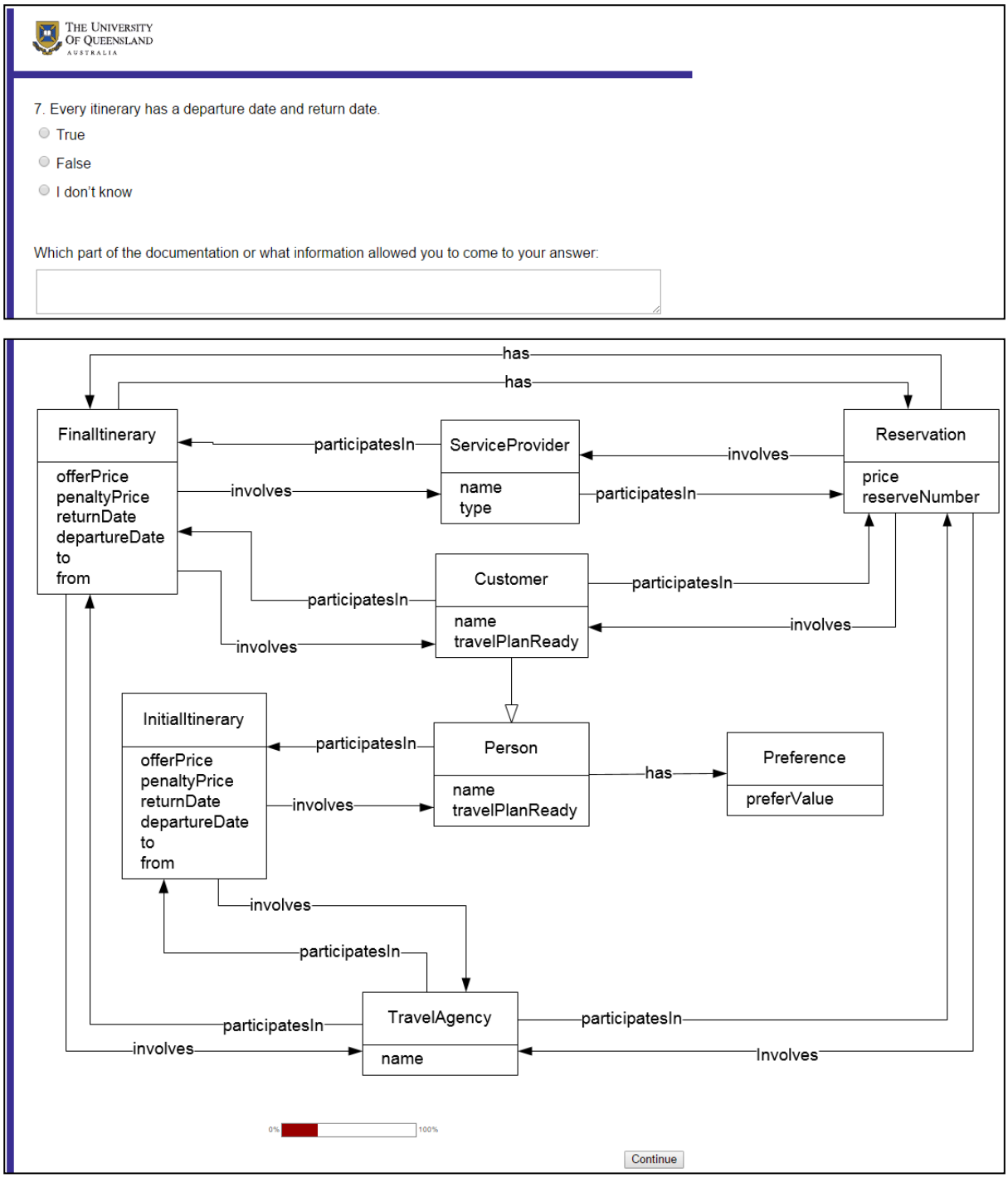


Figure D-12. Screenshot of the Practice Question 7

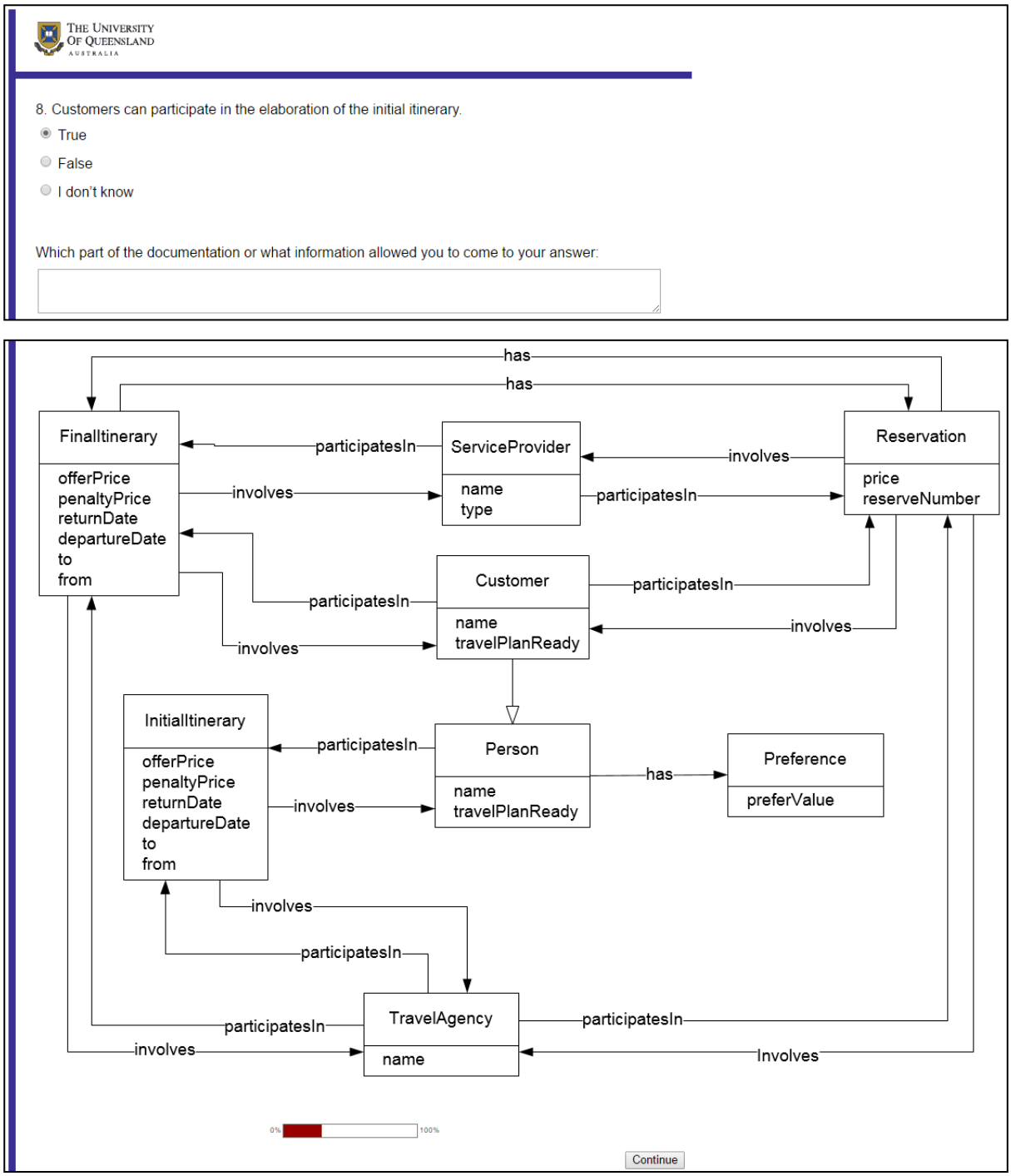


Figure D-13. Screenshot of the Practice Question 8

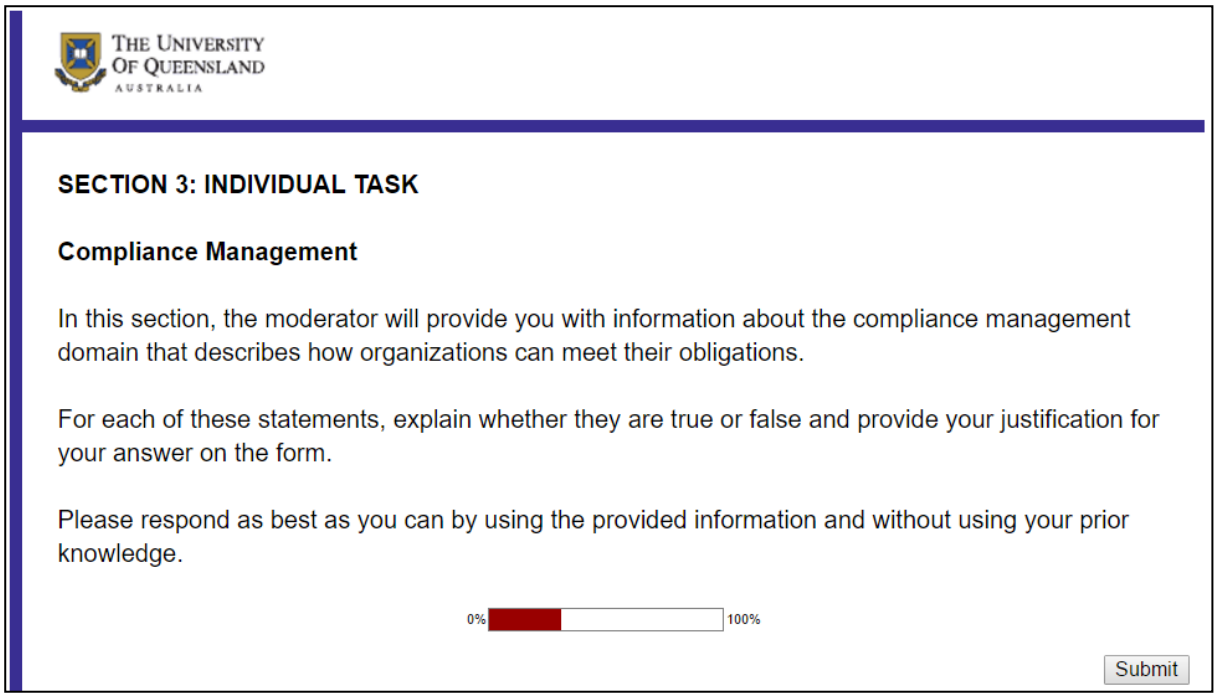


Figure D-14. Screenshot of the Individual Task Section

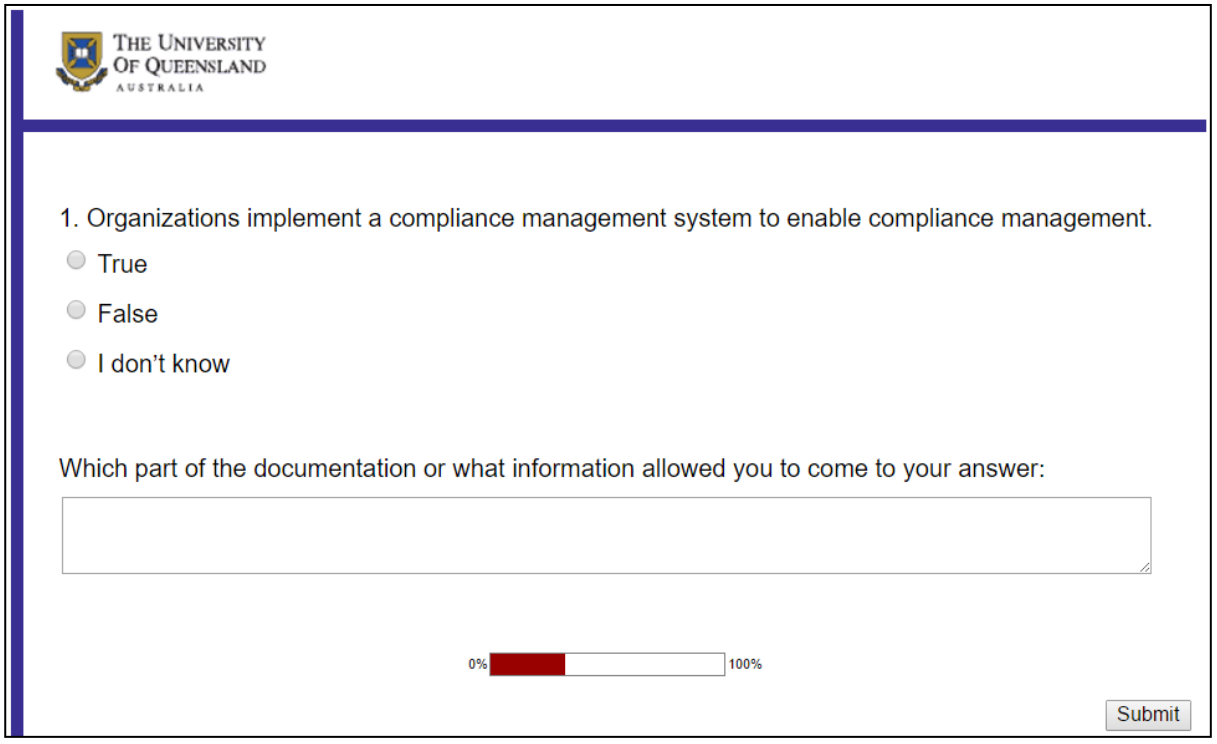


Figure D-15. Screenshot of the Compliance Management Question 1

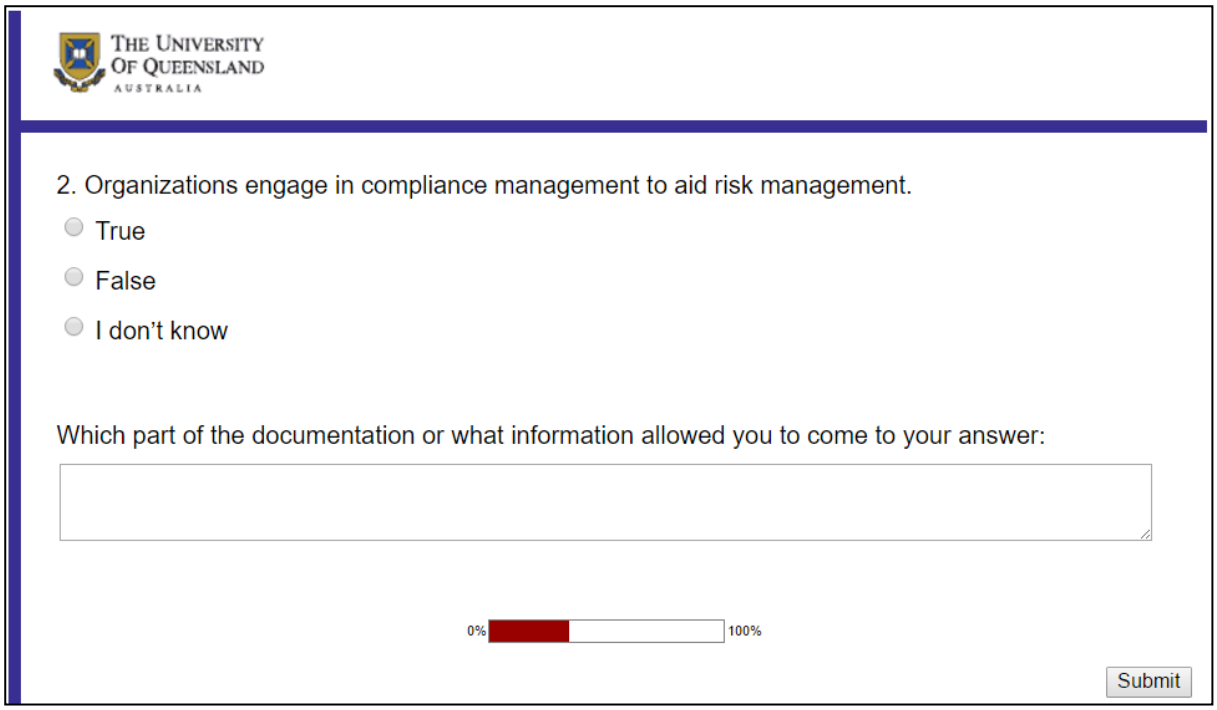


Figure D-16. Screenshot of the Compliance Management Question 2

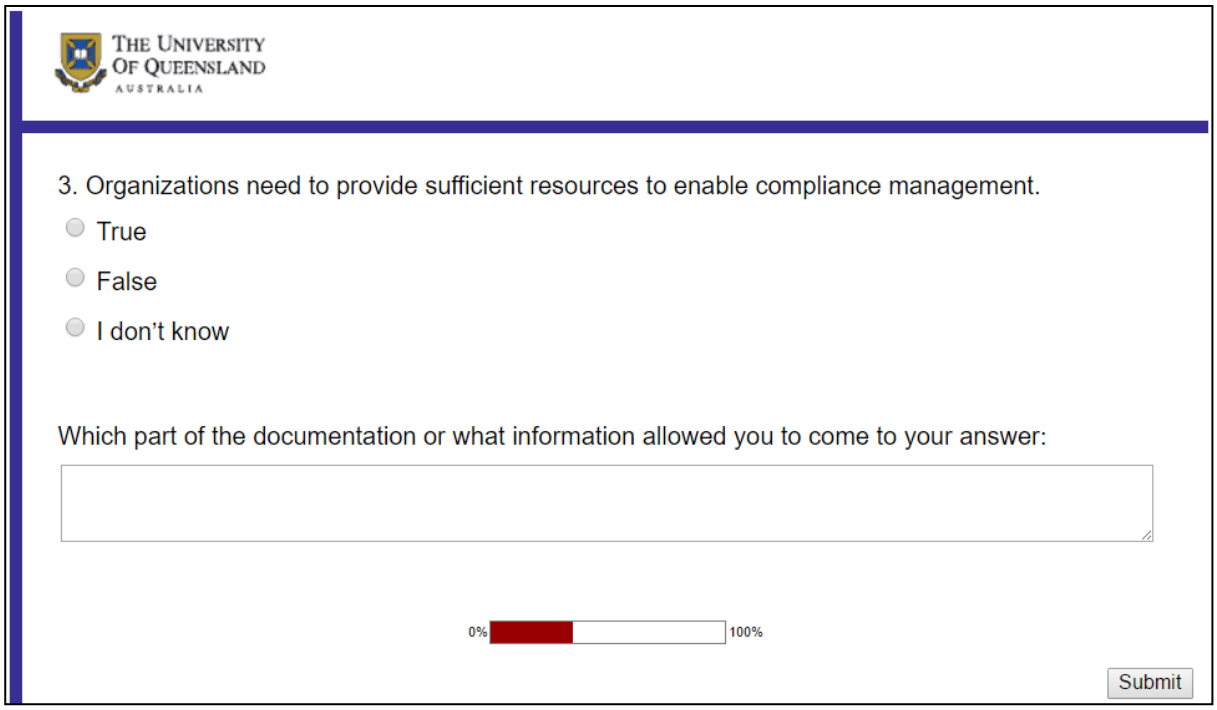


Figure D-17. Screenshot of the Compliance Management Question 3

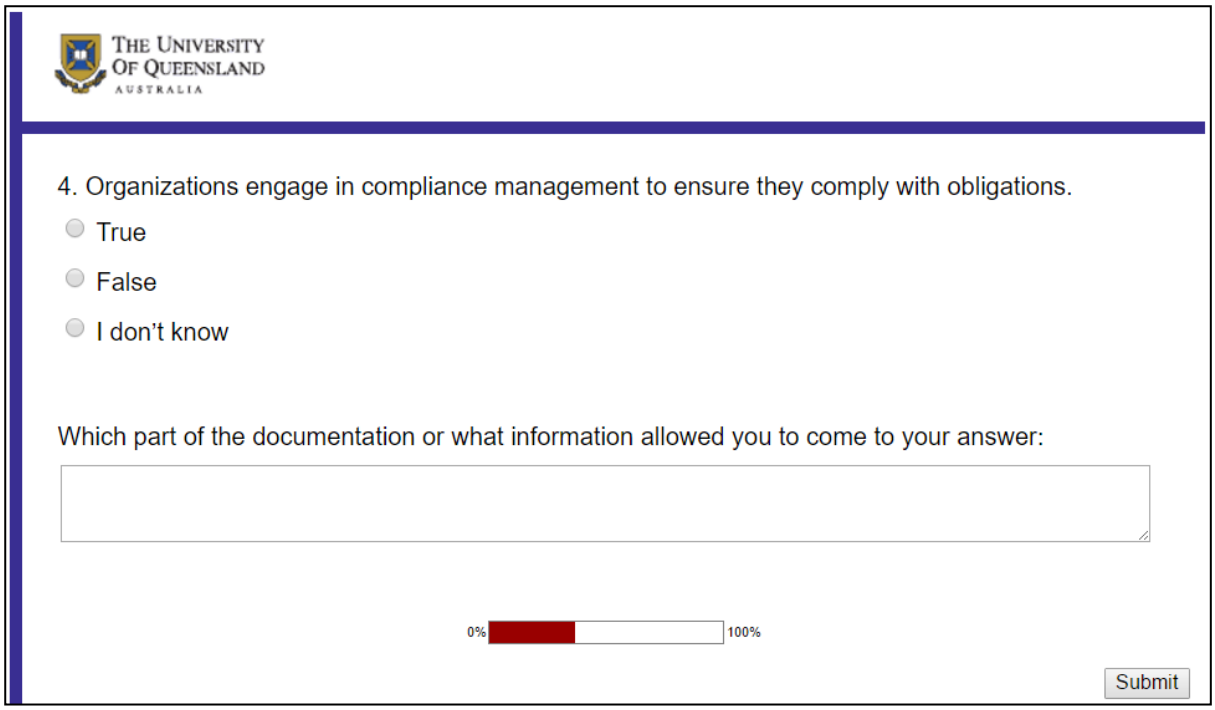


Figure D-18. Screenshot of the Compliance Management Question 4

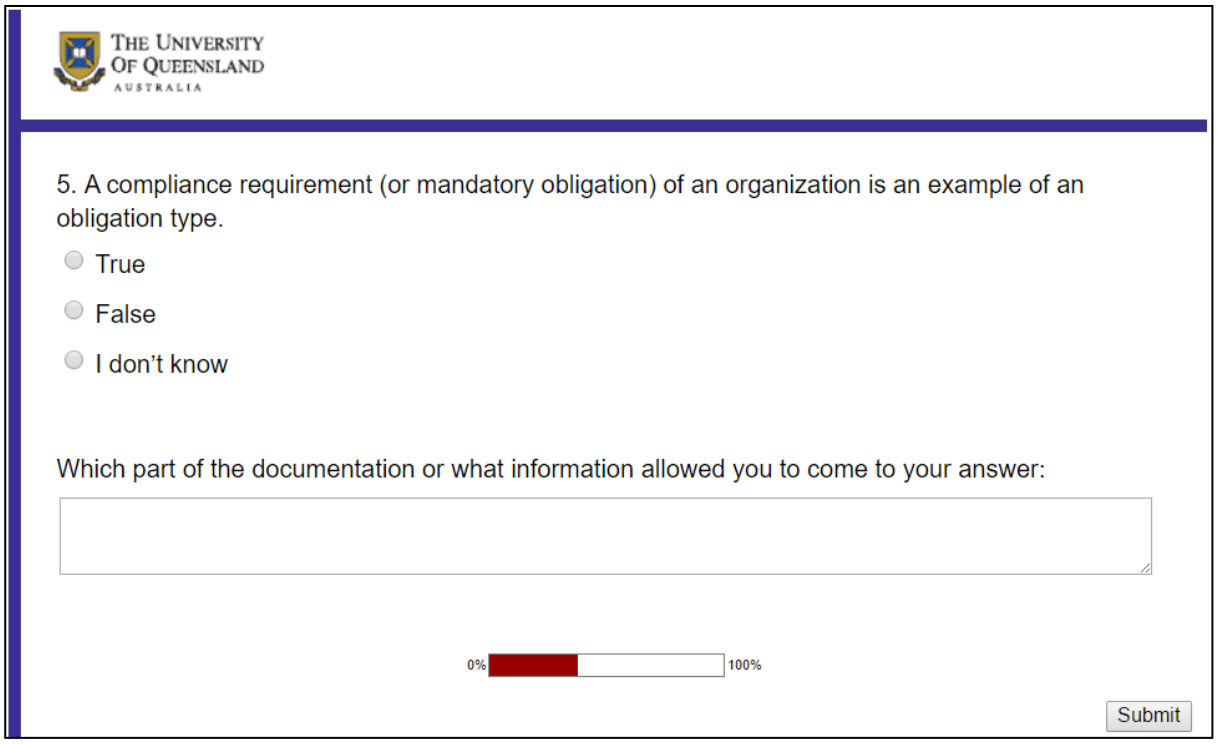


Figure D-19. Screenshot of the Compliance Management Question 5

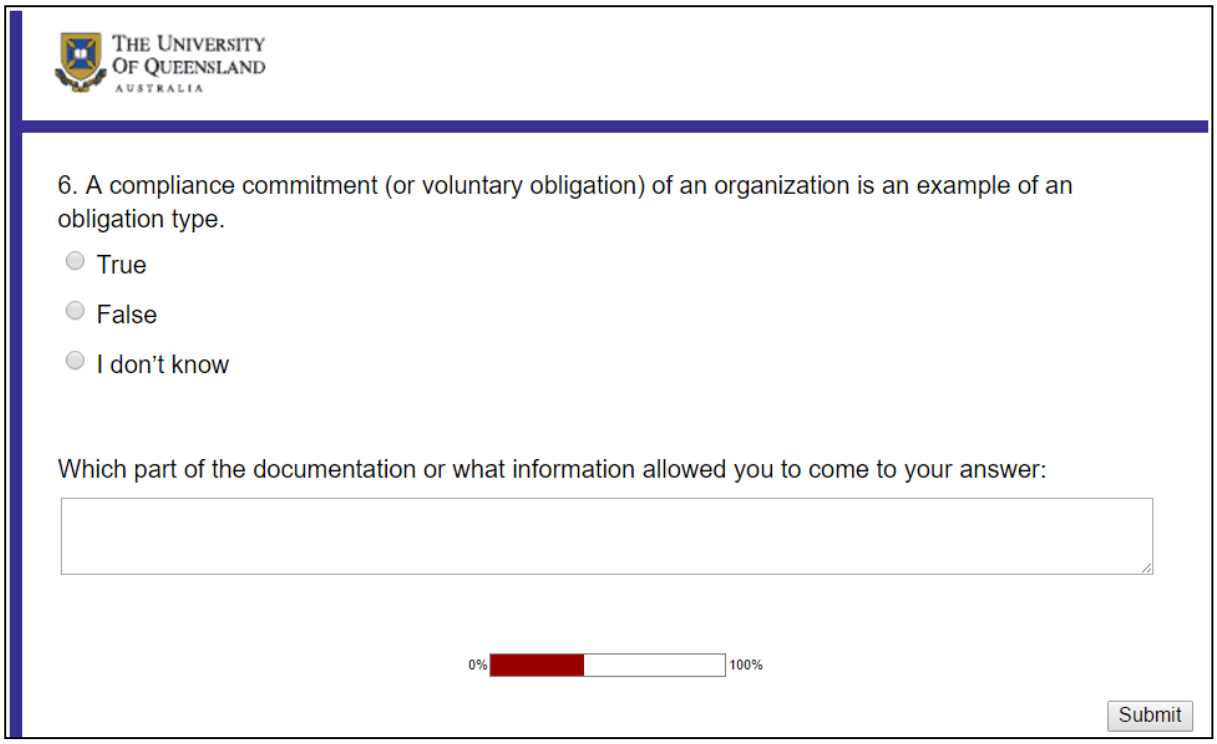


Figure D-20. Screenshot of the Compliance Management Question 6

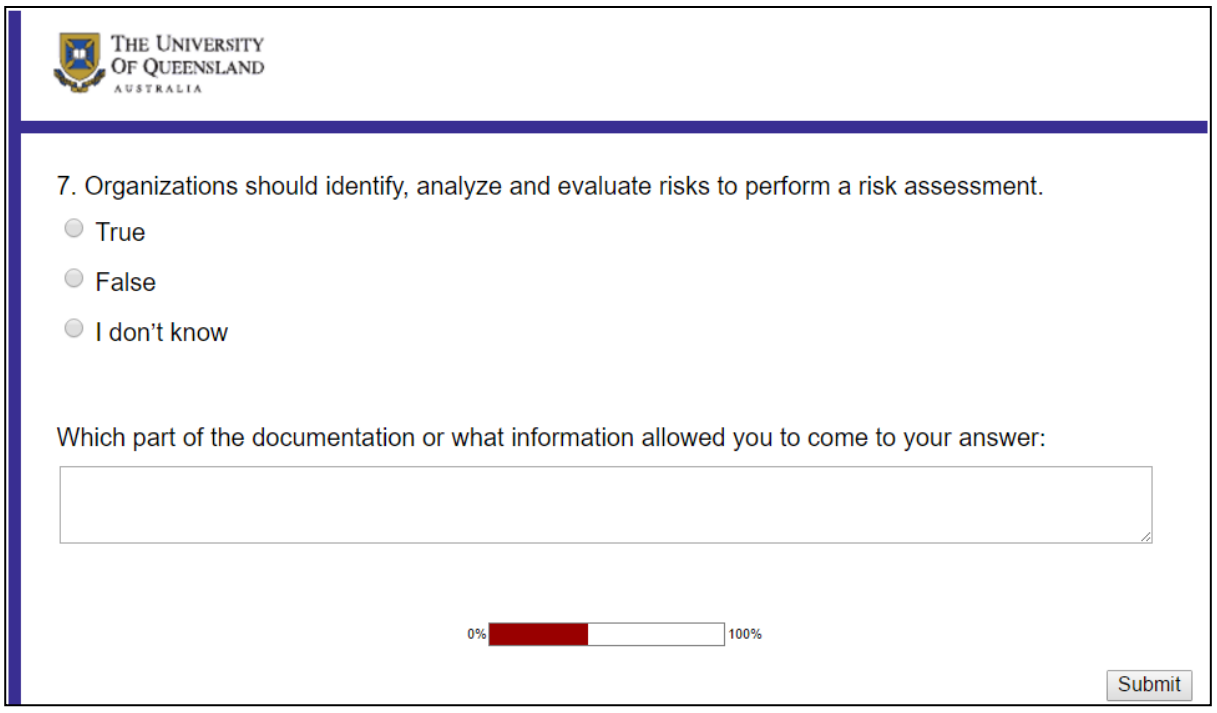


Figure D-21. Screenshot of the Compliance Management Question 7

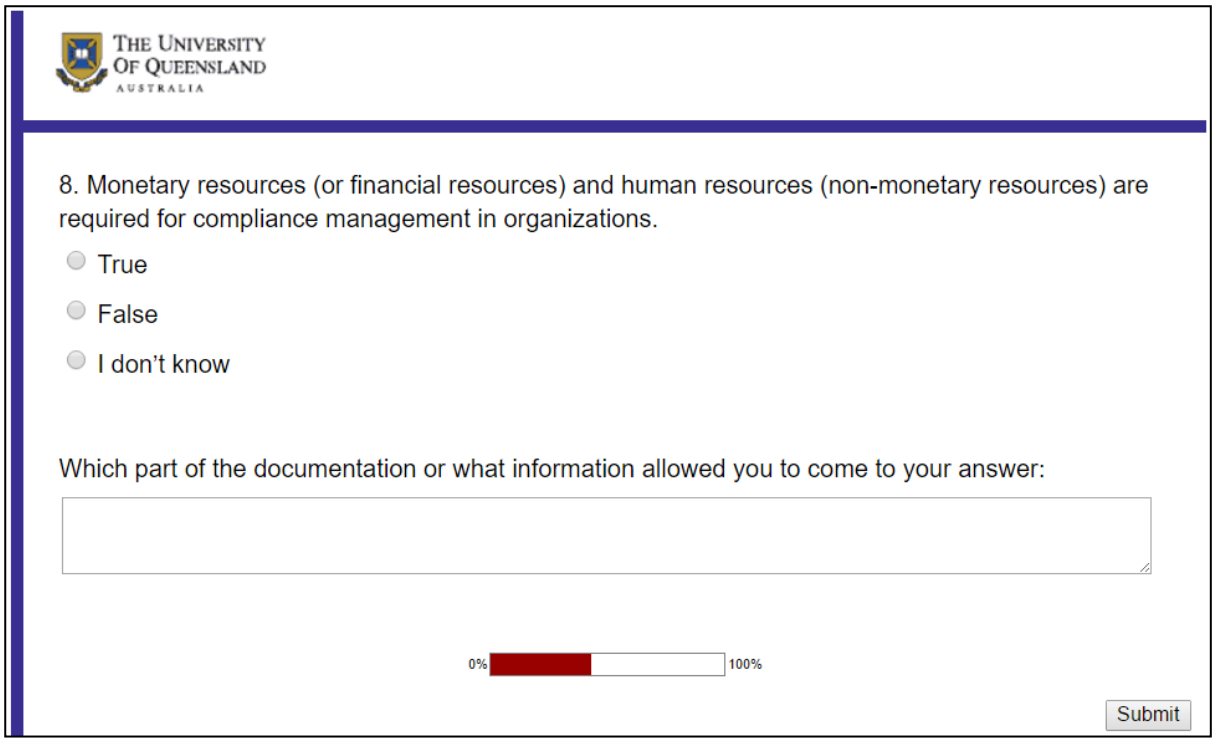


Figure D-22. Screenshot of the Compliance Management Question 8

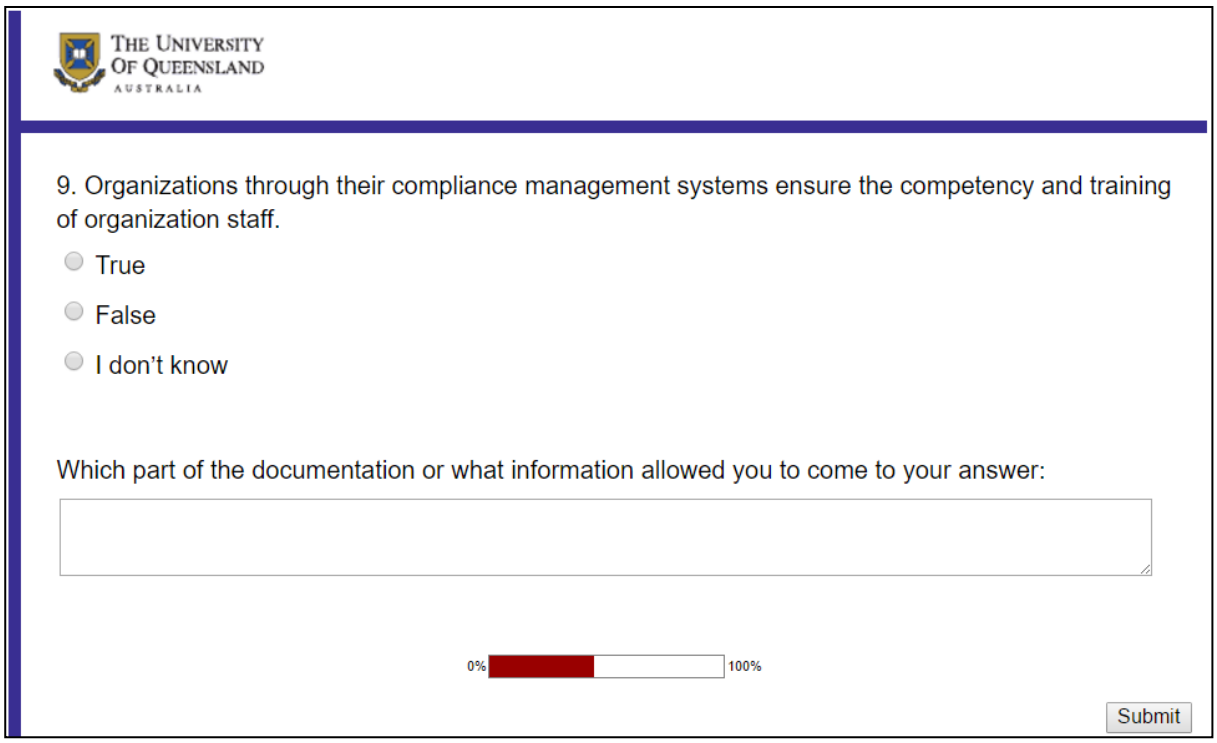


Figure D-23. Screenshot of the Compliance Management Question 9

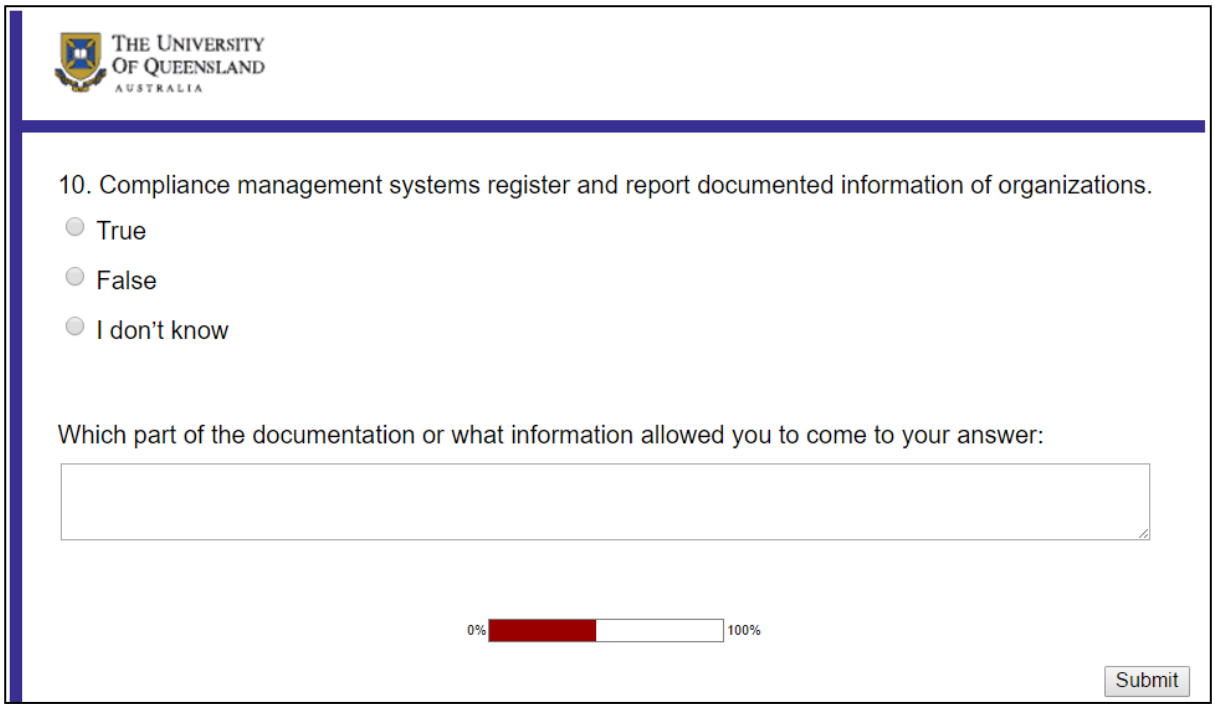


Figure D-24. Screenshot of the Compliance Management Question 10

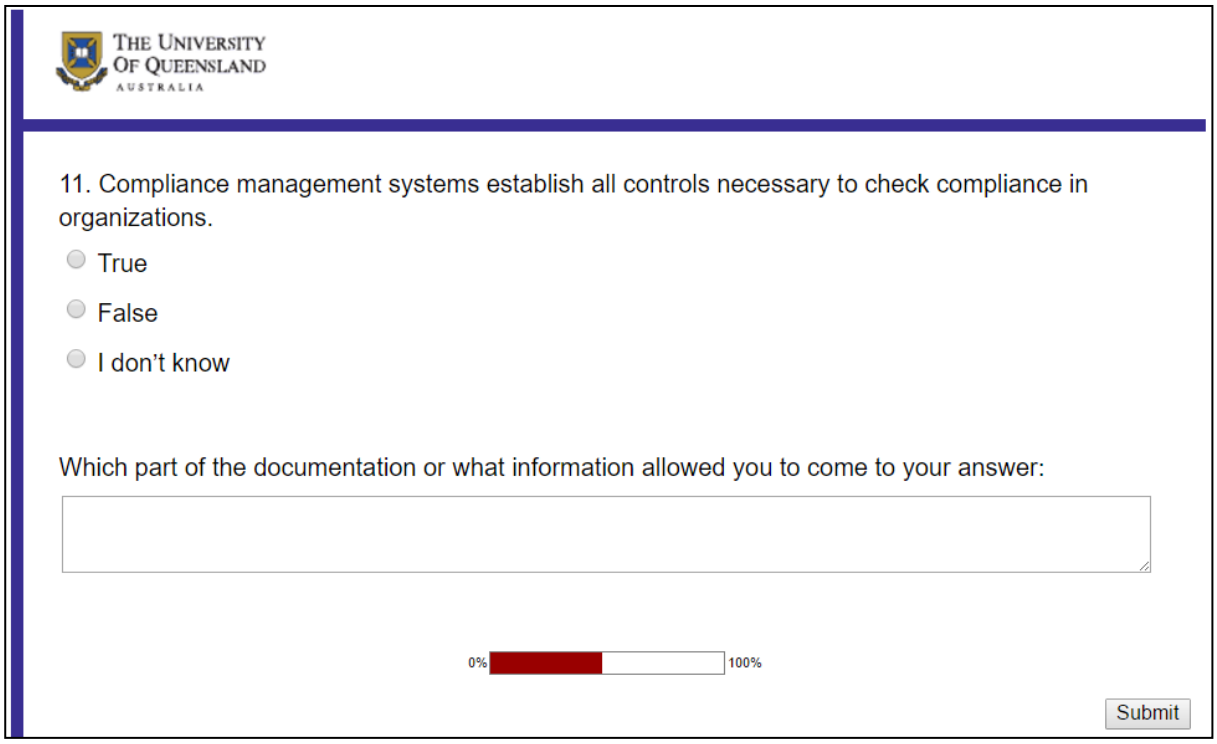


Figure D-25. Screenshot of the Compliance Management Question 11

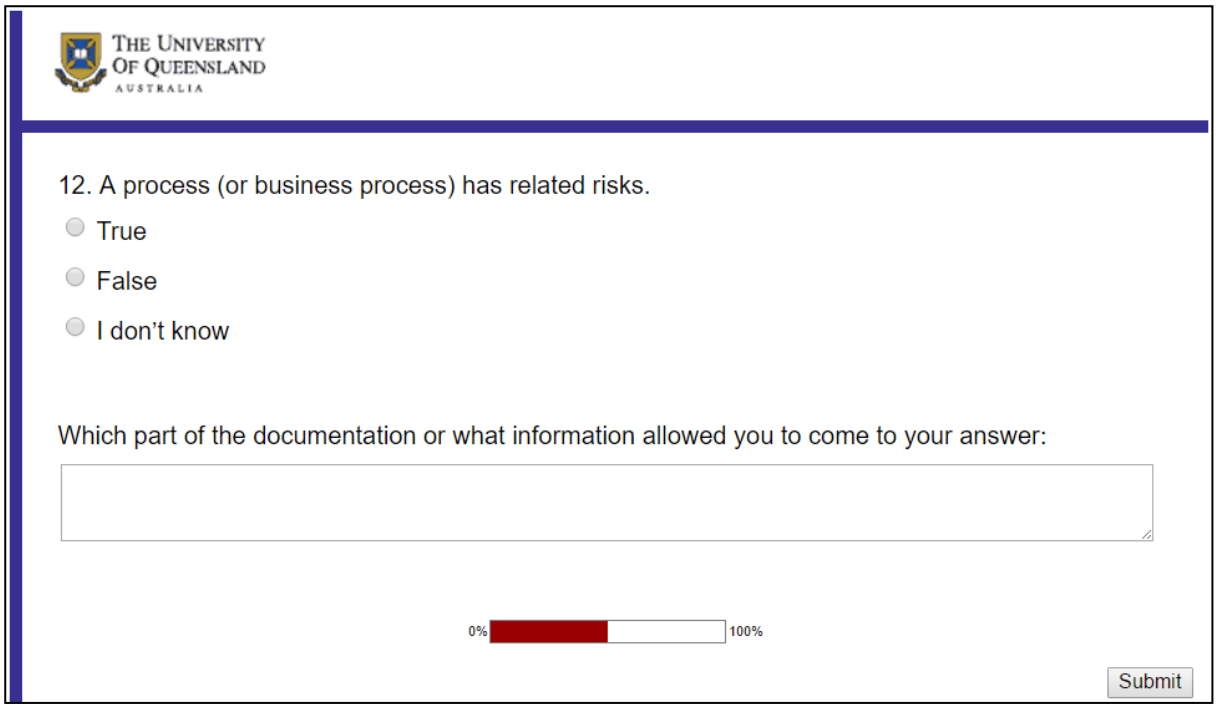


Figure D-26. Screenshot of the Compliance Management Question 12

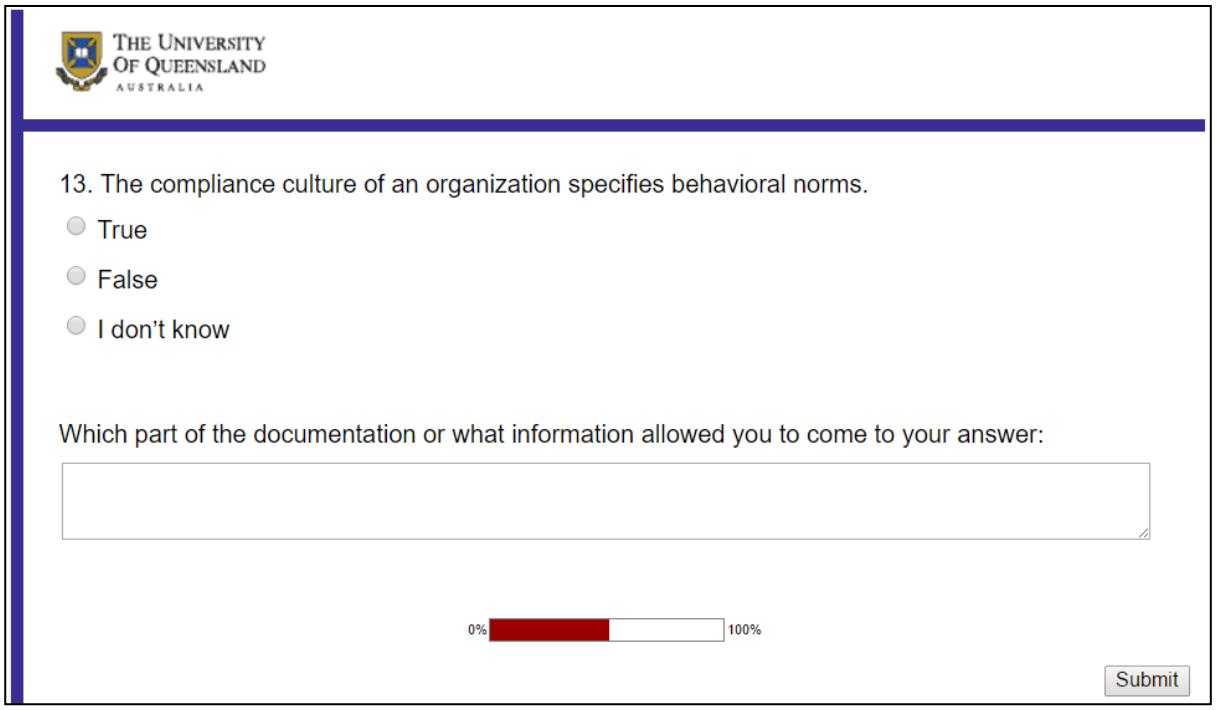


Figure D-27. Screenshot of the Compliance Management Question 13

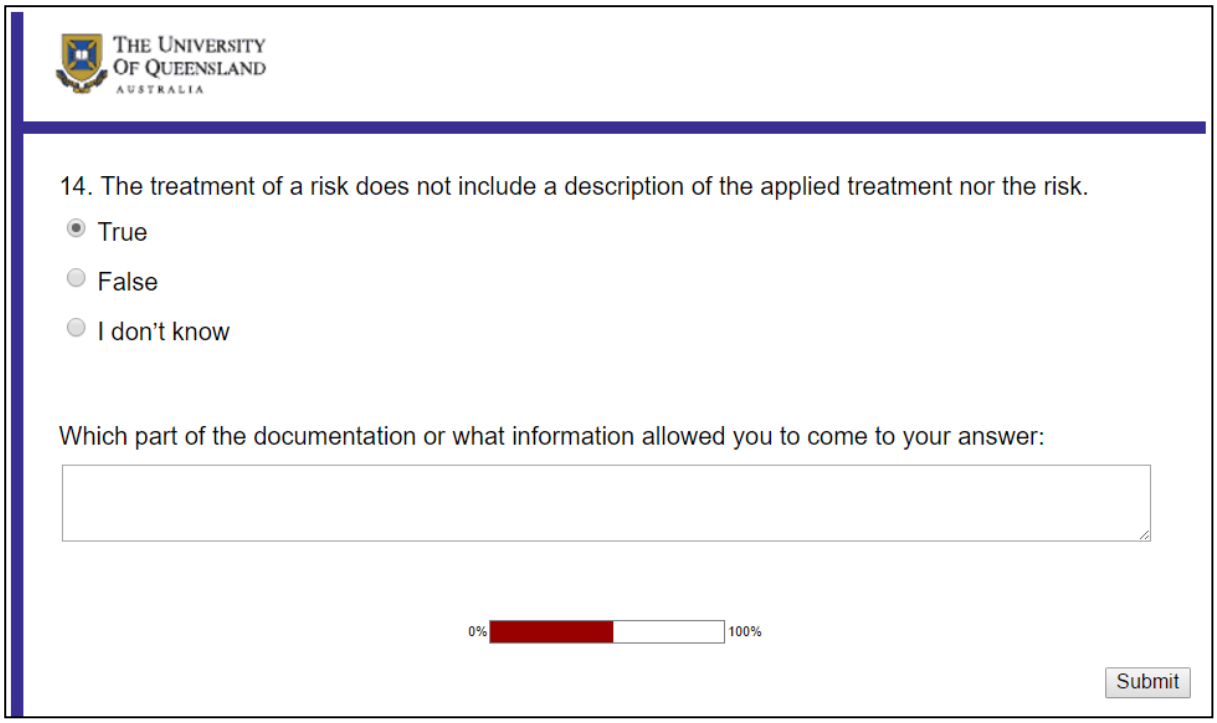


Figure D-28. Screenshot of the Compliance Management Question 14

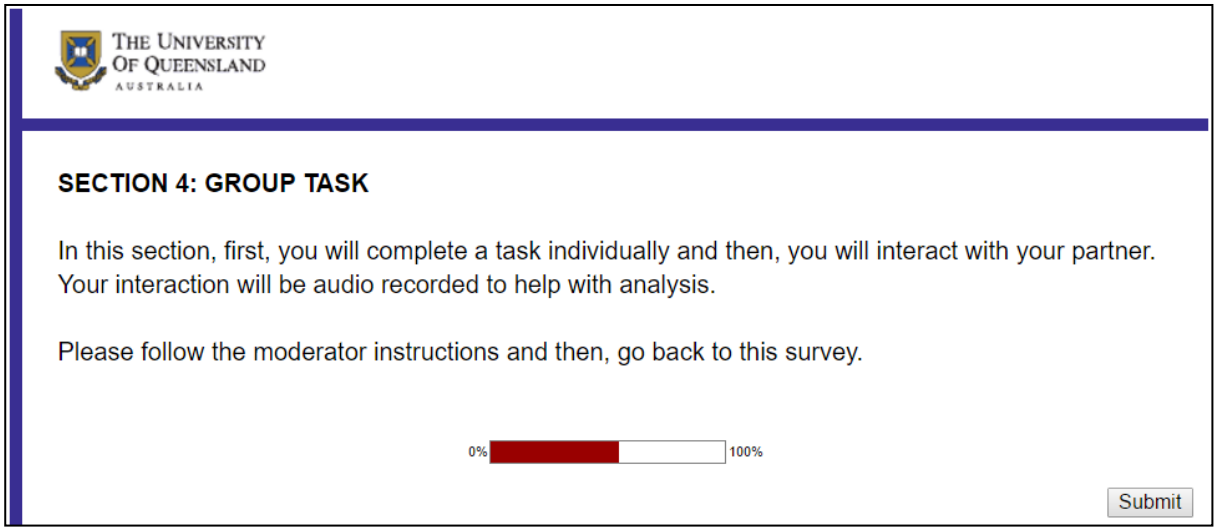


Figure D-29. Screenshot of the Group Task Section

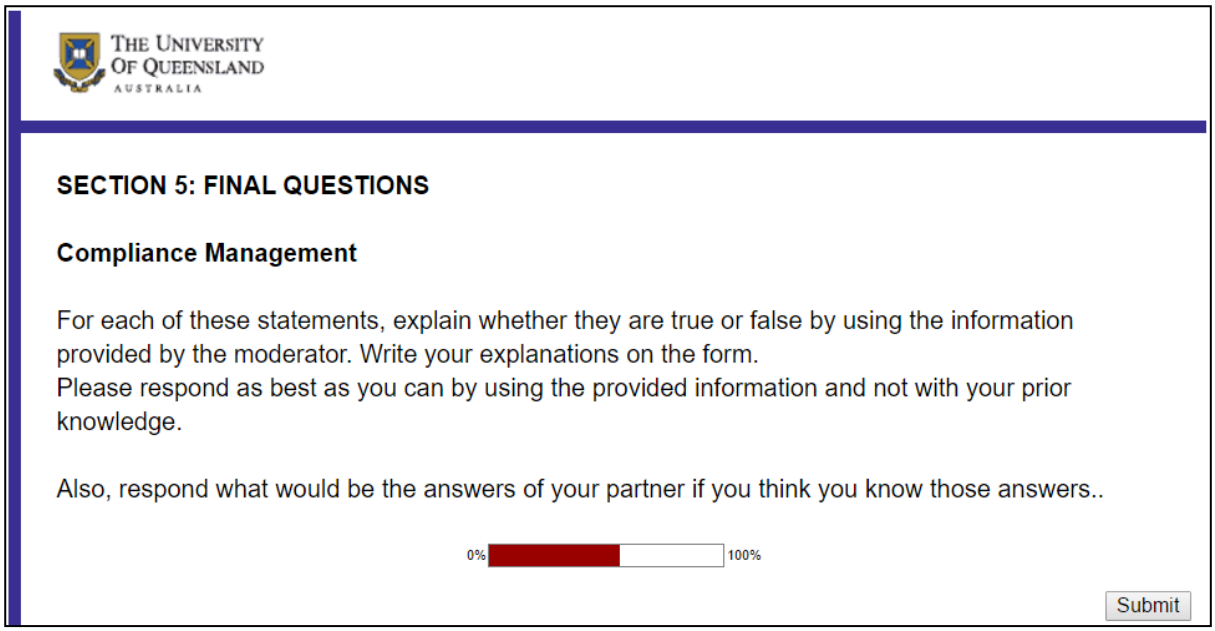


Figure D-30. Screenshot of the Final Question Section

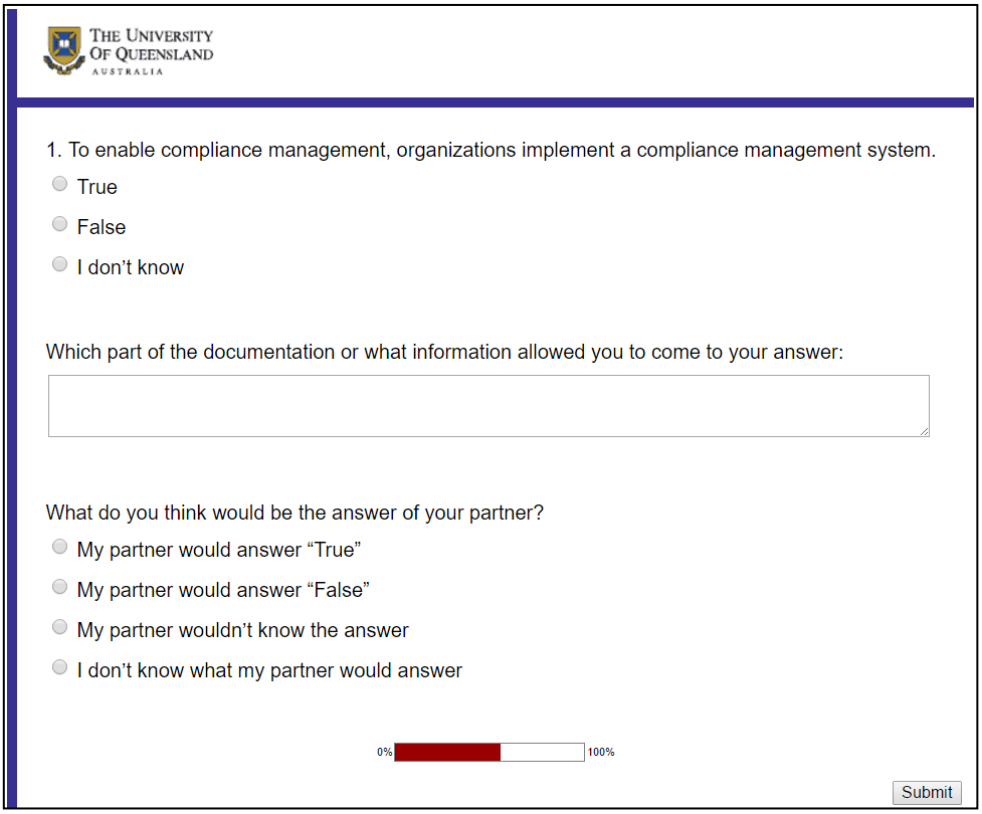


Figure D-31. Screenshot of the Compliance Management Question 1

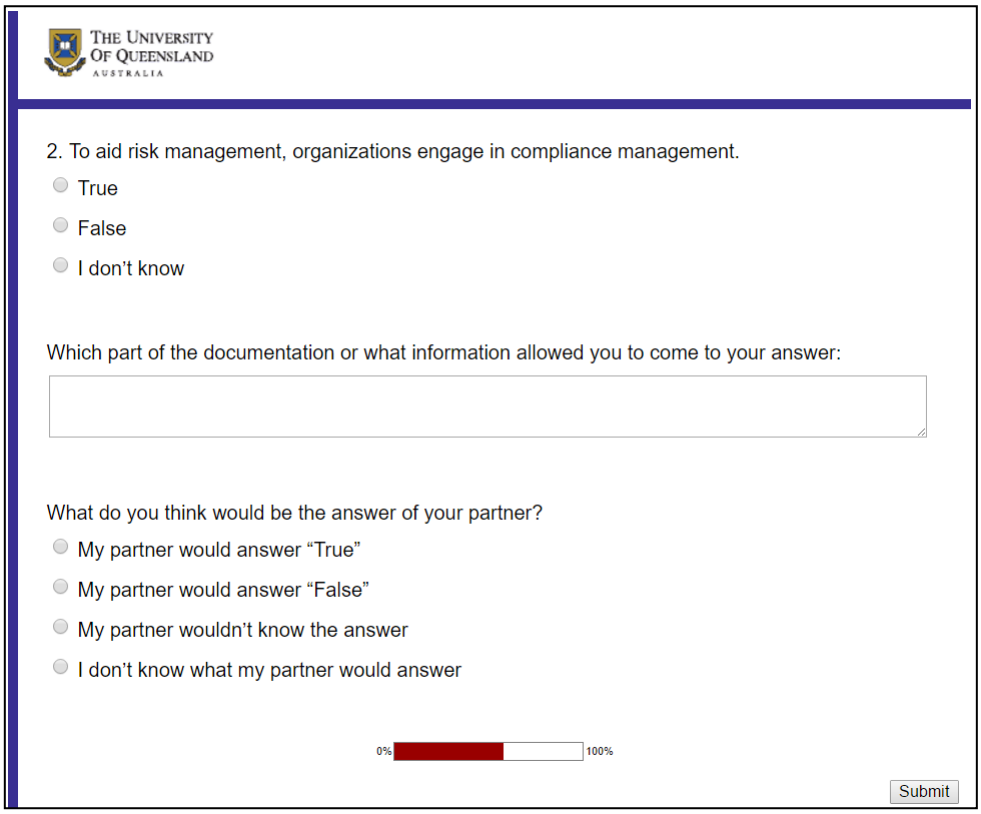


Figure D-32. Screenshot of the Compliance Management Question 2

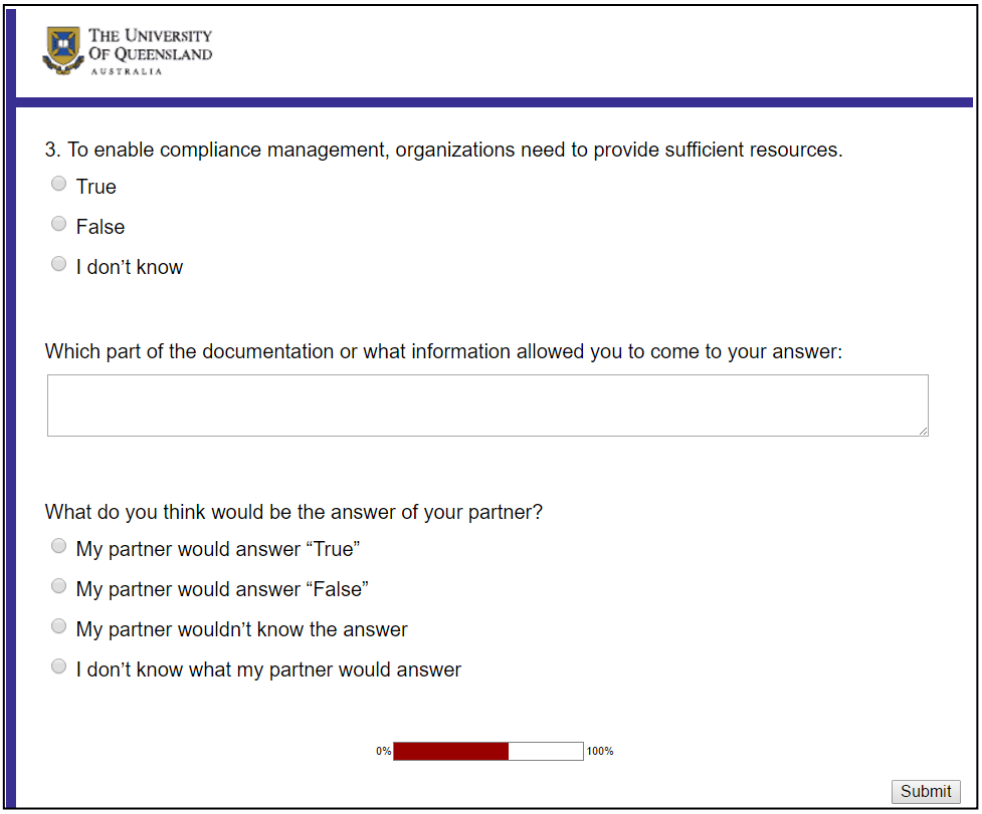


Figure D-33. Screenshot of the Compliance Management Question 3

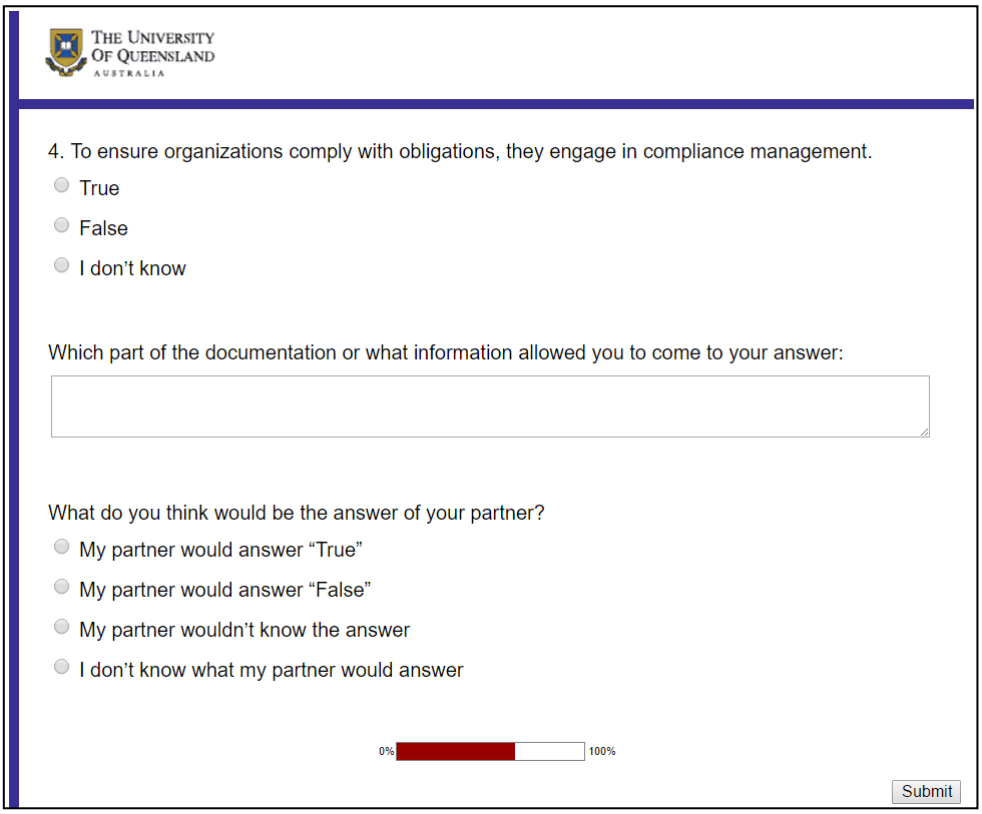


Figure D-34. Screenshot of the Compliance Management Question 4

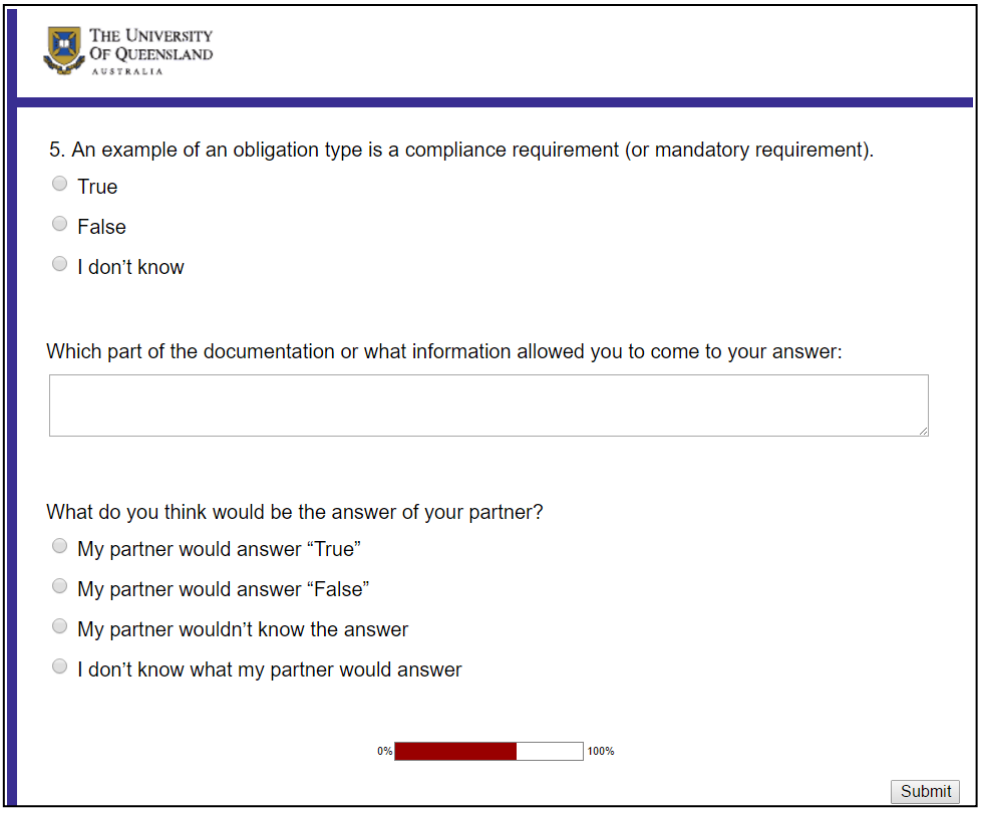


Figure D-35. Screenshot of the Compliance Management Question 5

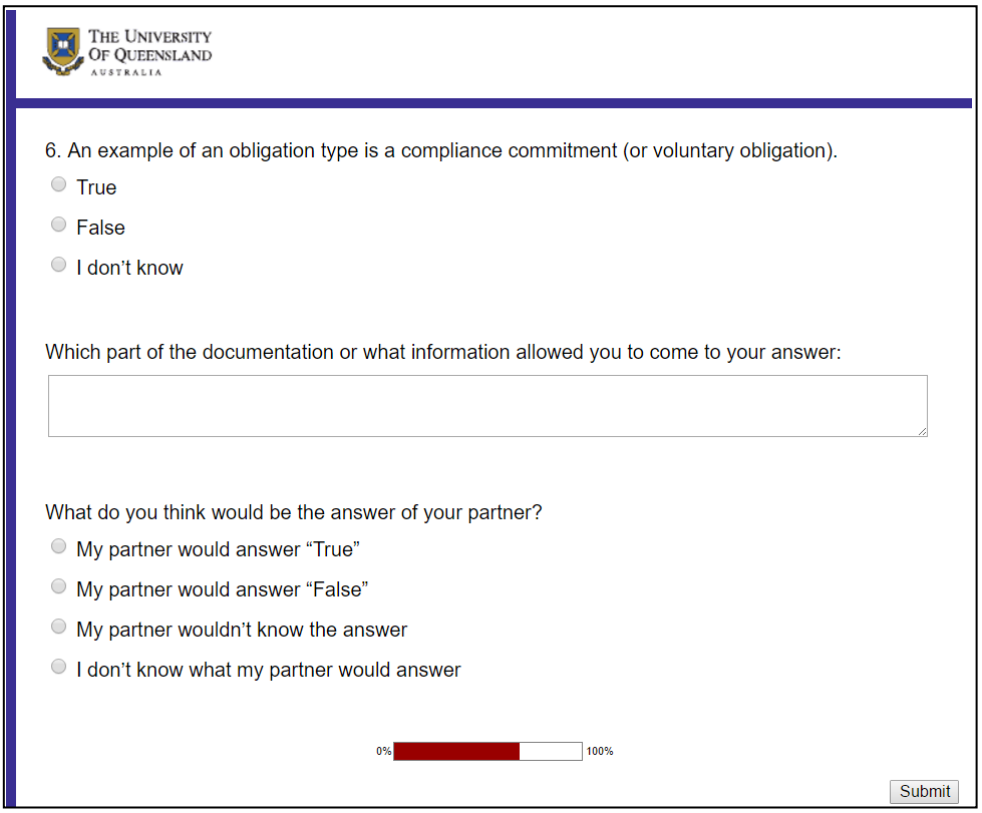


Figure D-36. Screenshot of the Compliance Management Question 6

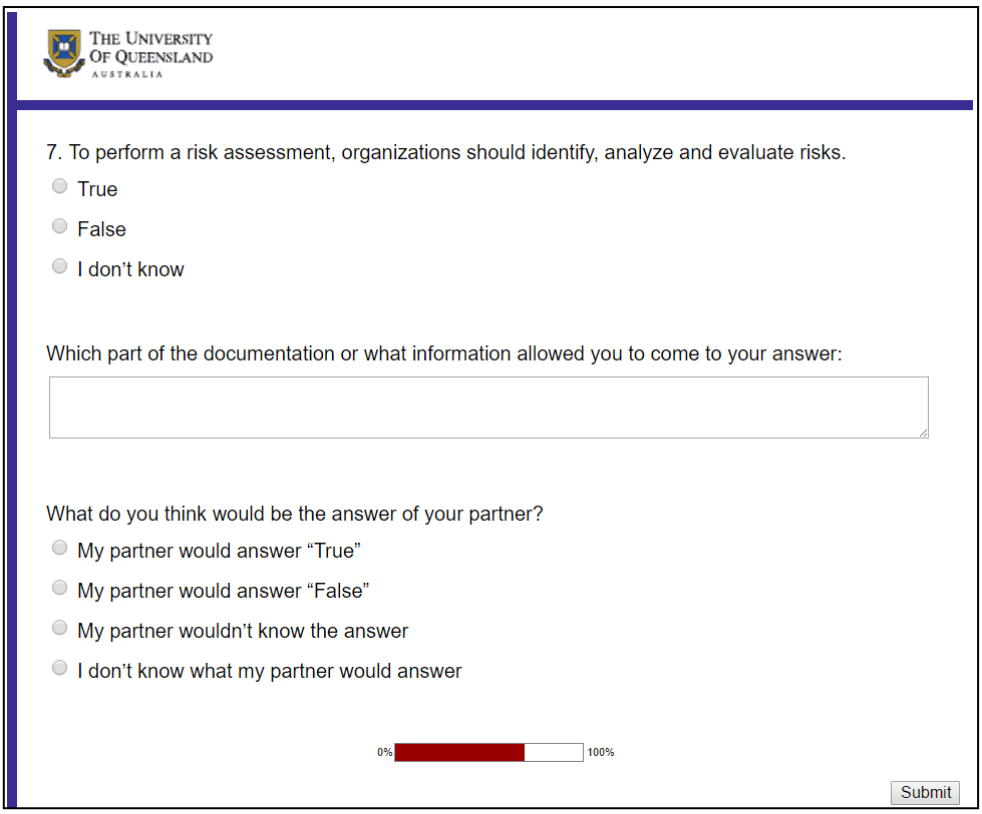


Figure D-37. Screenshot of the Compliance Management Question 7

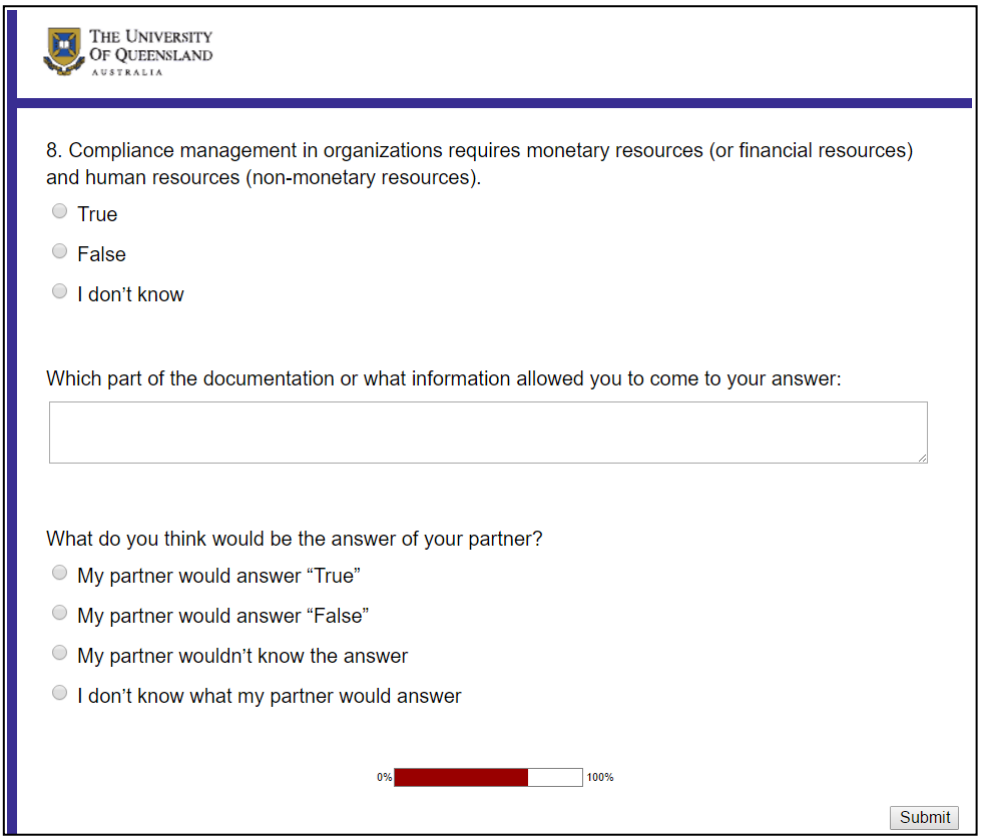


Figure D-38. Screenshot of the Compliance Management Question 8

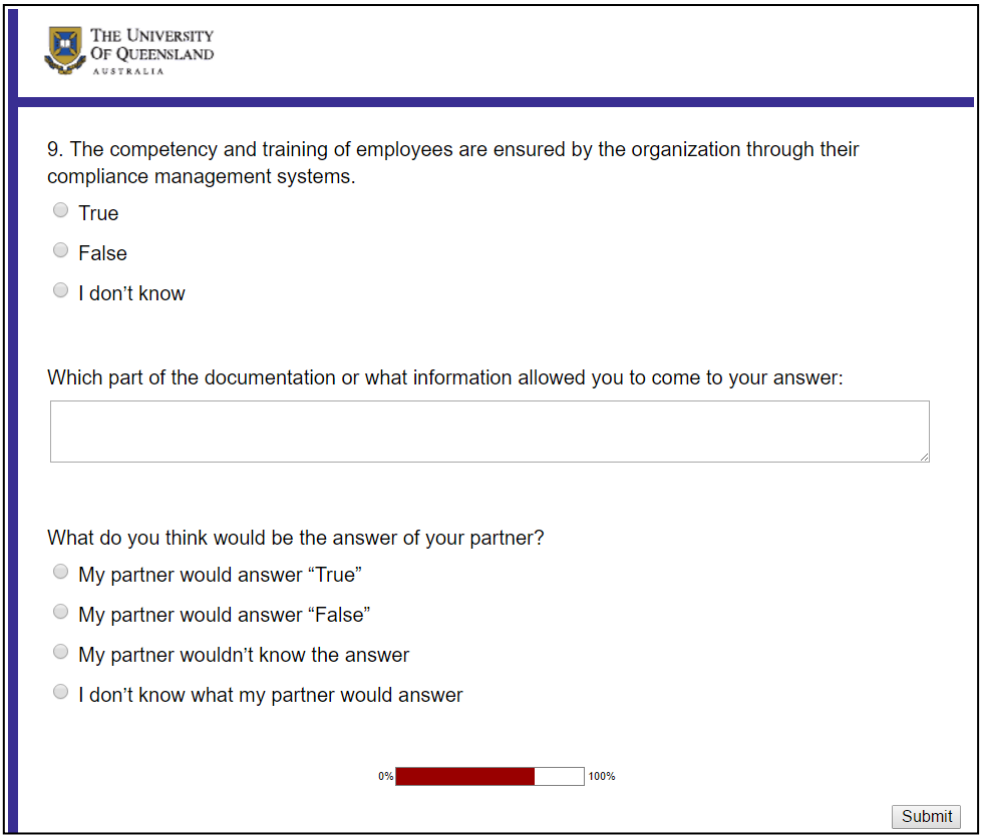


Figure D-39. Screenshot of the Compliance Management Question 9

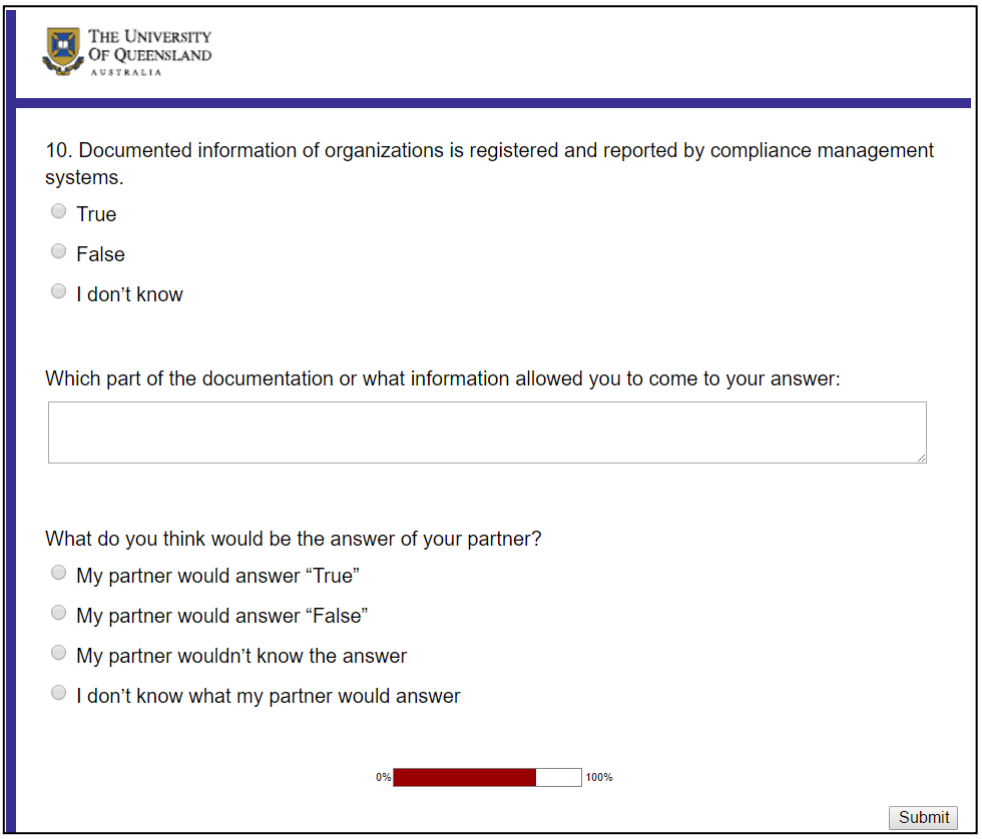


Figure D-40. Screenshot of the Compliance Management Question 10

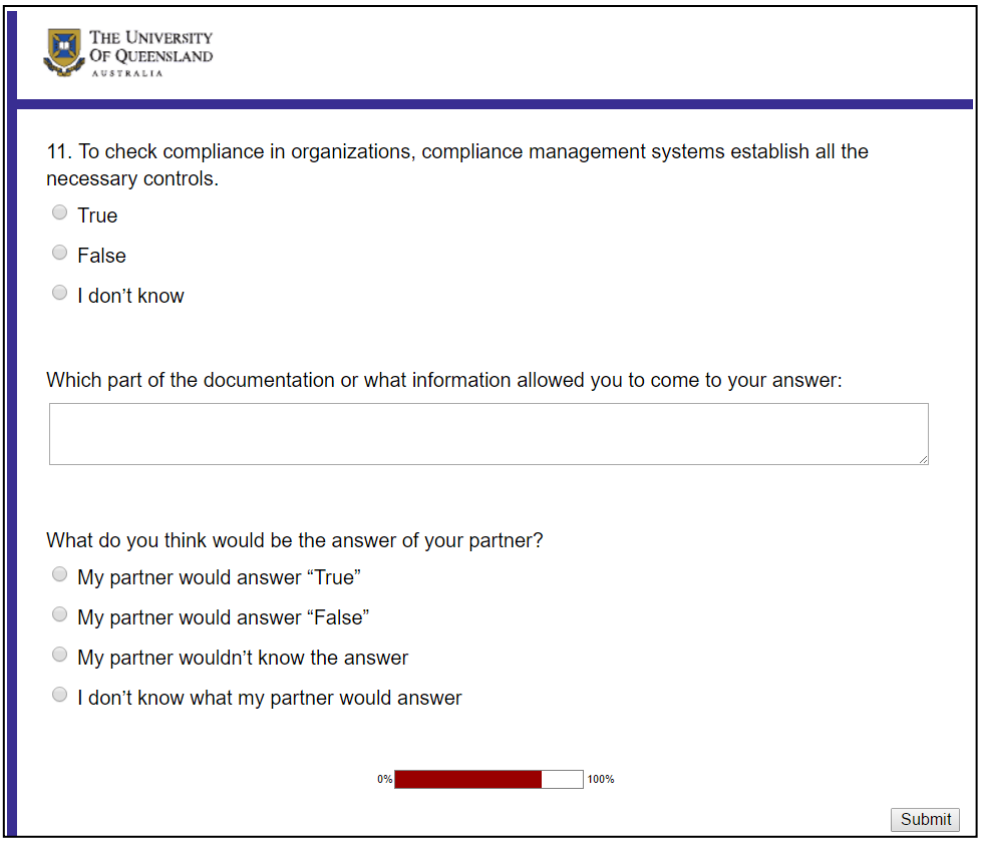


Figure D-41. Screenshot of the Compliance Management Question 11

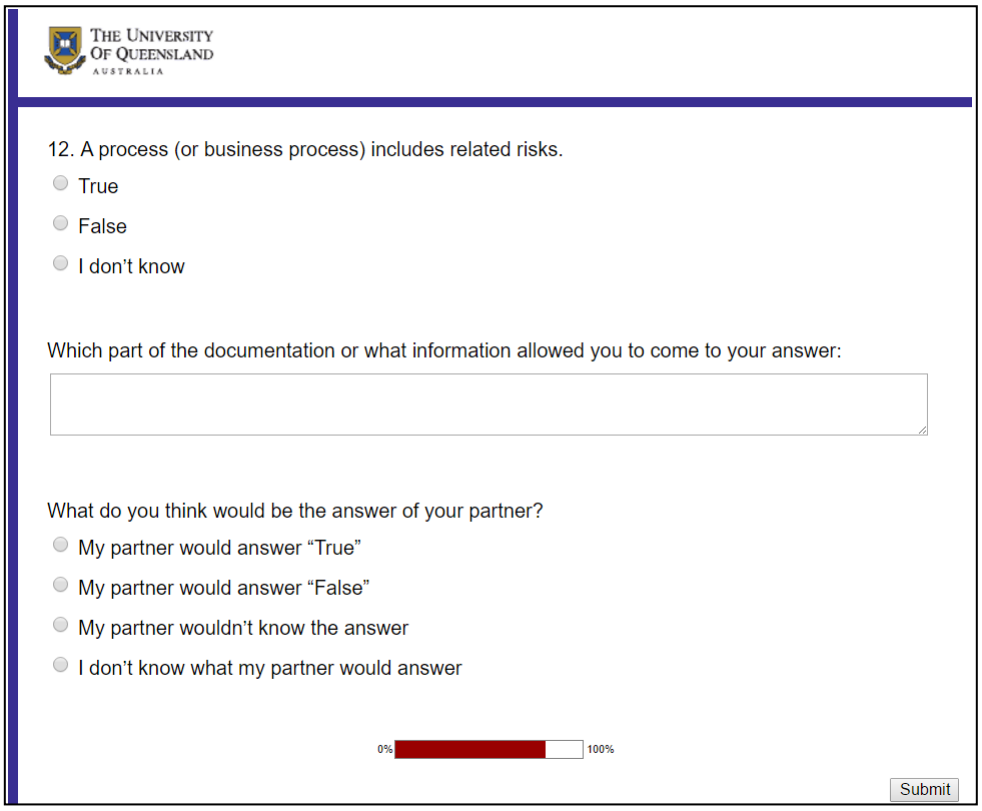


Figure D-42. Screenshot of the Compliance Management Question 12

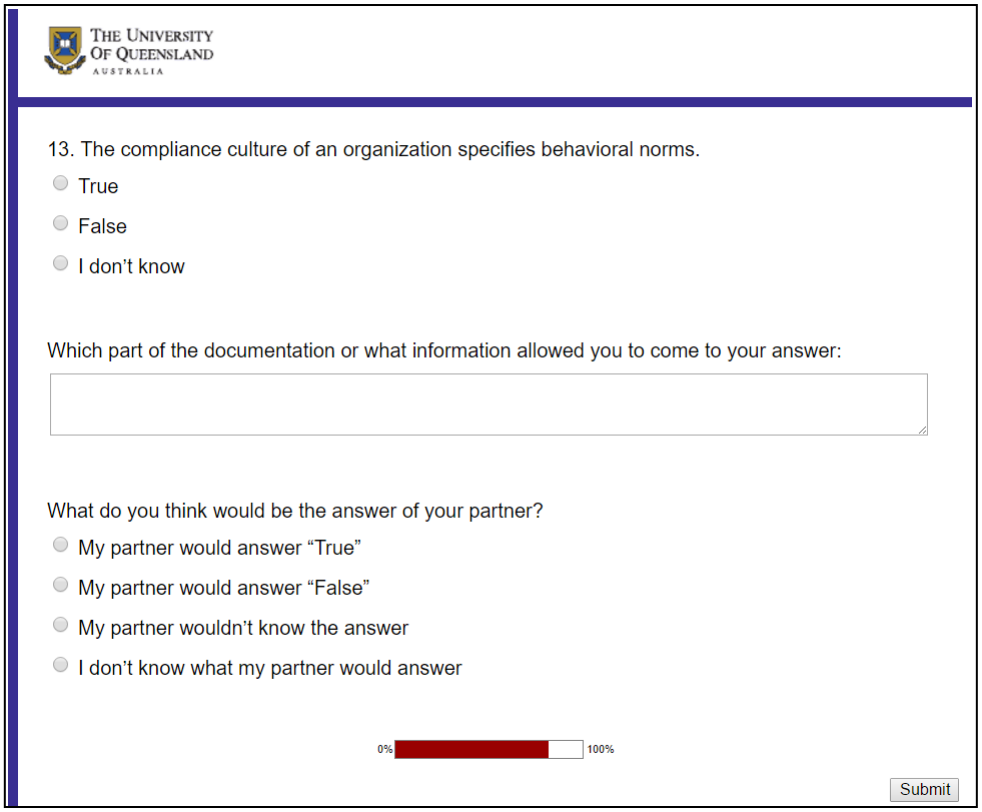


Figure D-43. Screenshot of the Compliance Management Question 13

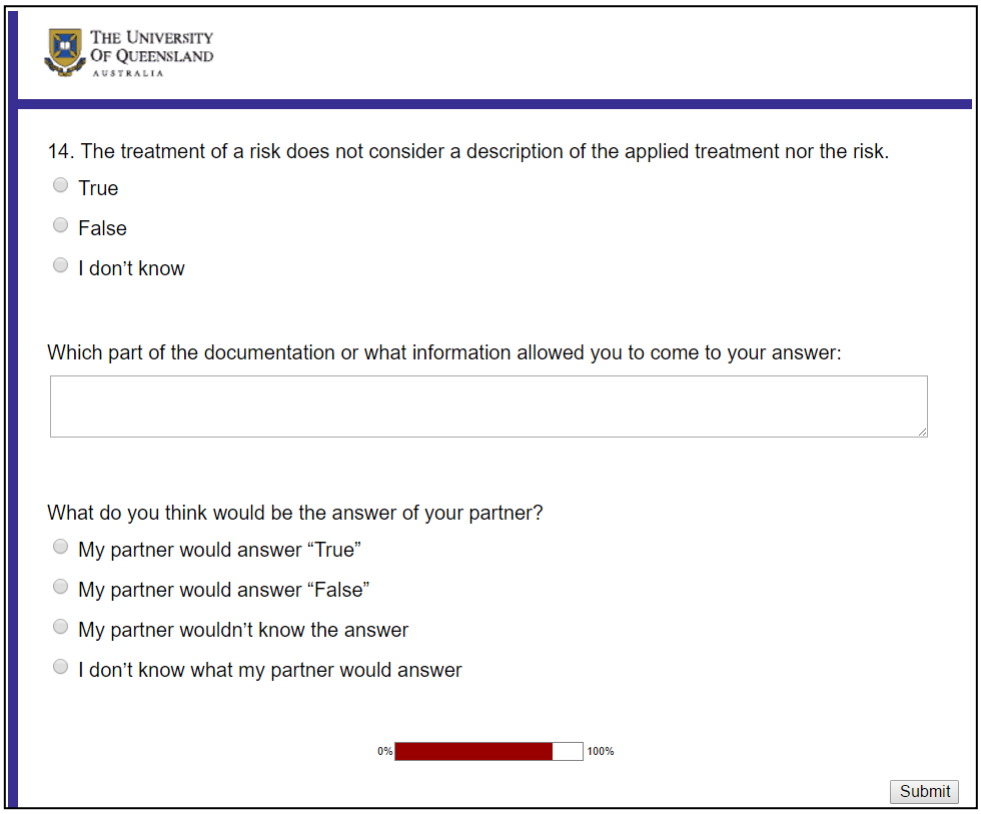


Figure D-44. Screenshot of the Compliance Management Question 14

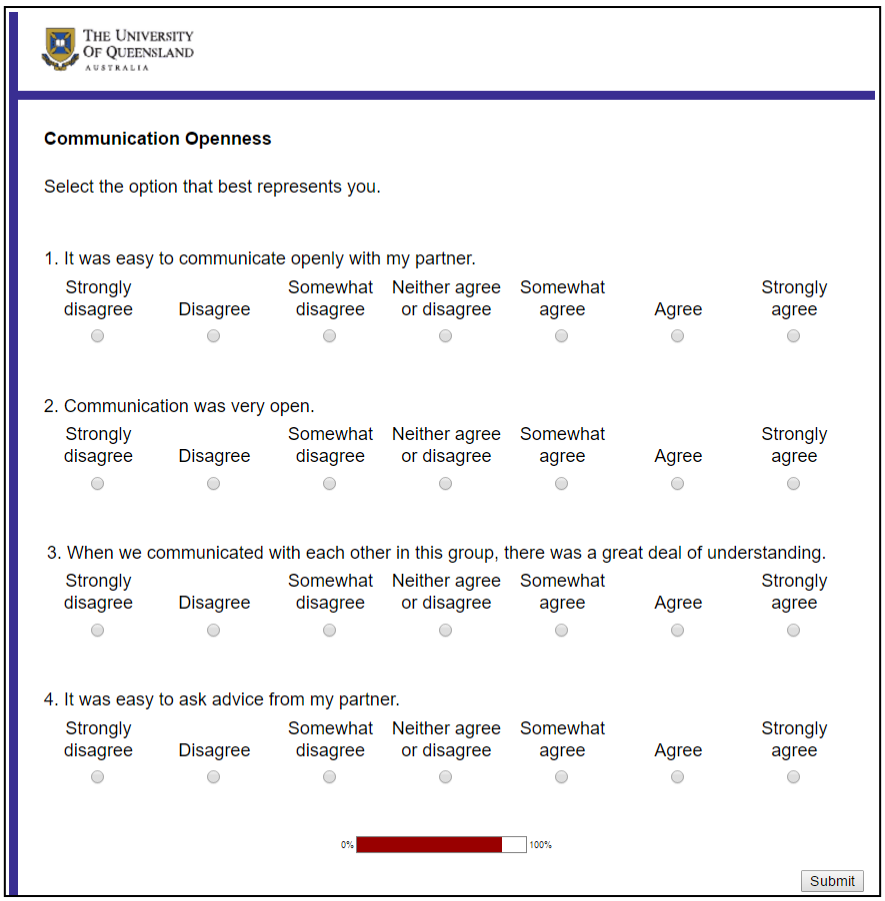


Figure D-45. Screenshot of the Communication Openness Questions

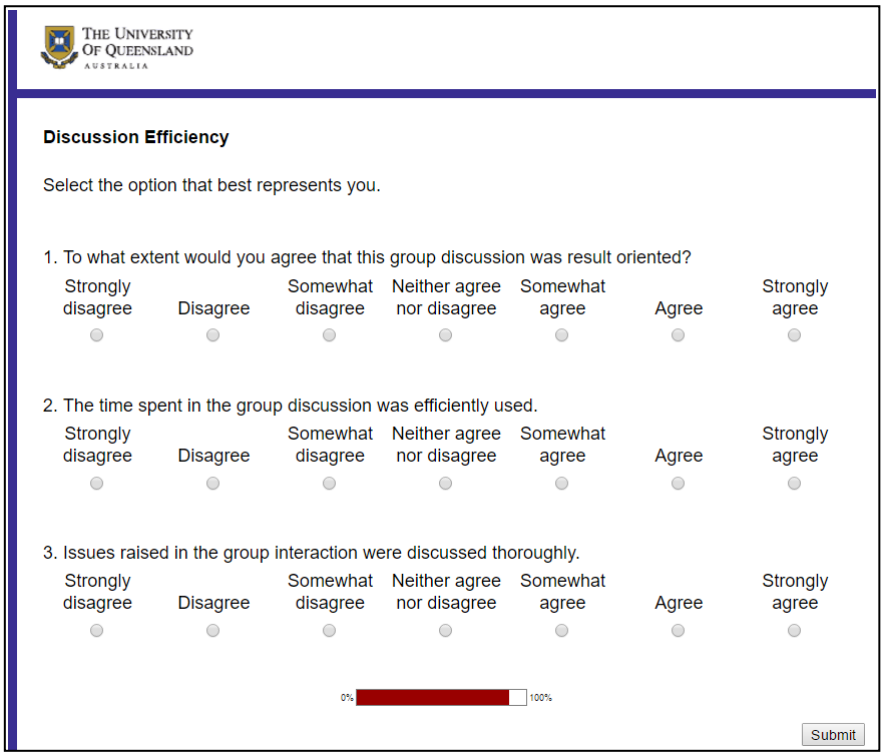


Figure D-46. Screenshot of the Discussion Efficiency Questions

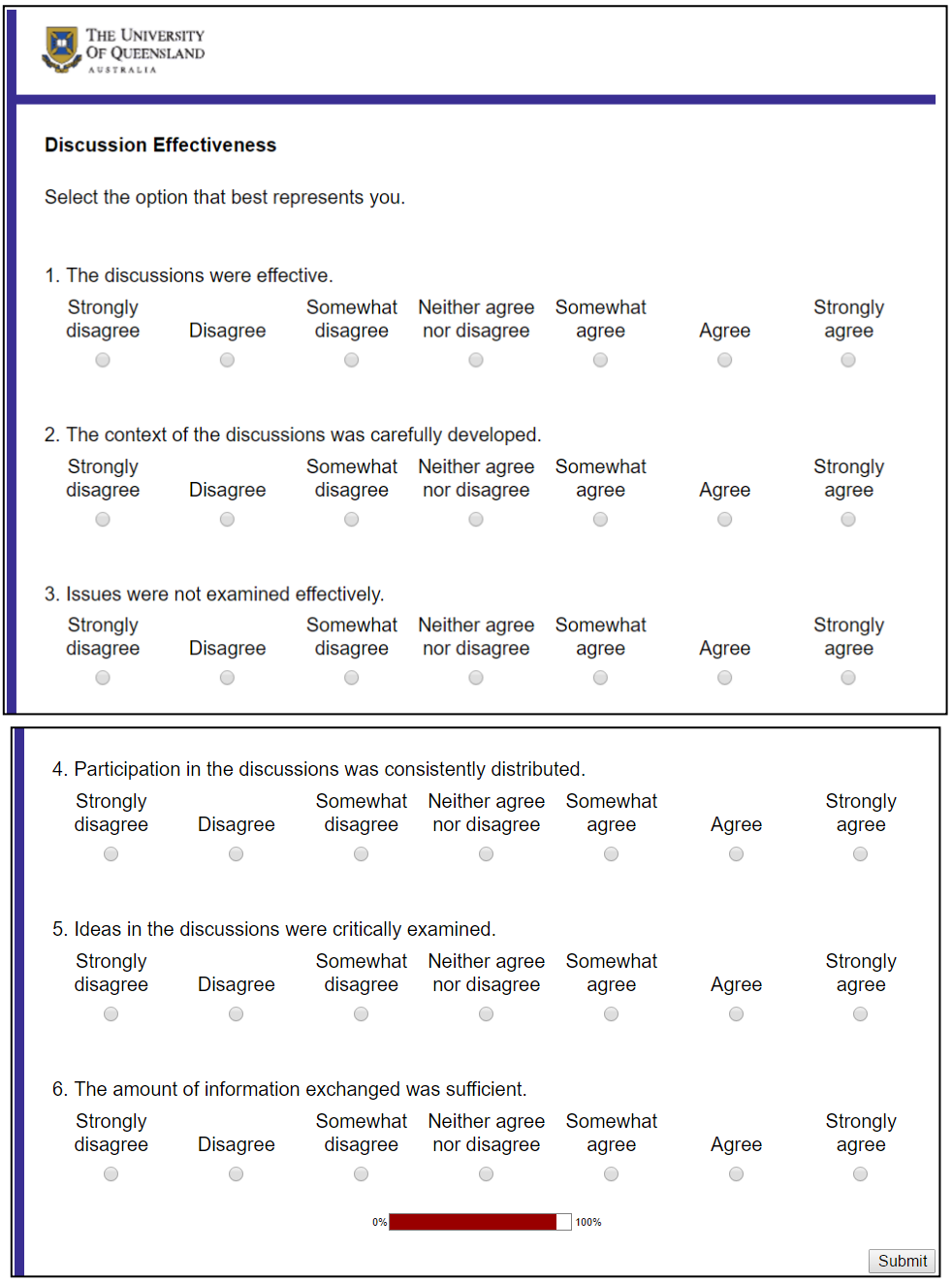


Figure D-47. Screenshot of the Discussion Effectiveness Questions

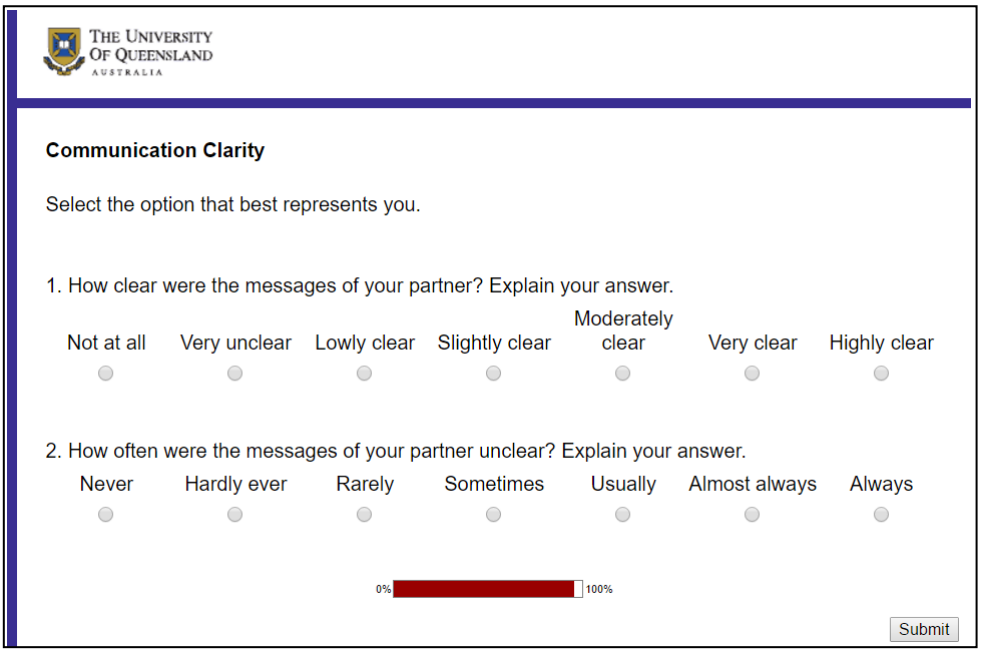


Figure D-48. Screenshot of the Communication Clarity Questions

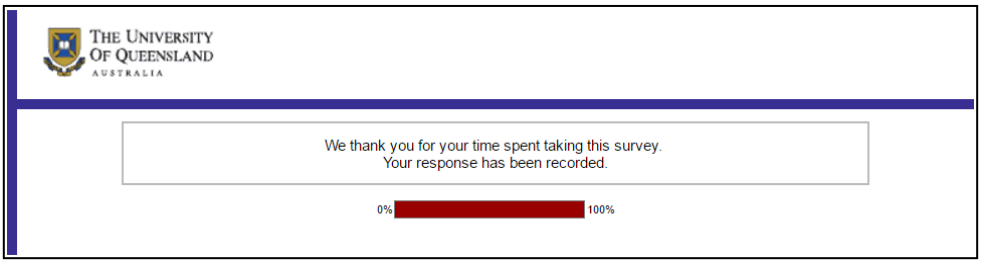


Figure D-49. Screenshot of the End of the Experiment

D.2 INSTRUMENT FOR THE CONTROL GROUP

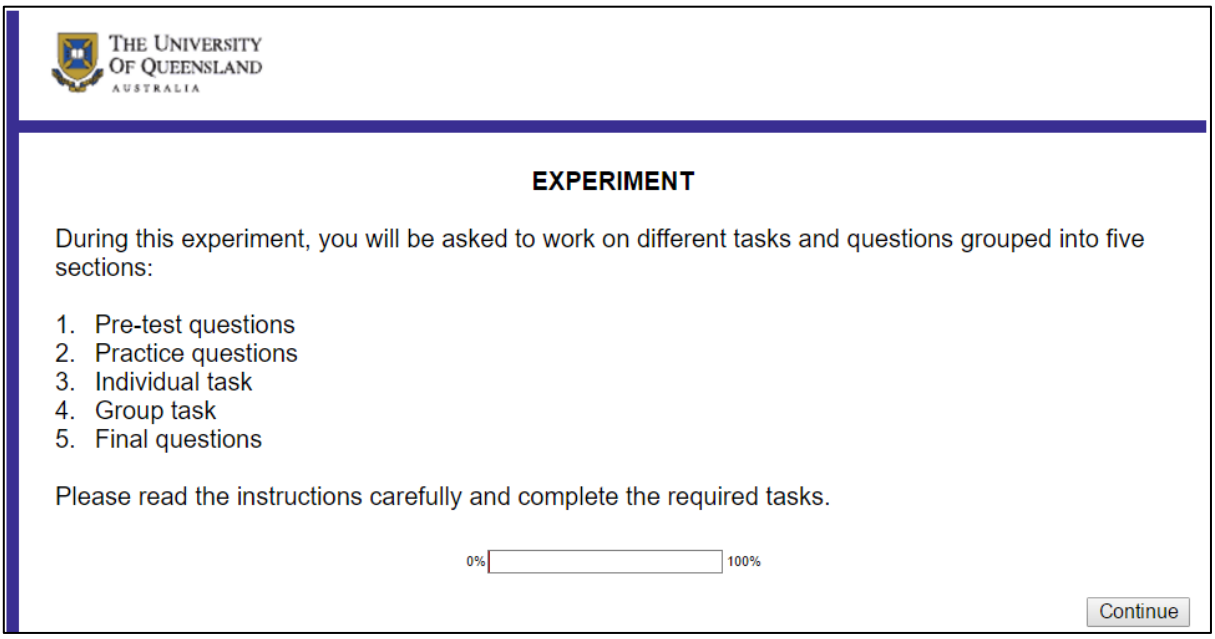


Figure D-50. Screenshot of the Experiment Introduction

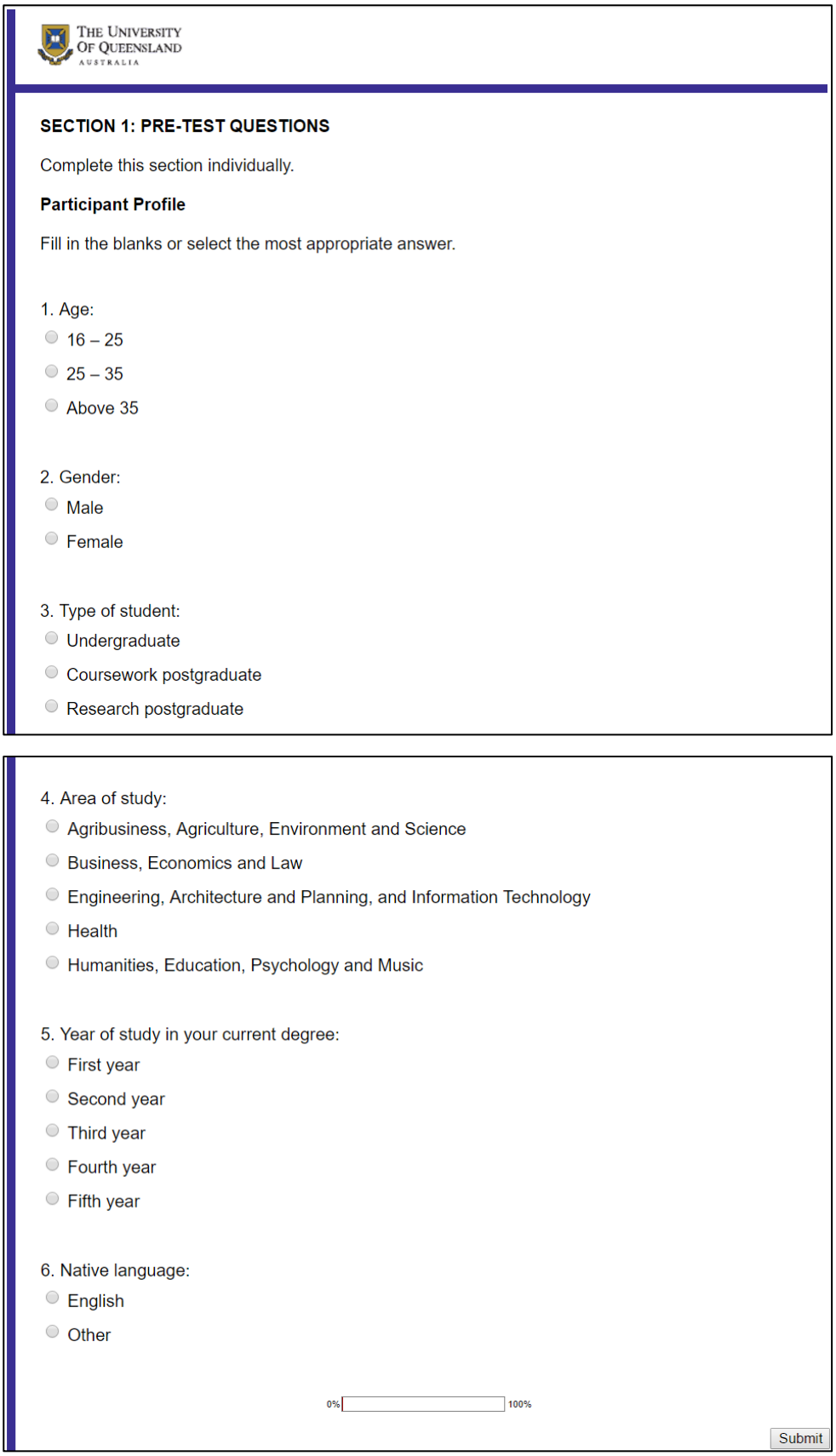


Figure D-51. Screenshots of the Pre-Test Questions

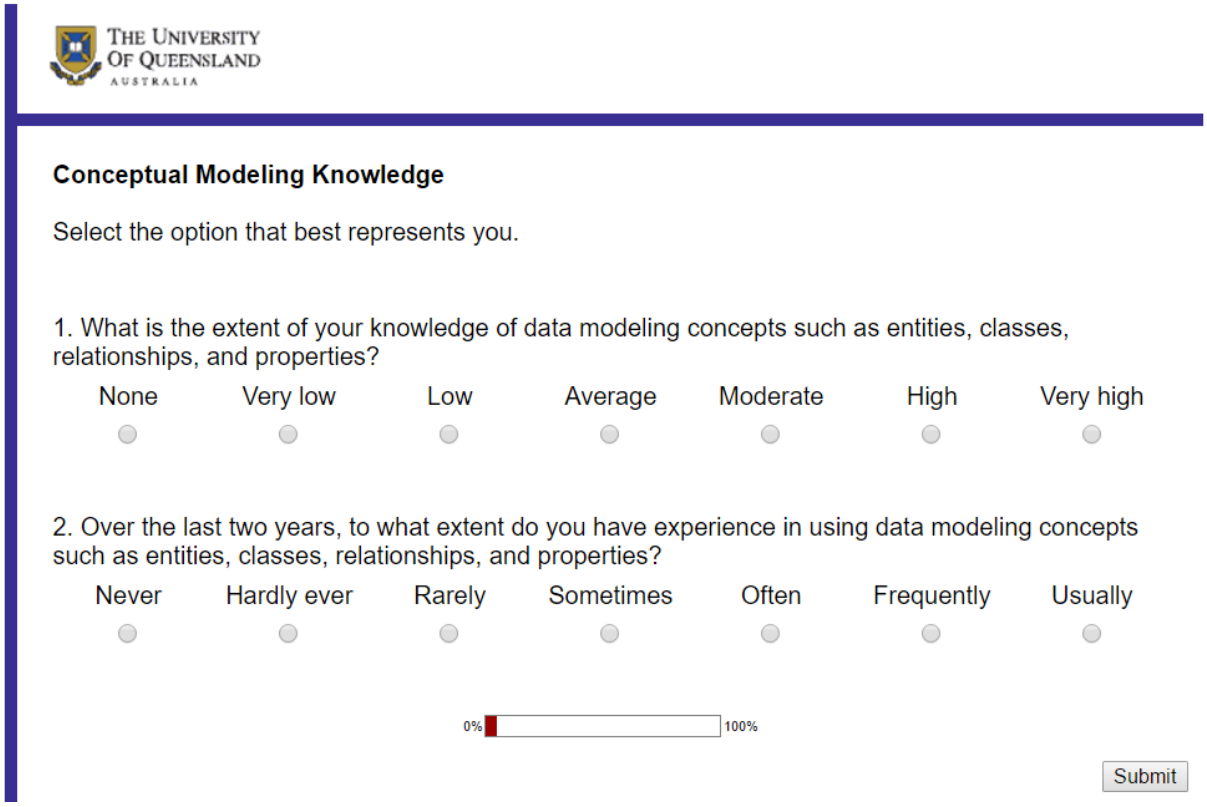


Figure D-52. Screenshot of the Conceptual Modeling Knowledge Questions

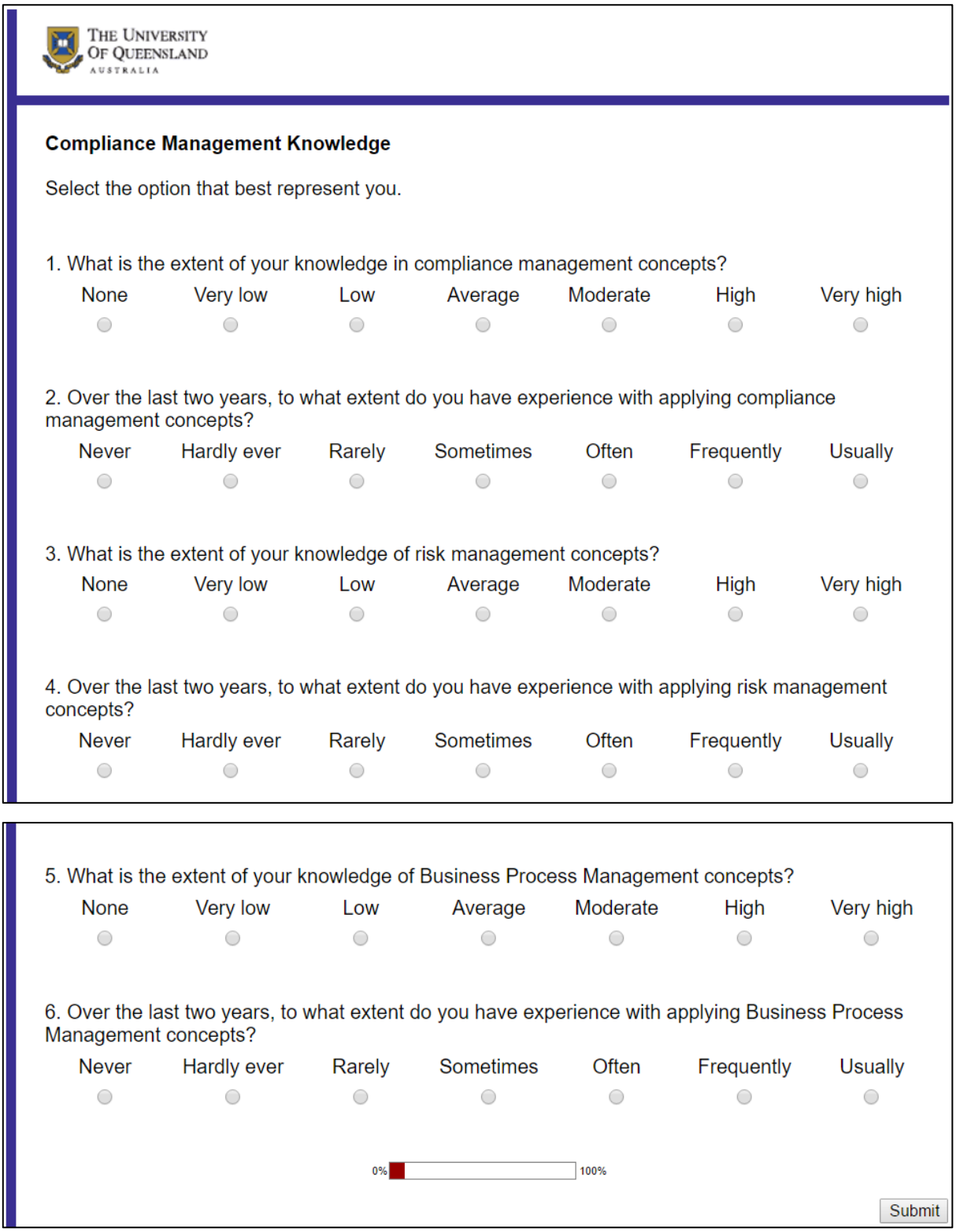


Figure D-53. Screenshot of the Compliance Management Knowledge Questions

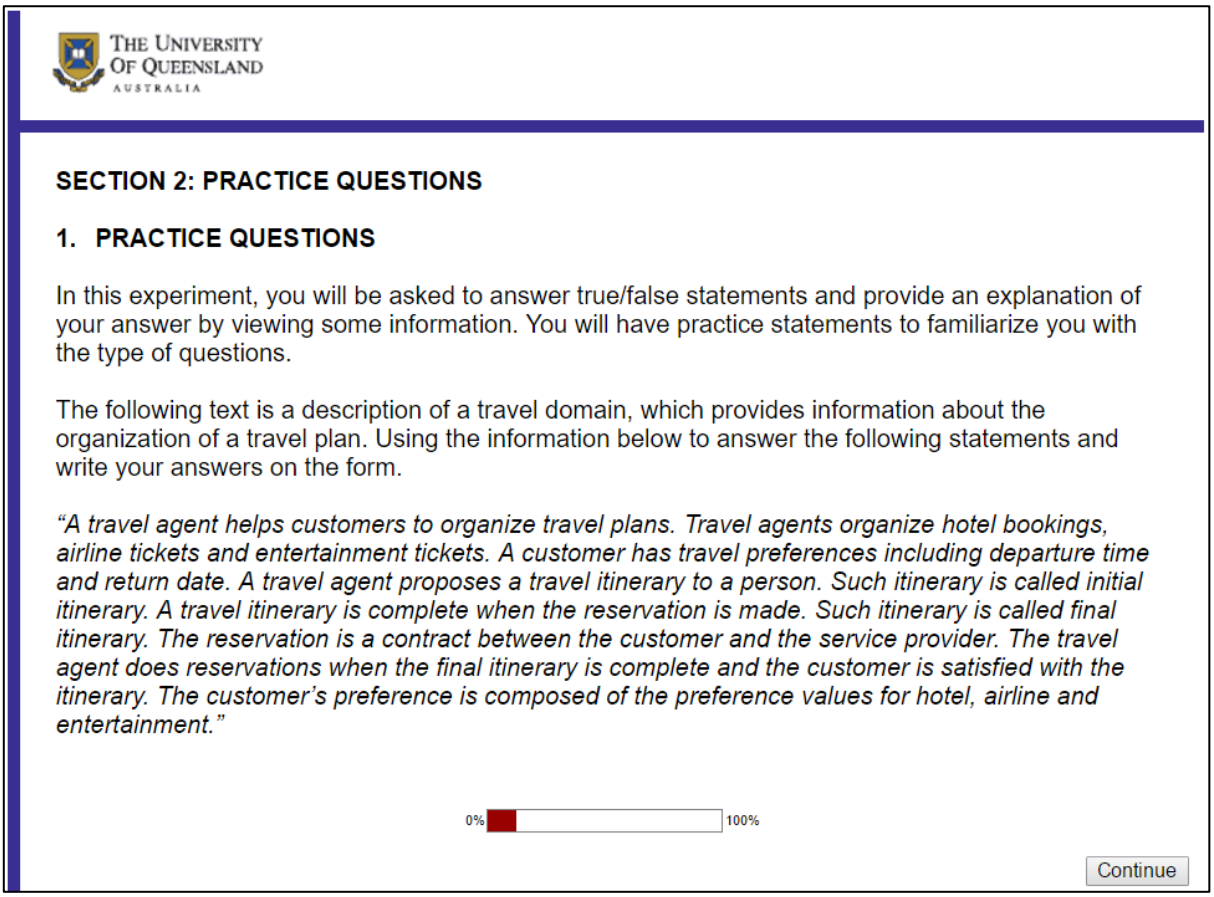


Figure D-54. Screenshot of the Practice Questions Section

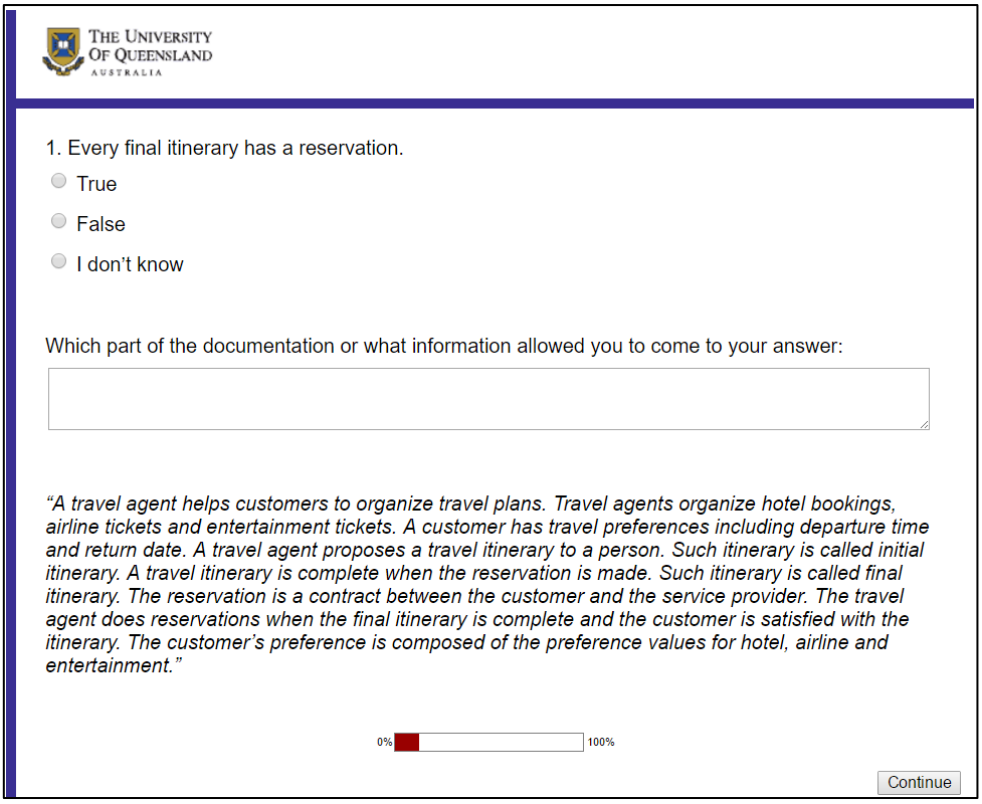


Figure D-55. Screenshot of the Practice Question 1

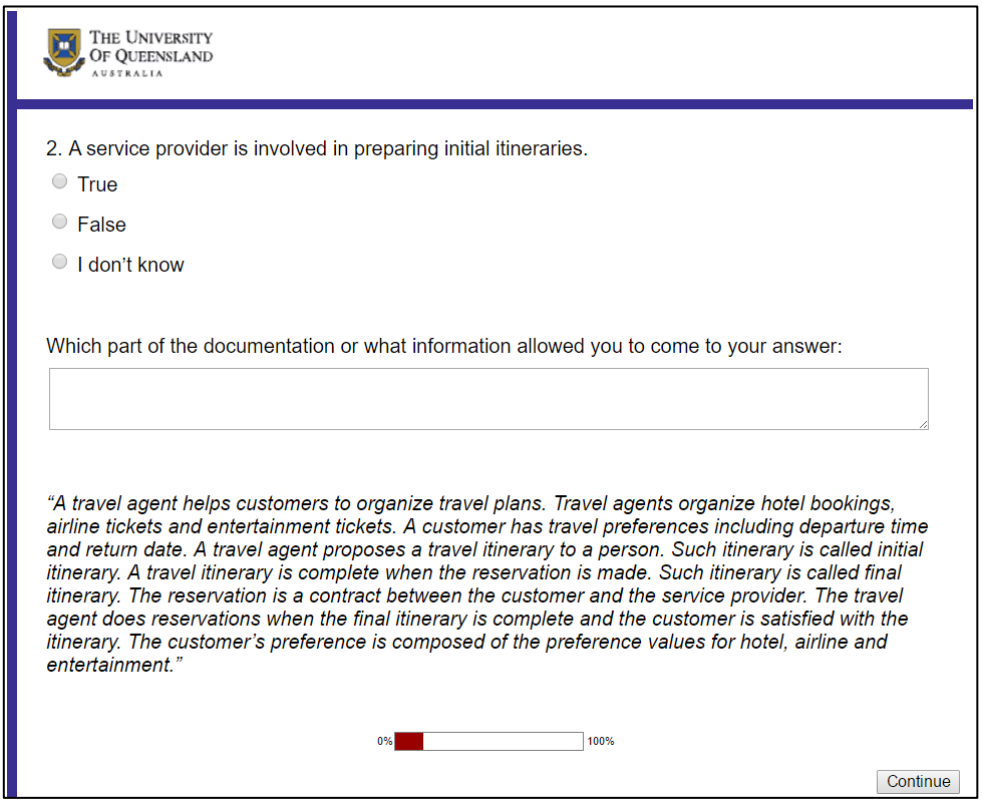


Figure D-56. Screenshot of the Practice Question 2

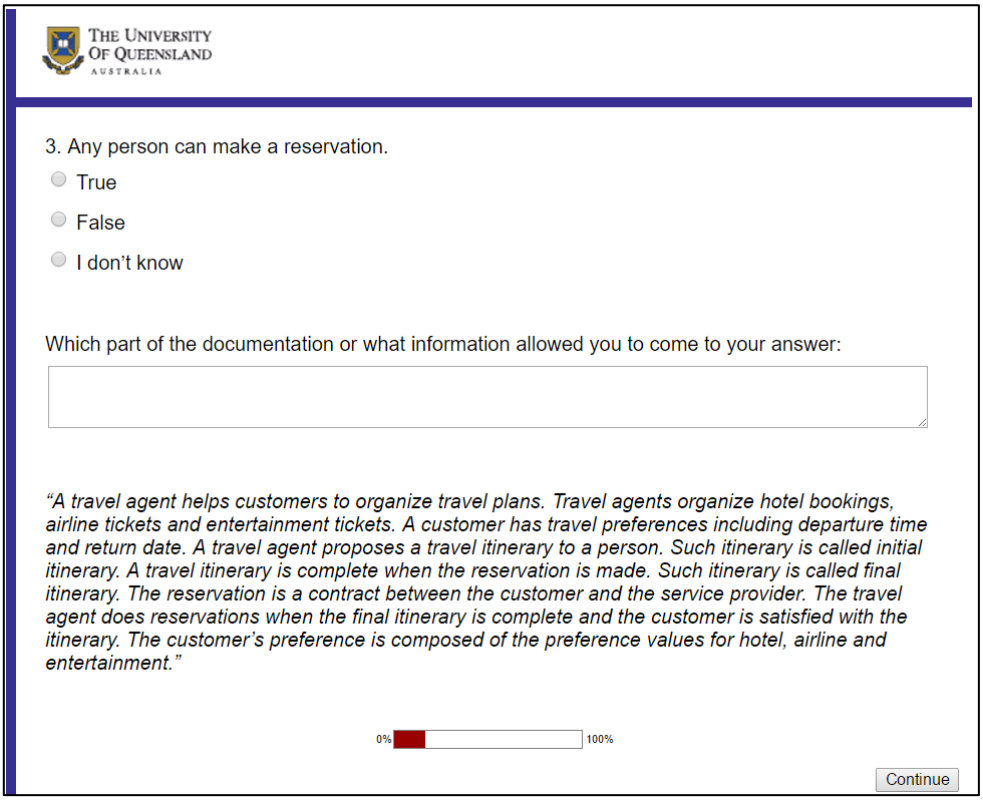


Figure D-57. Screenshot of the Practice Question 3

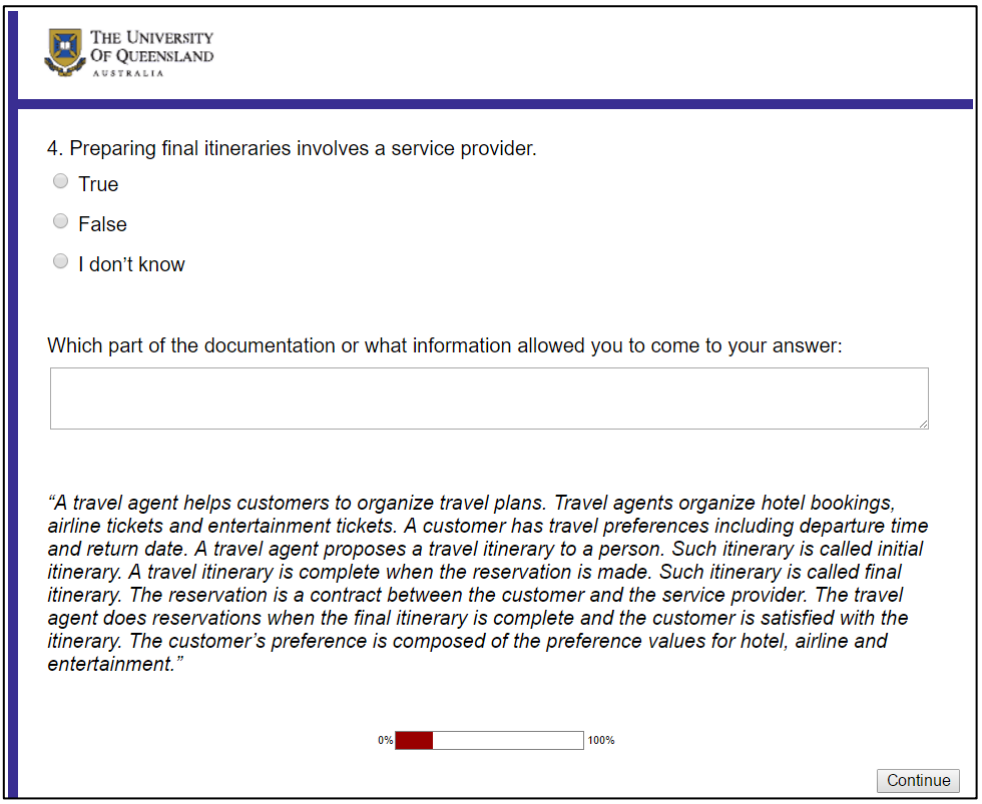


Figure D-58. Screenshot of the Practice Question 4

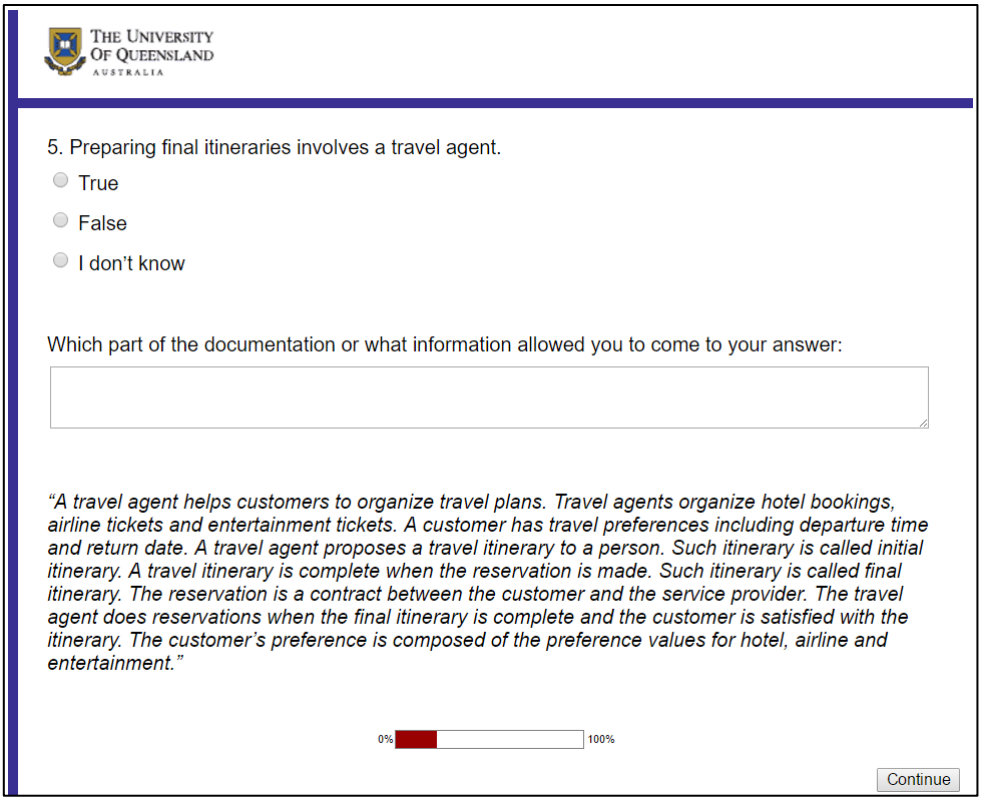


Figure D-59. Screenshot of the Practice Question 5

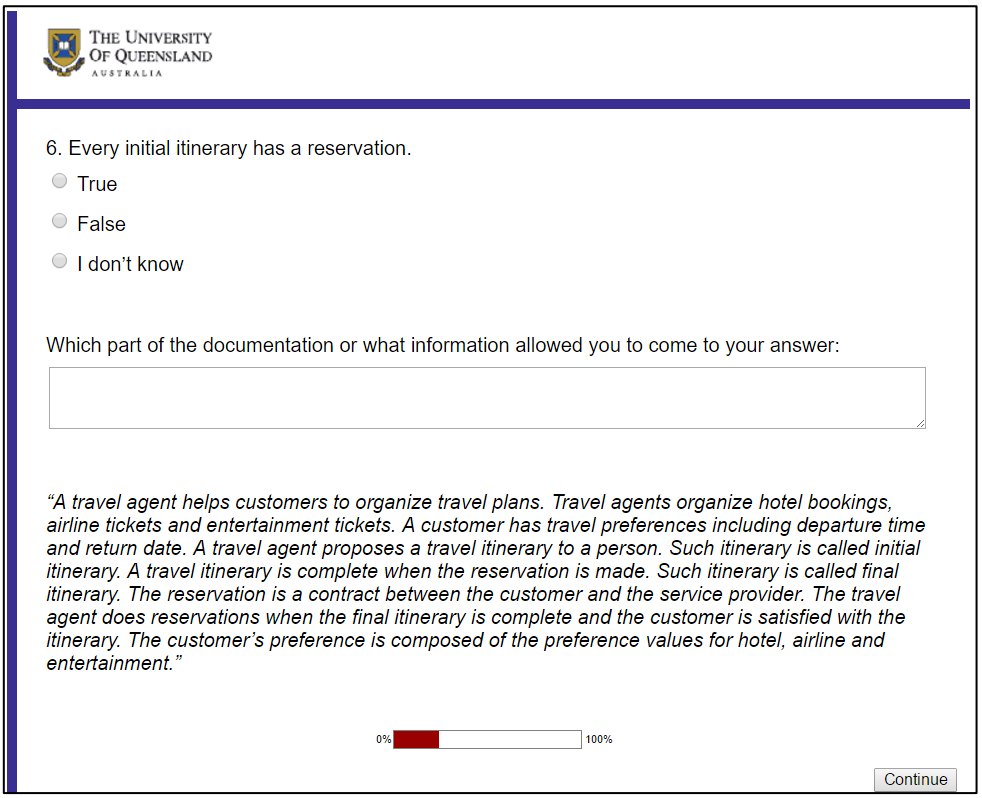


Figure D-60. Screenshot of the Practice Question 6

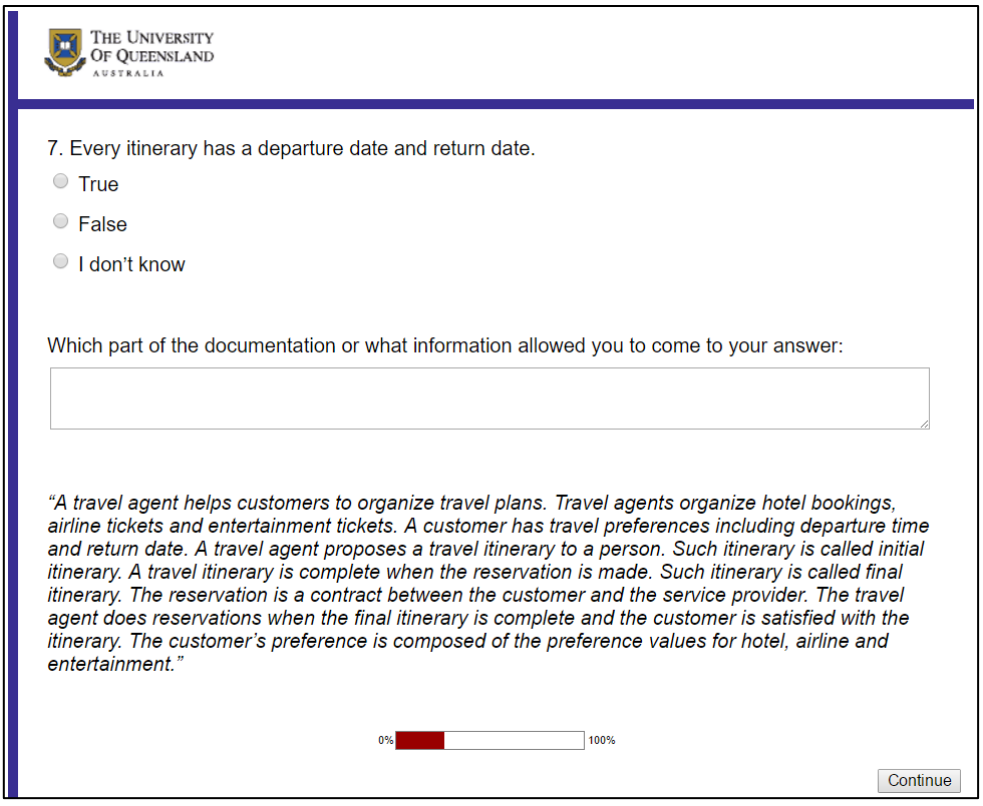


Figure D-61. Screenshot of the Practice Question 7

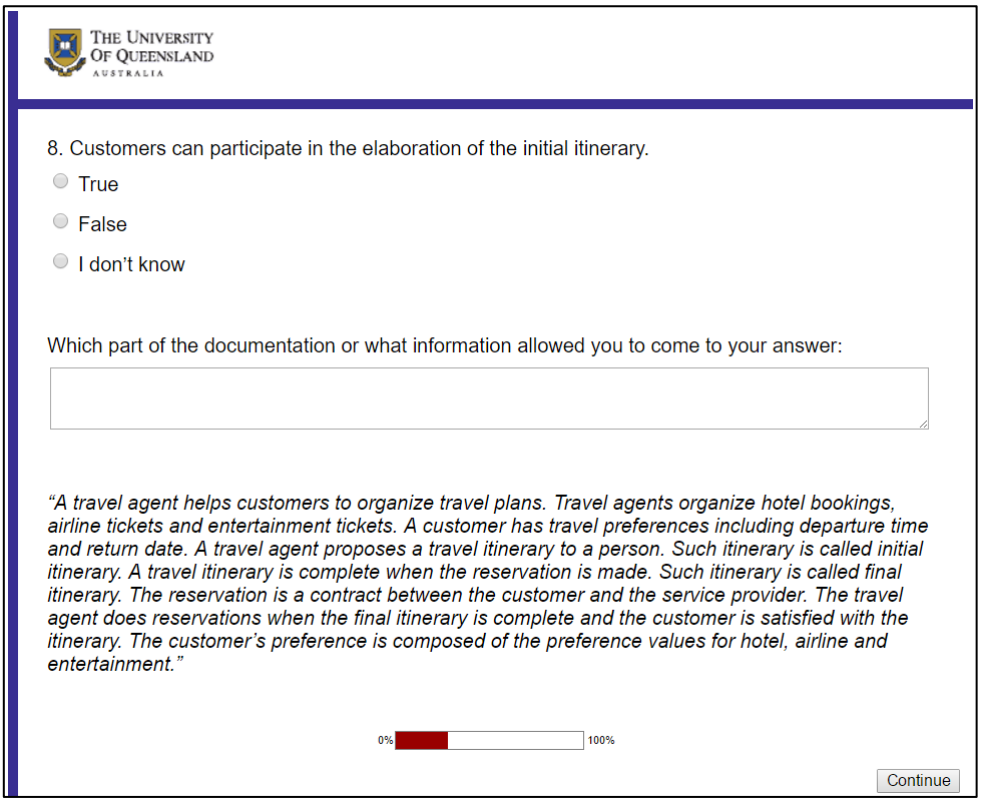


Figure D-62. Screenshot of the Practice Question 8

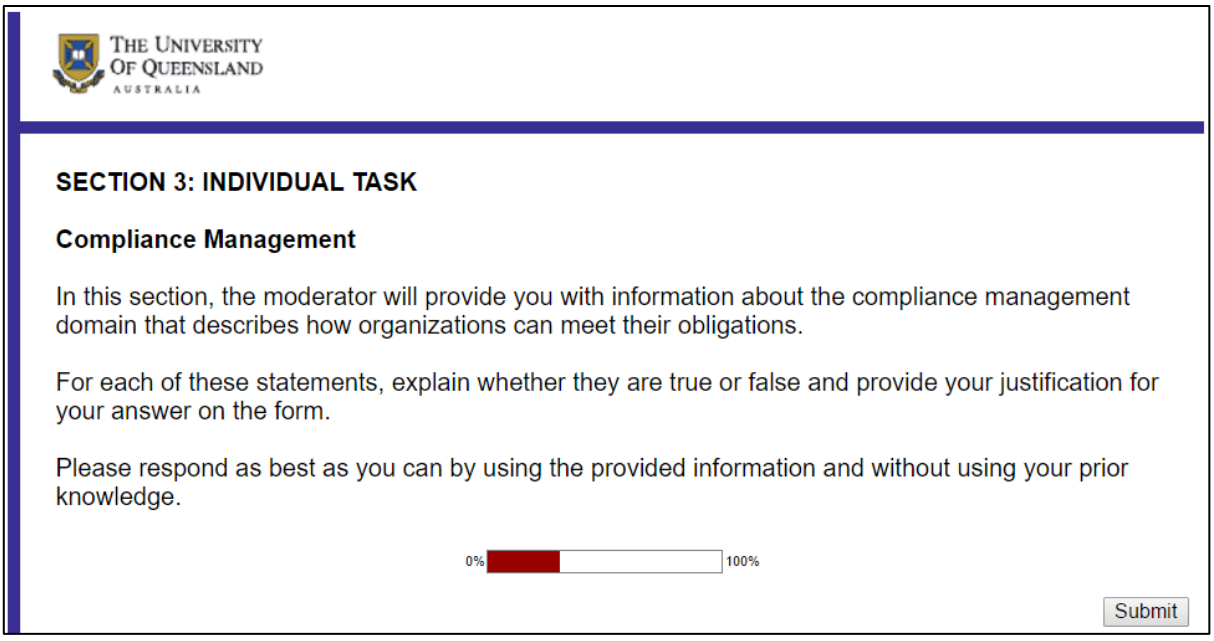


Figure D-63. Screenshot of the Individual Task Section

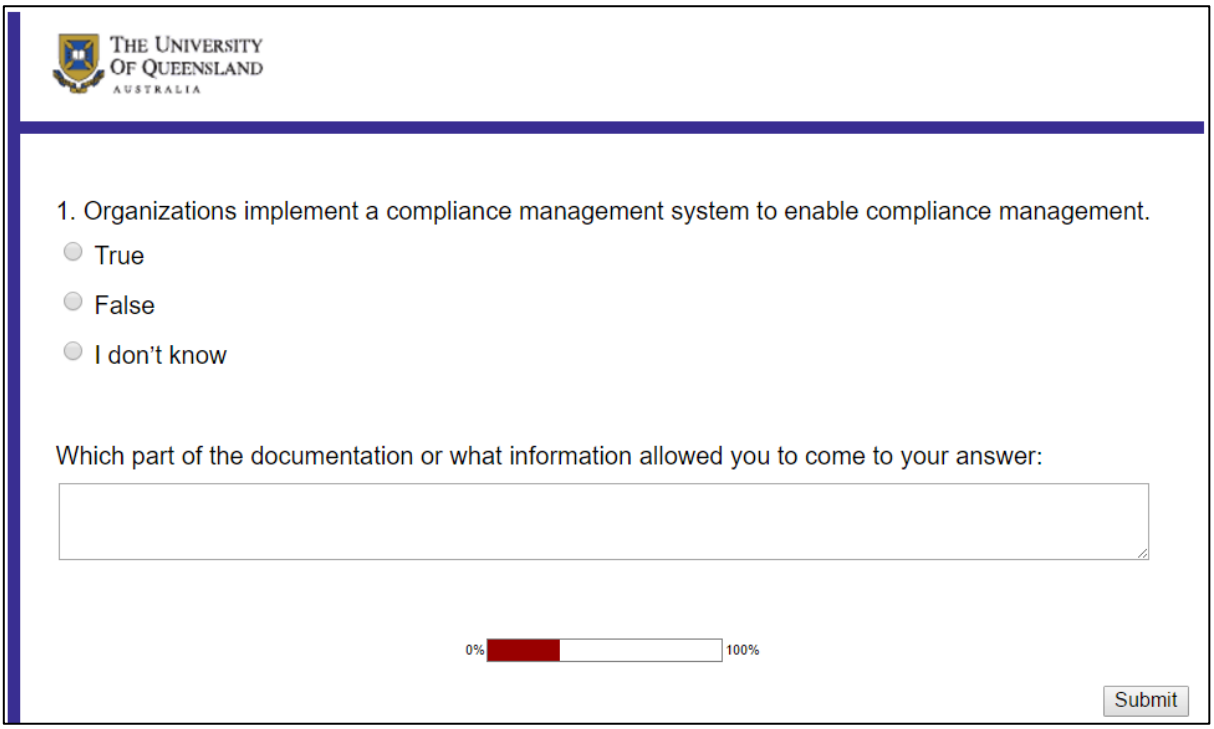


Figure D-64. Screenshot of the Compliance Management Question 1

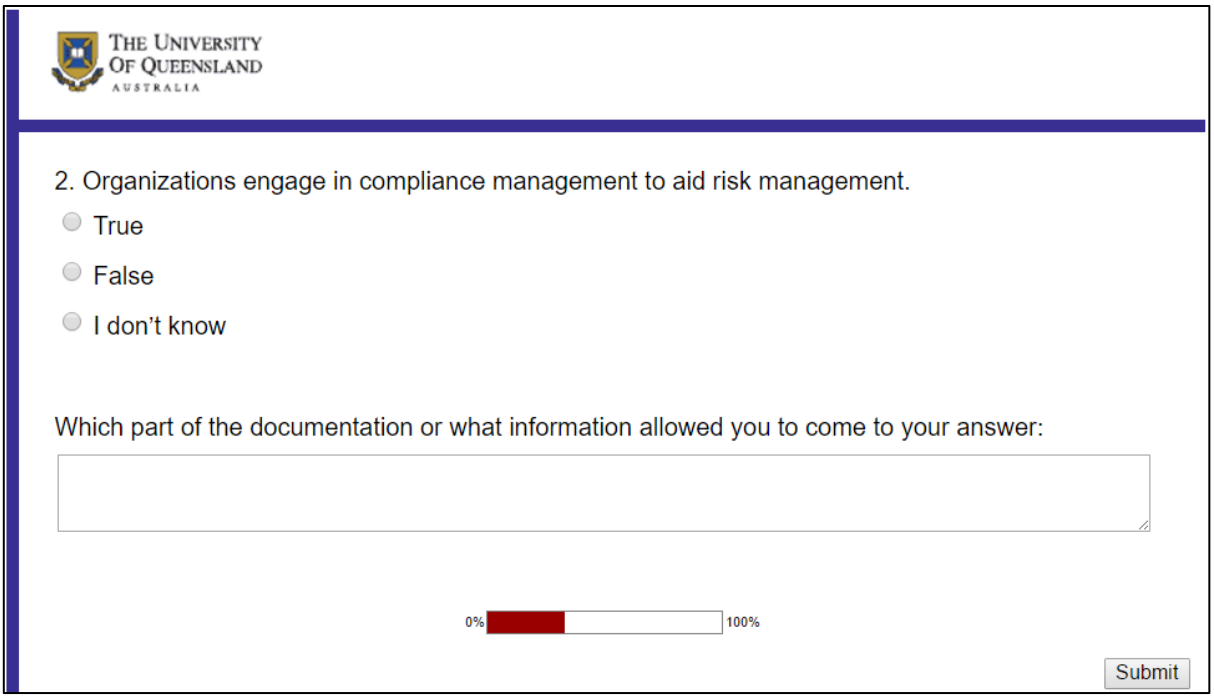


Figure D-65. Screenshot of the Compliance Management Question 2

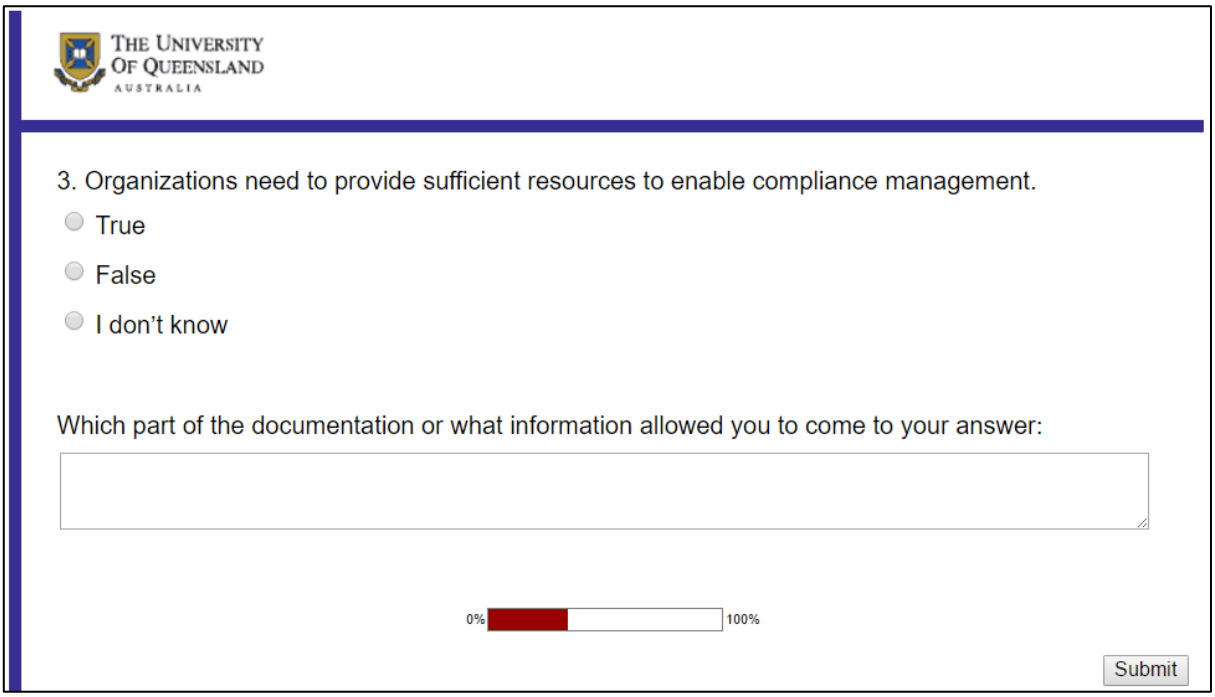


Figure D-66. Screenshot of the Compliance Management Question 3

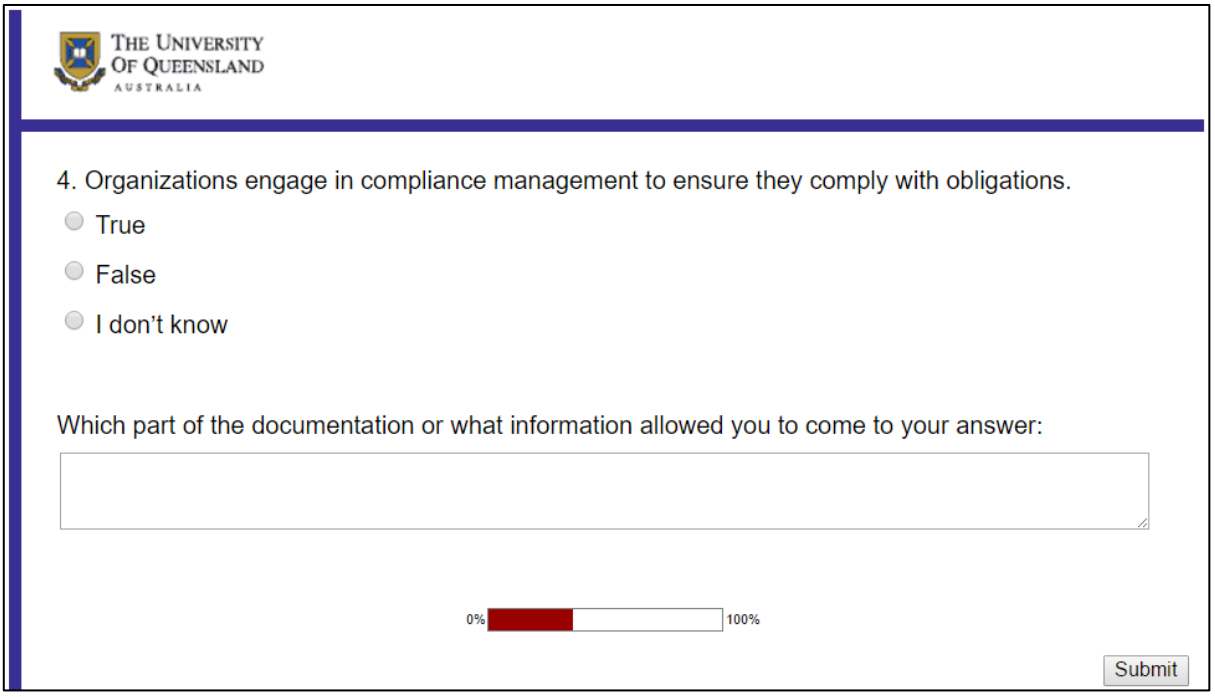


Figure D-67. Screenshot of the Compliance Management Question 4

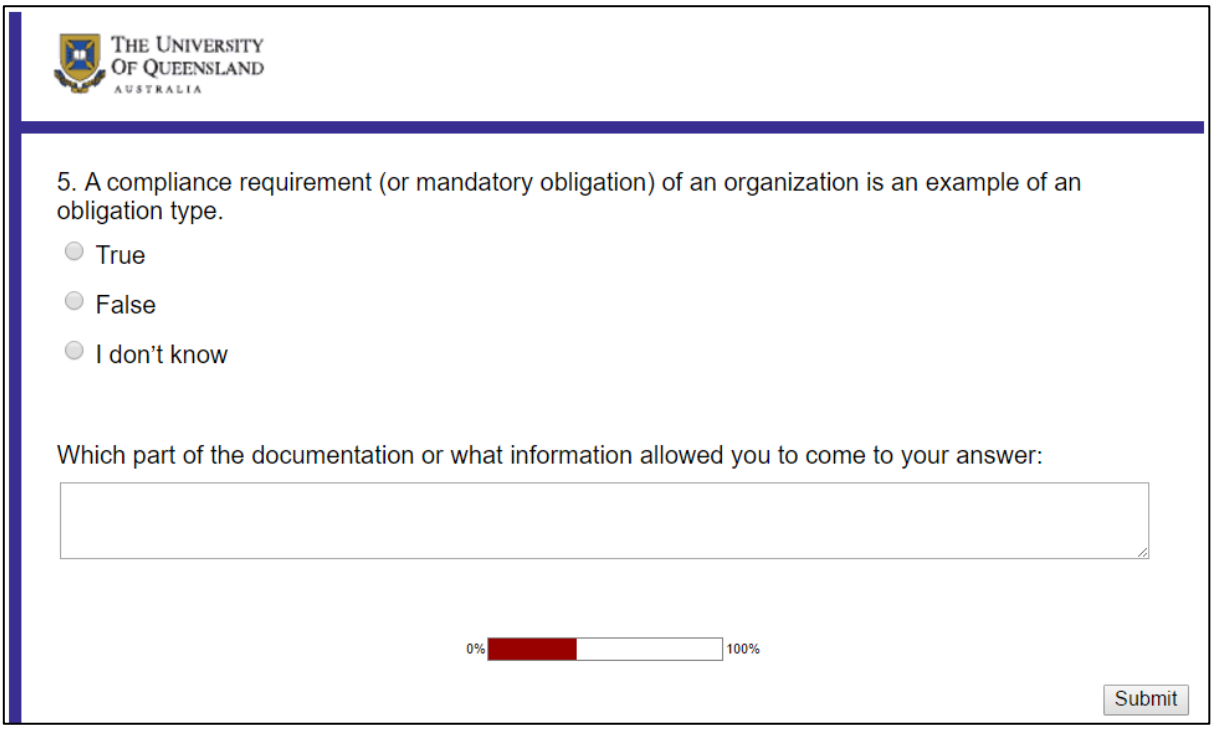


Figure D-68. Screenshot of the Compliance Management Question 5

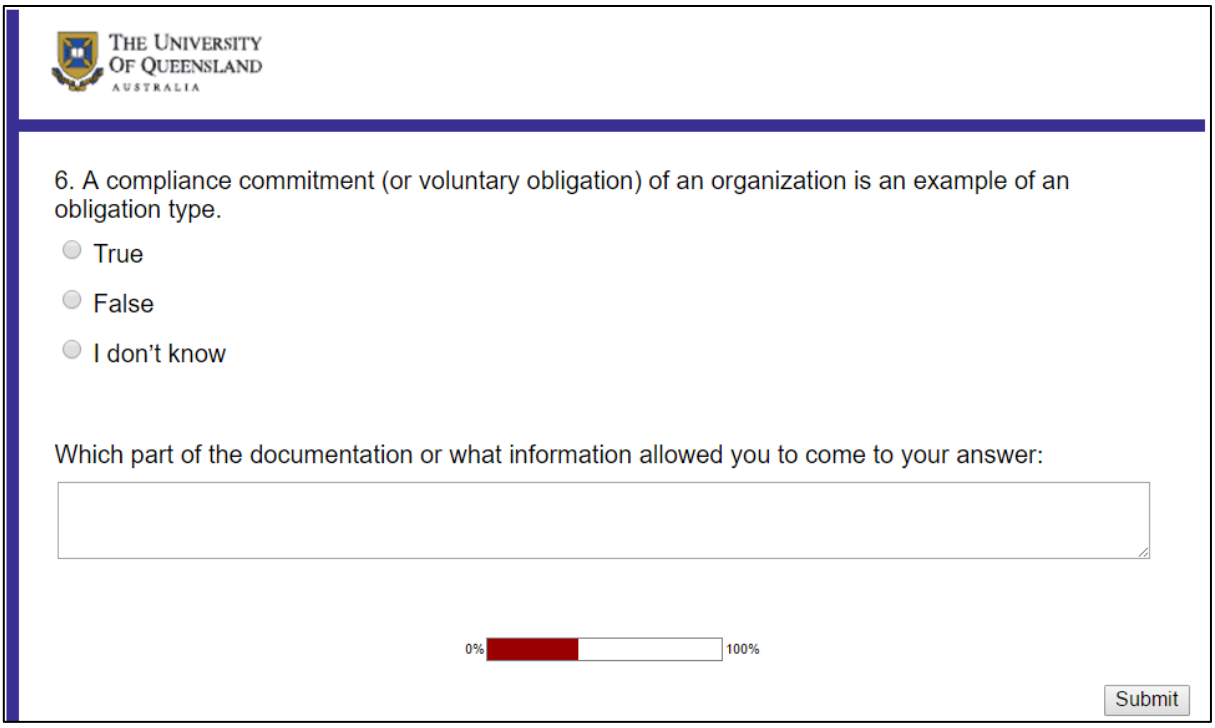


Figure D-69. Screenshot of the Compliance Management Question 6

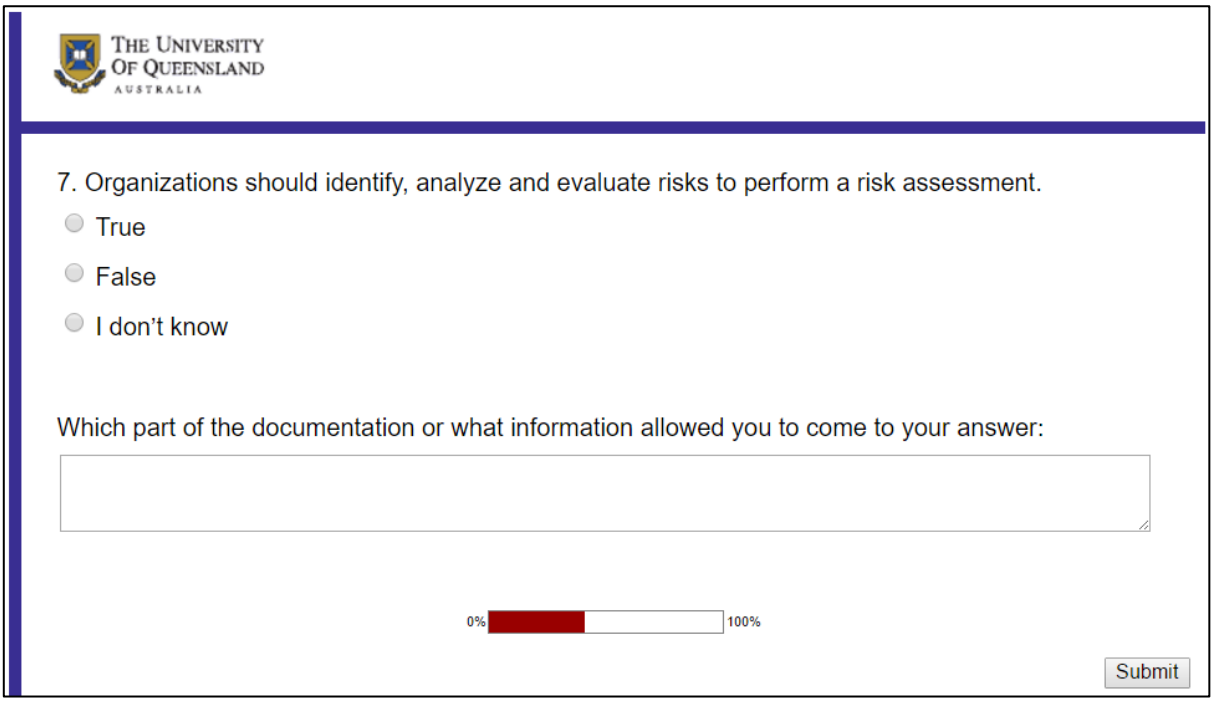


Figure D-70. Screenshot of the Compliance Management Question 7

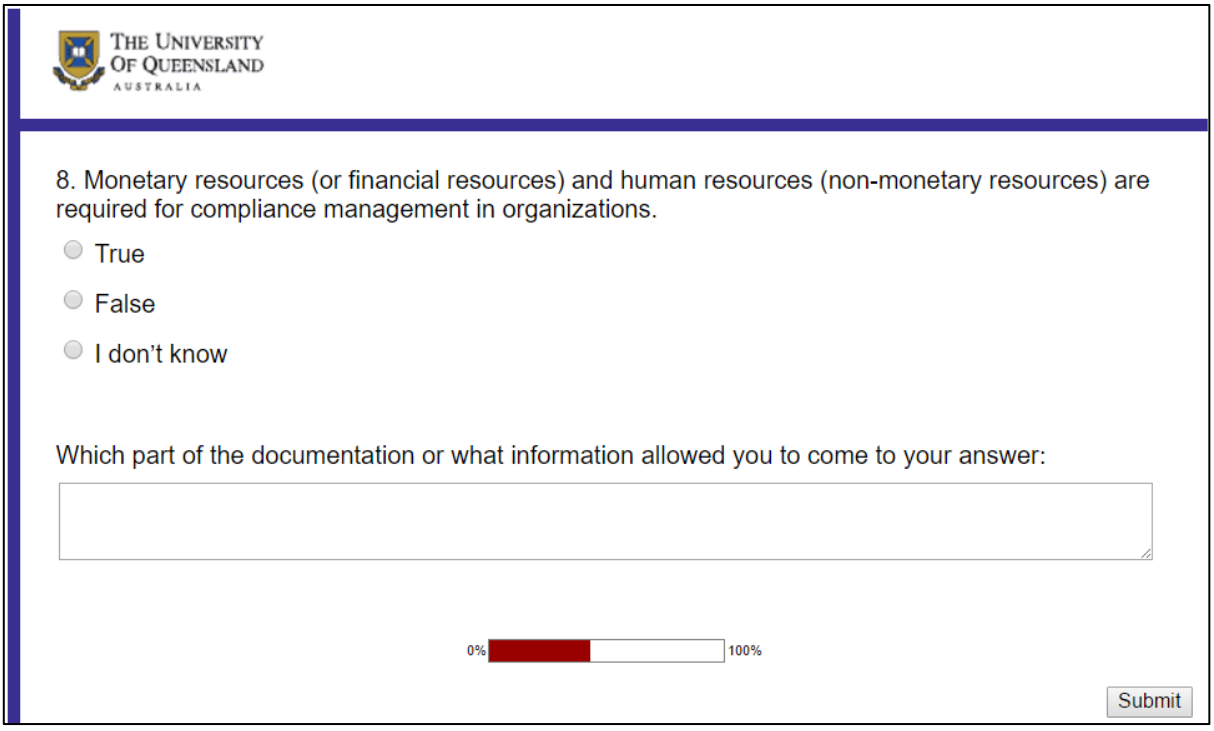


Figure D-71. Screenshot of the Compliance Management Question 8

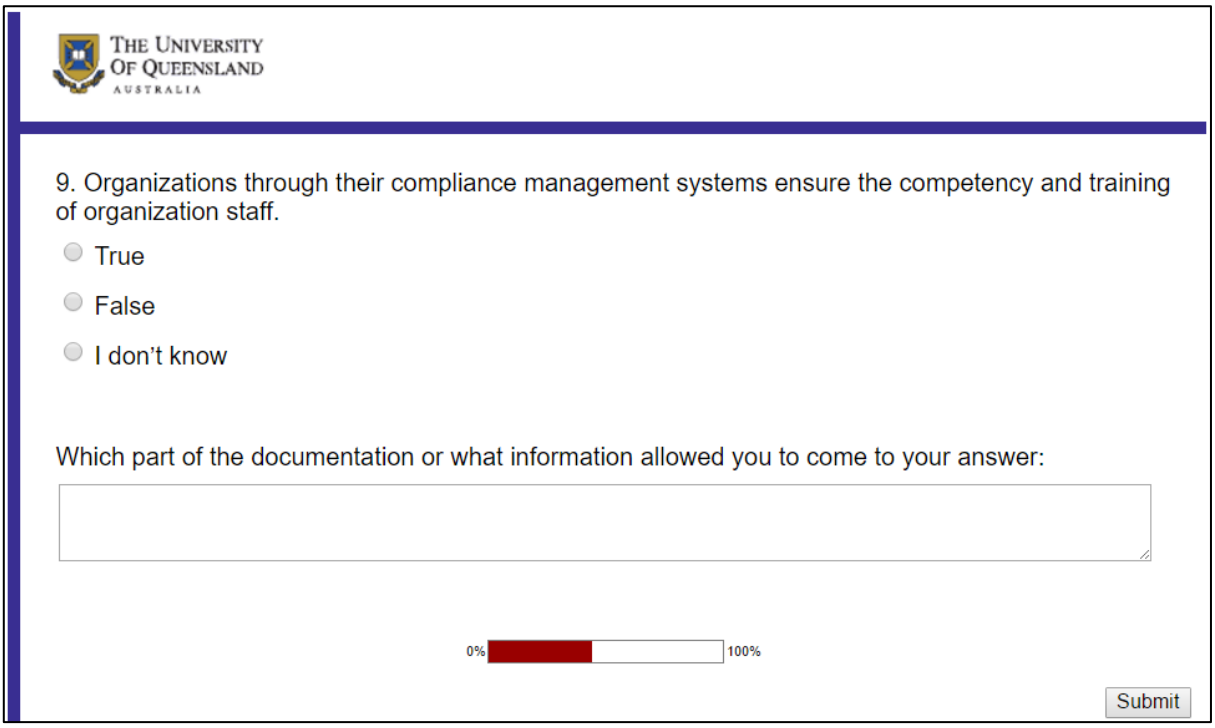


Figure D-72. Screenshot of the Compliance Management Question 9

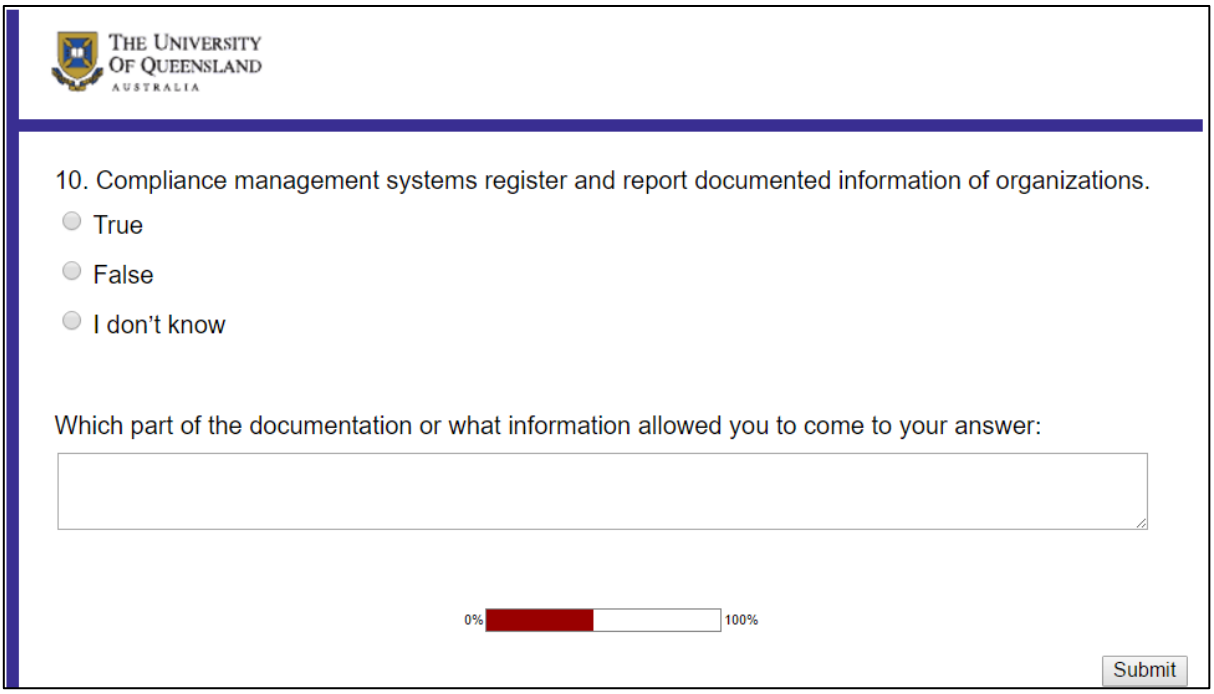


Figure D-73. Screenshot of the Compliance Management Question 10

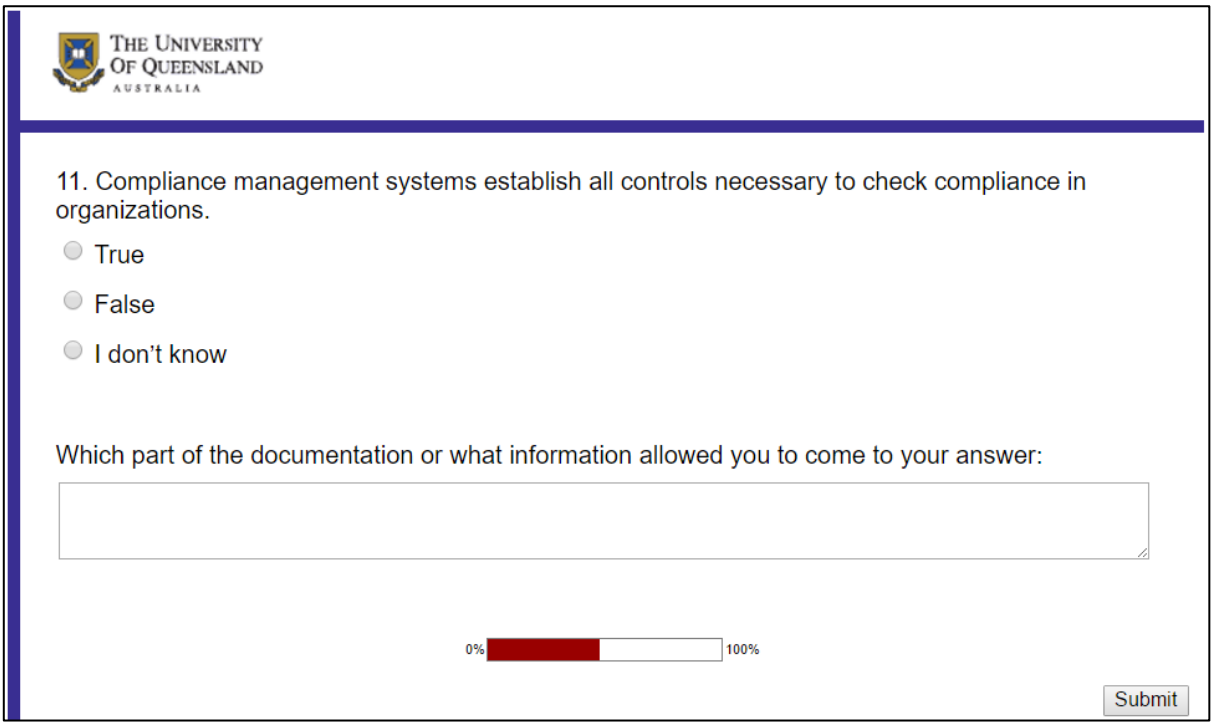


Figure D-74. Screenshot of the Compliance Management Question 11

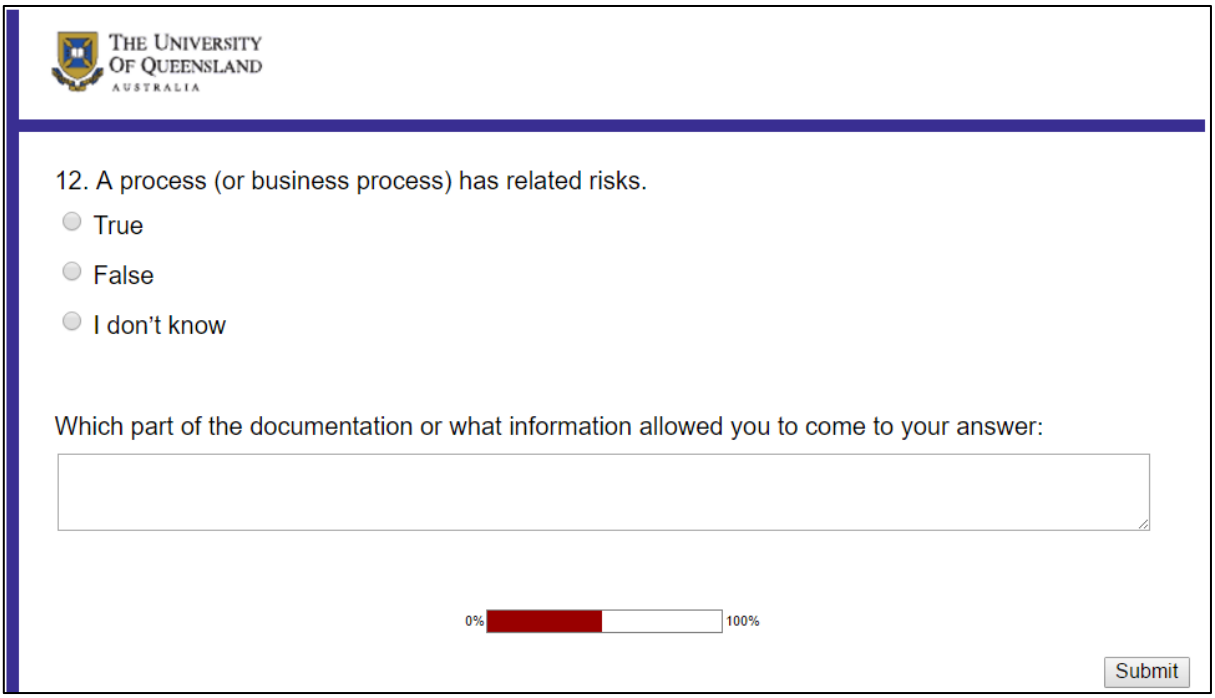


Figure D-75. Screenshot of the Compliance Management Question 12

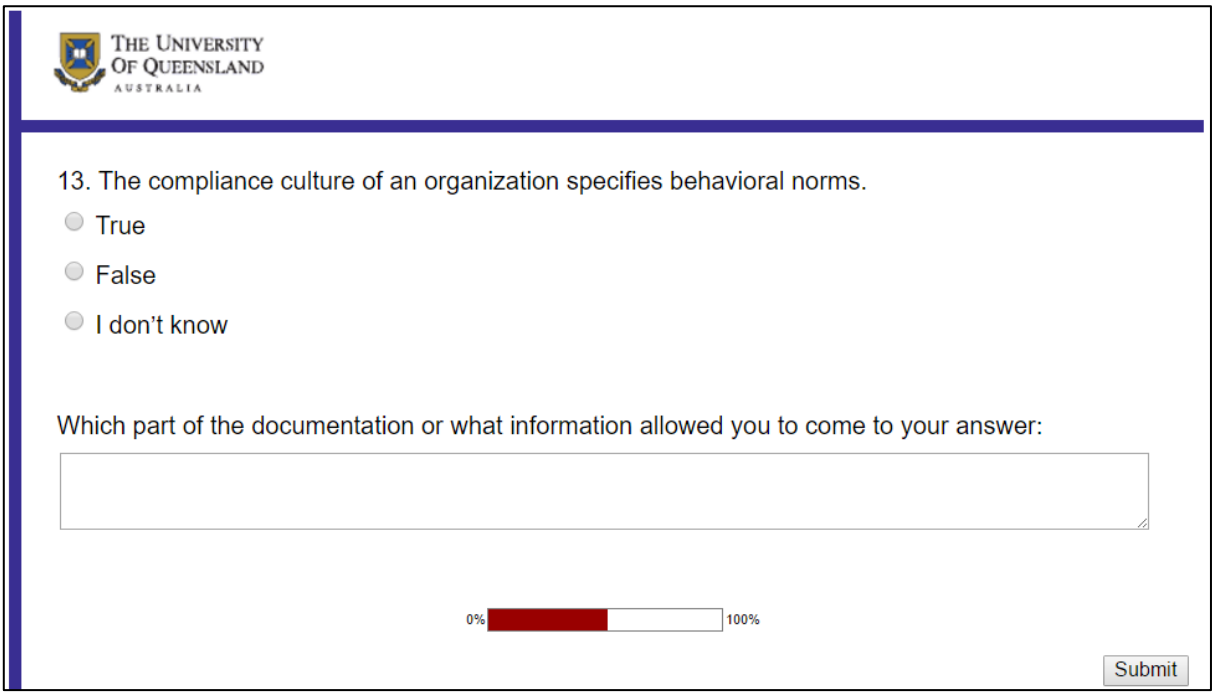


Figure D-76. Screenshot of the Compliance Management Question 13

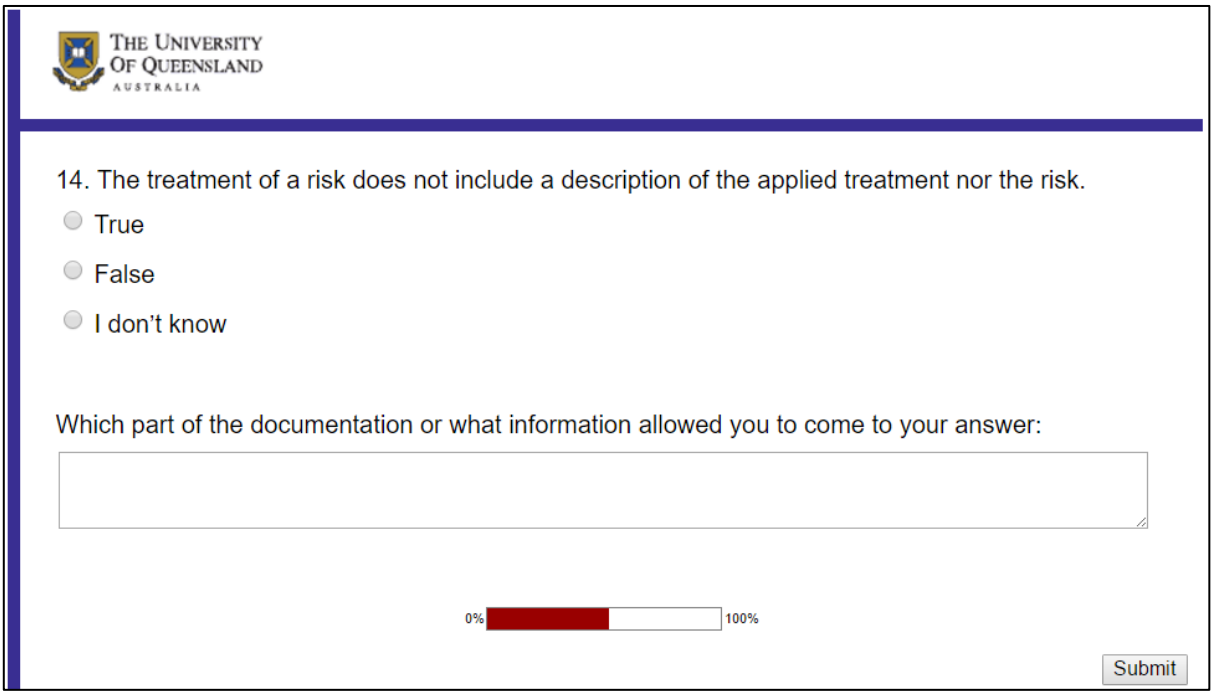


Figure D-77. Screenshot of the Compliance Management Question 14

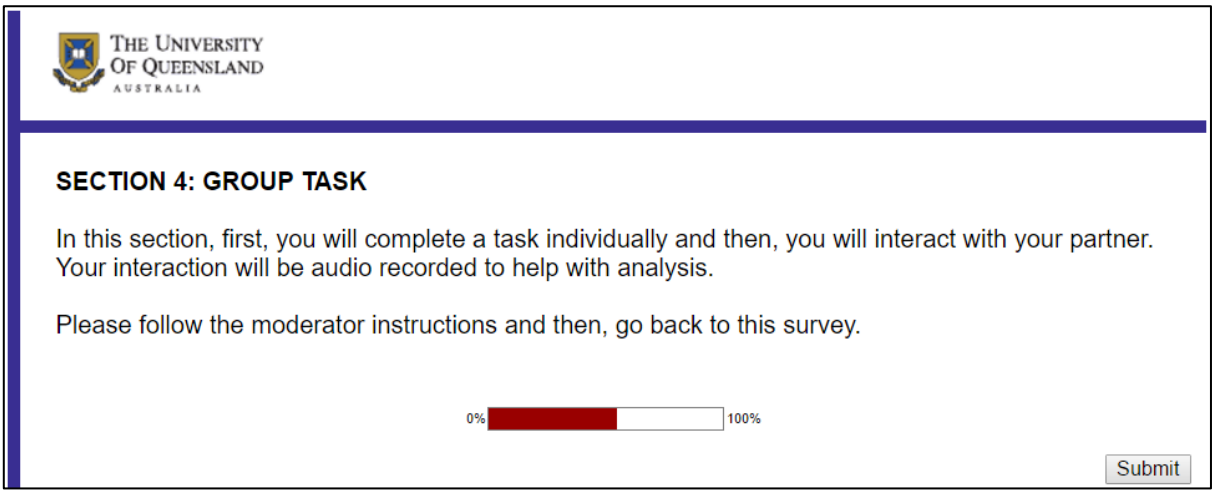


Figure D-78. Screenshot of the Group Task Section

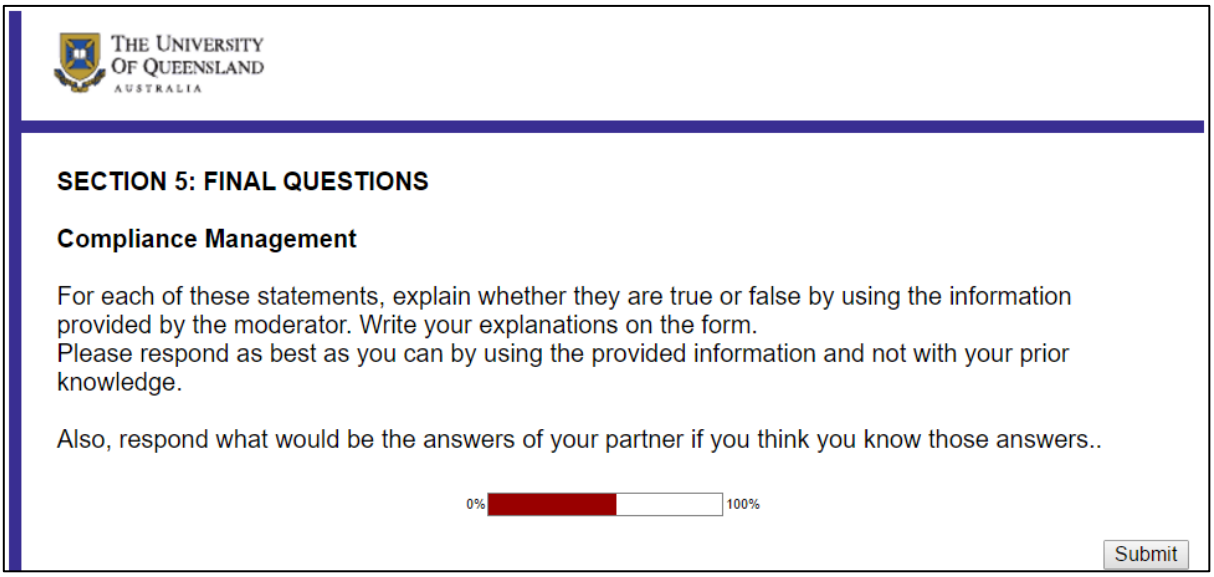


Figure D-79. Screenshot of the Final Question Section

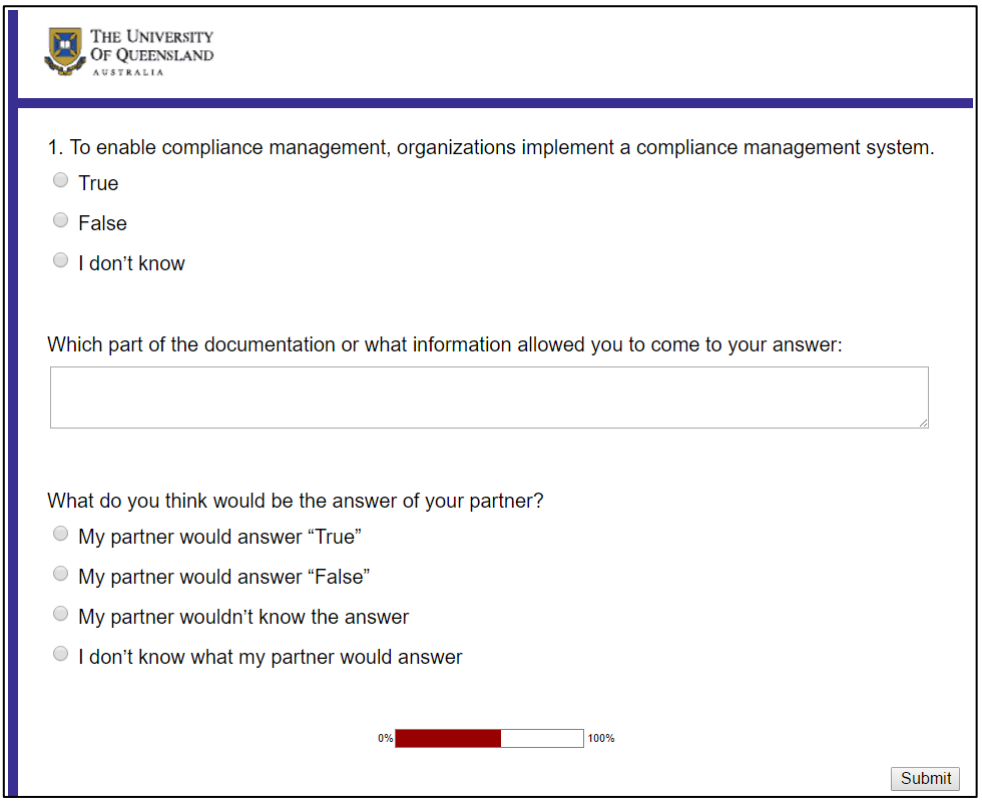


Figure D-80. Screenshot of the Compliance Management Question 1

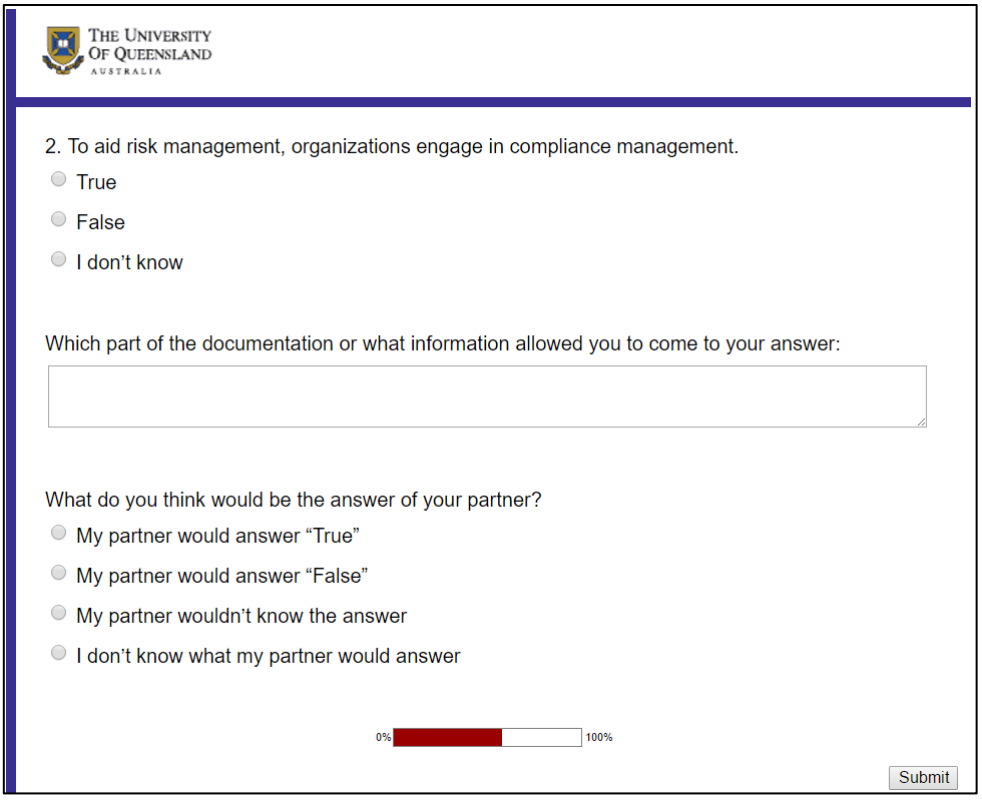


Figure D-81. Screenshot of the Compliance Management Question 2

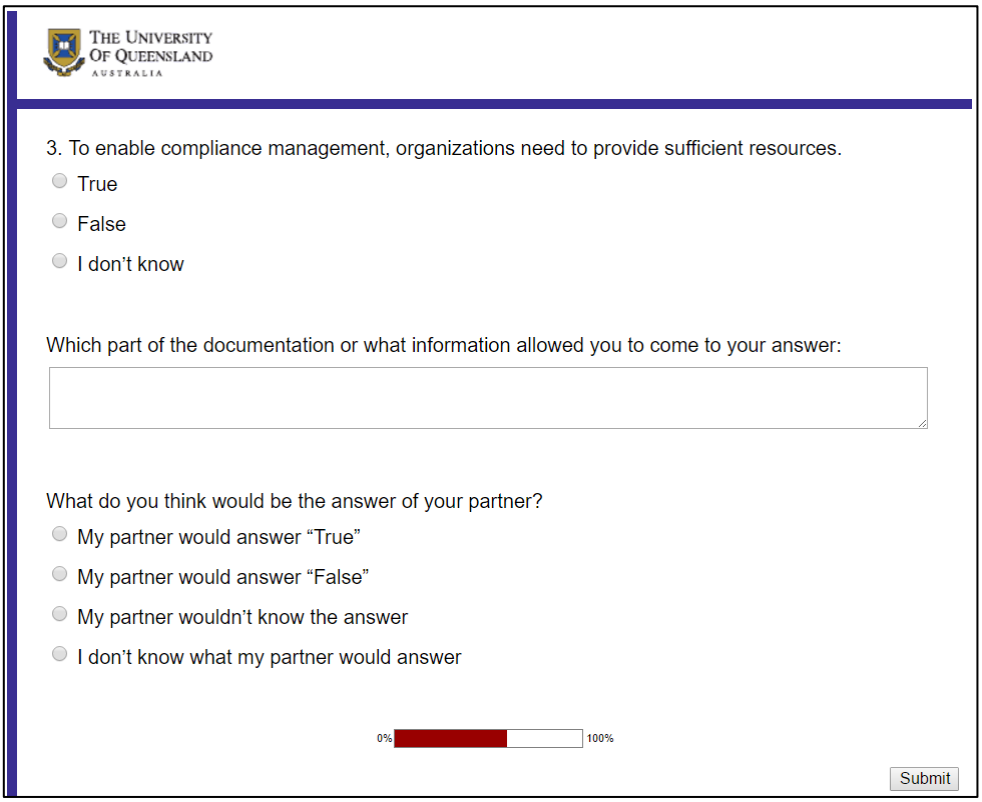


Figure D-82. Screenshot of the Compliance Management Question 3

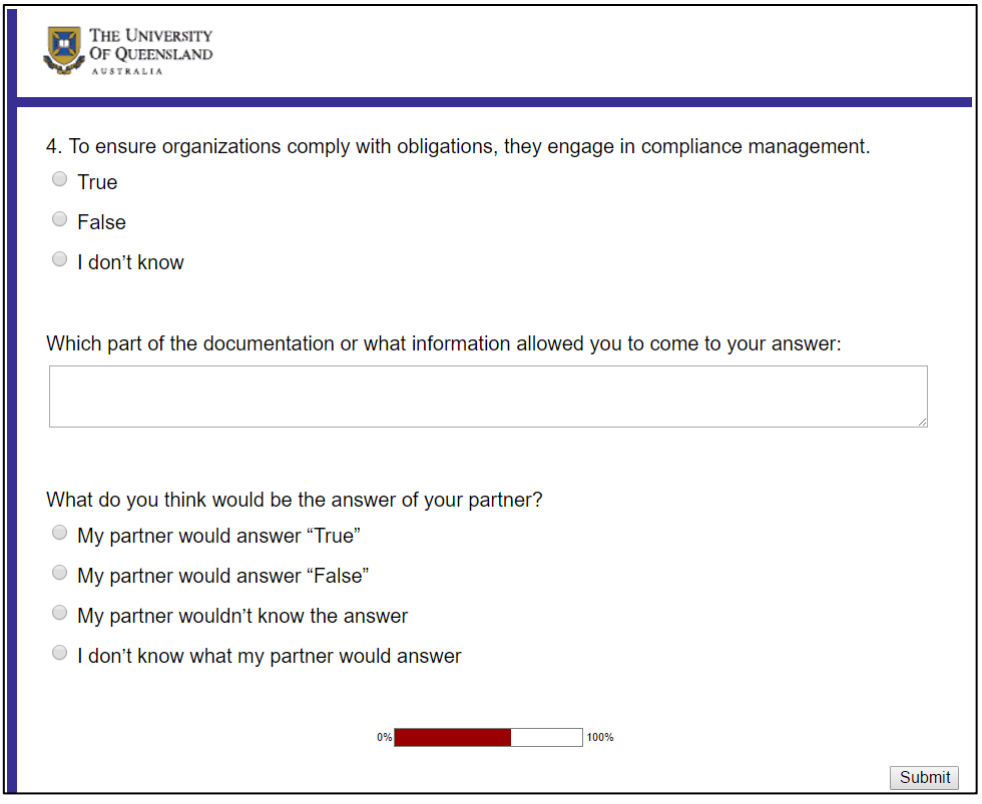


Figure D-83. Screenshot of the Compliance Management Question 4

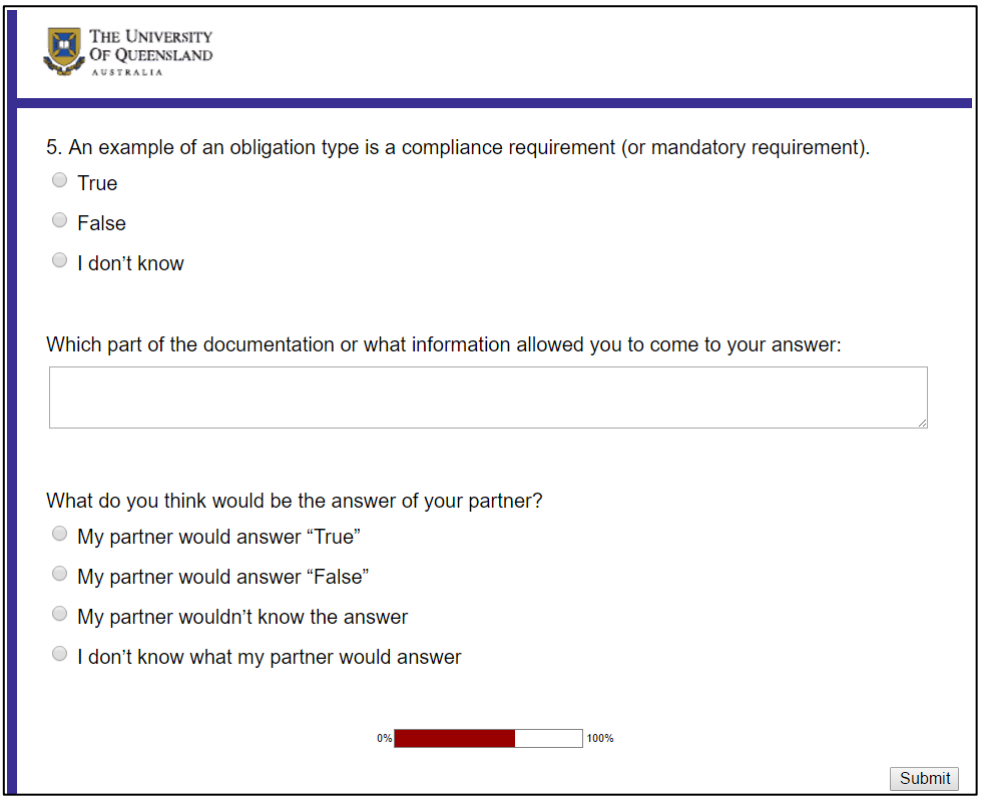


Figure D-84. Screenshot of the Compliance Management Question 5

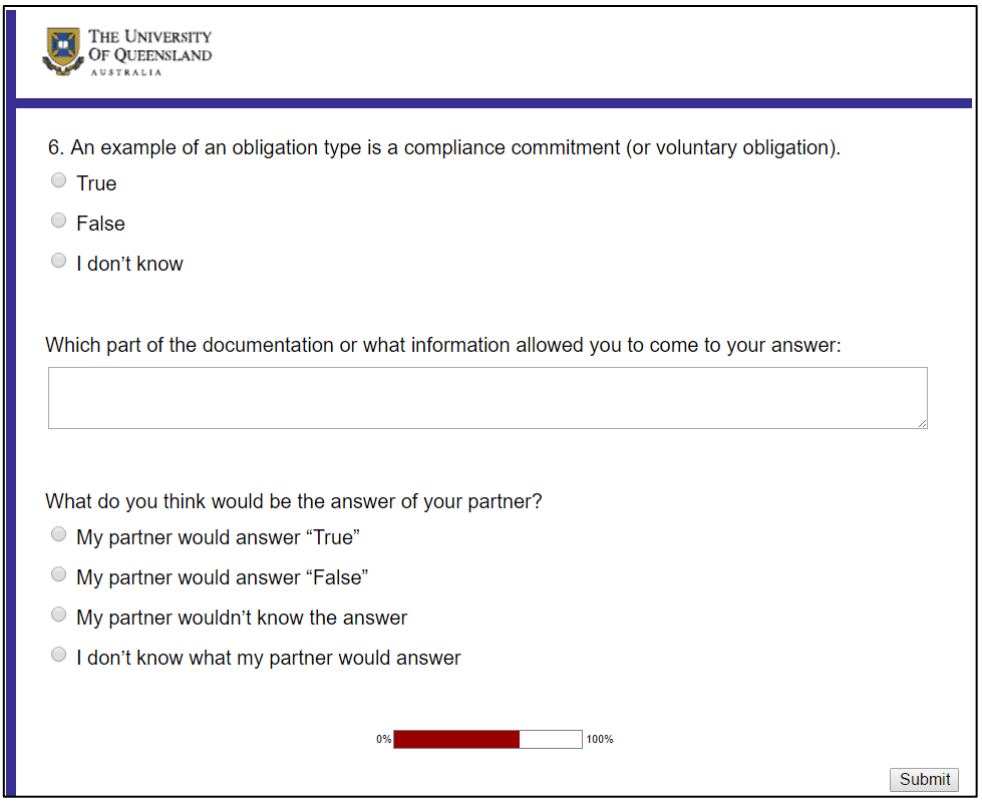


Figure D-85. Screenshot of the Compliance Management Question 6

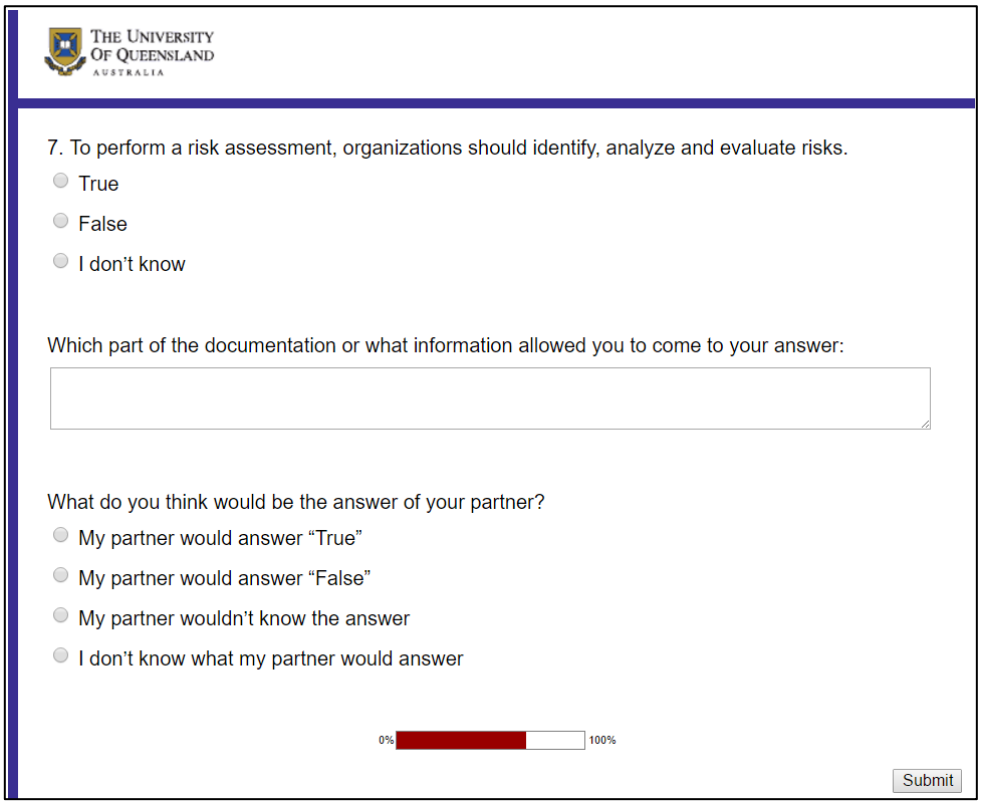


Figure D-86. Screenshot of the Compliance Management Question 7

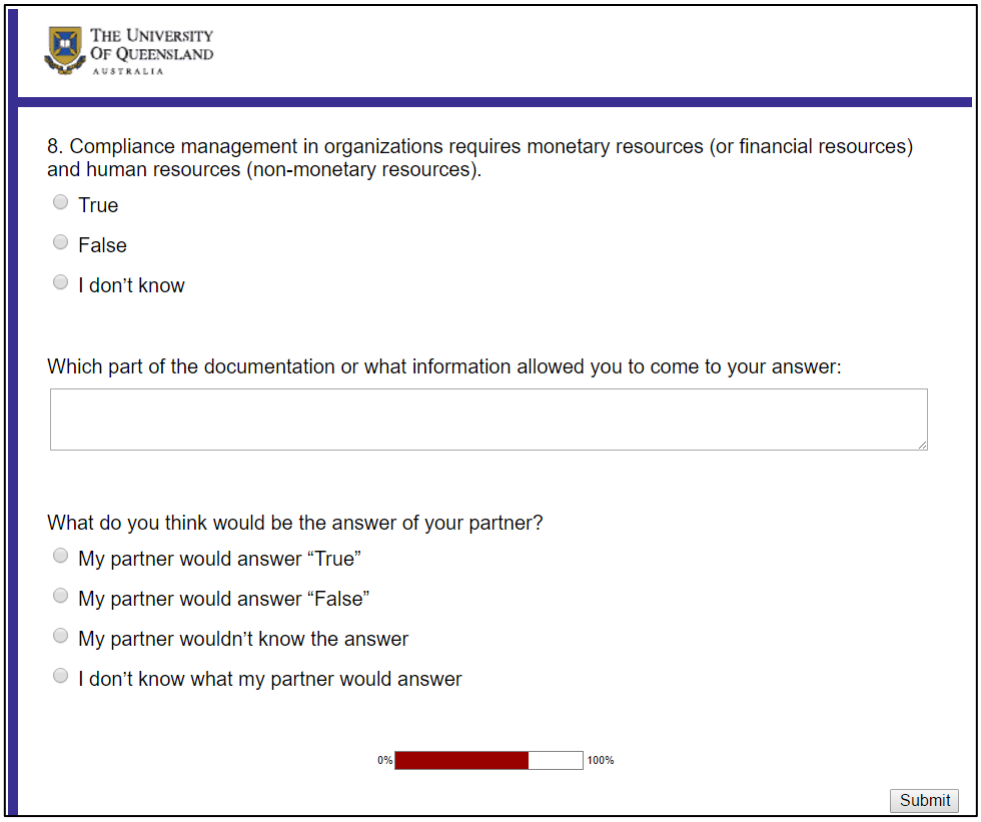


Figure D-87. Screenshot of the Compliance Management Question 8

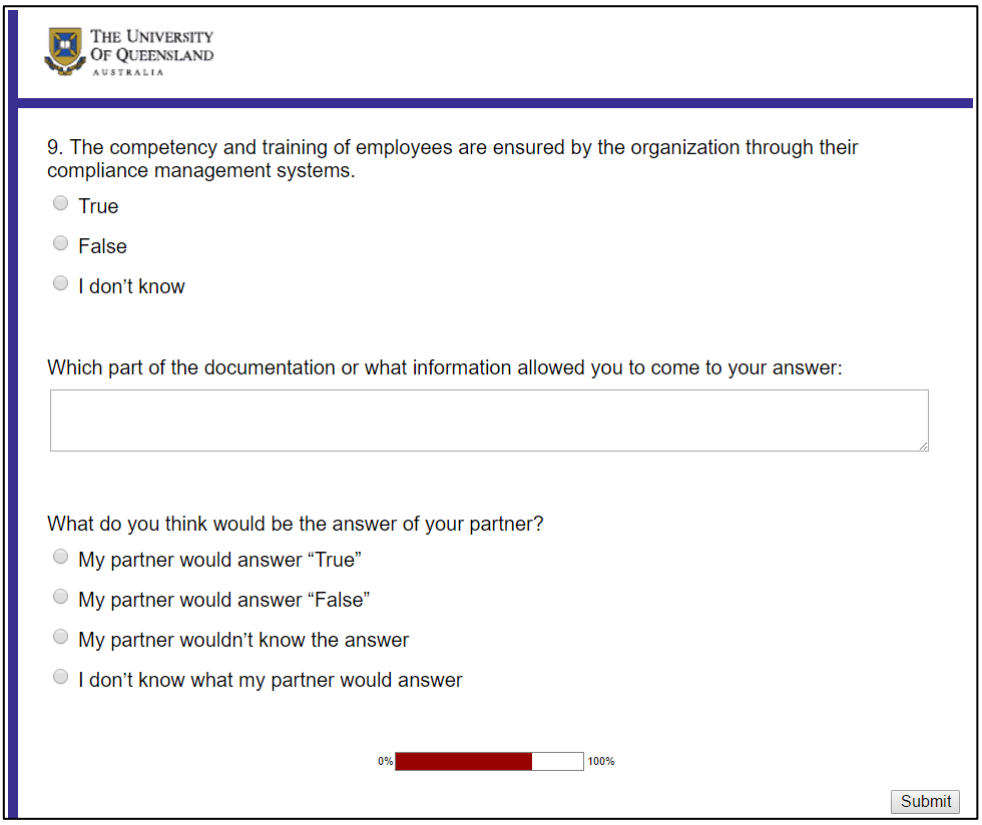


Figure D-88. Screenshot of the Compliance Management Question 9

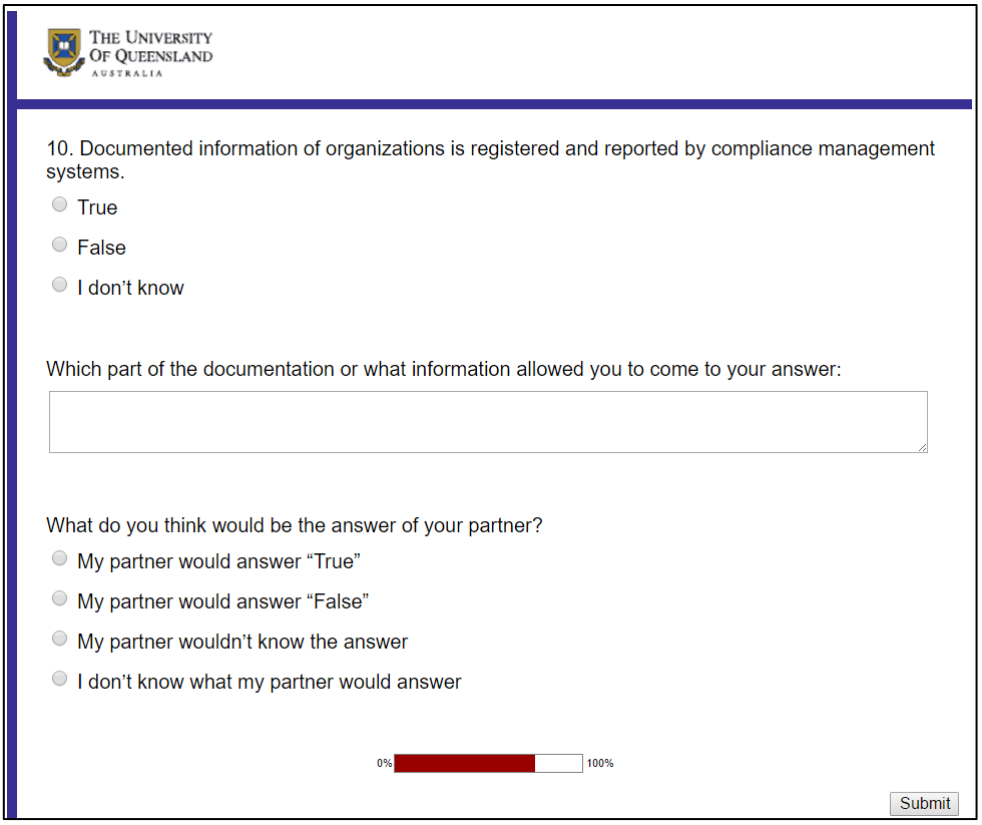


Figure D-89. Screenshot of the Compliance Management Question 10

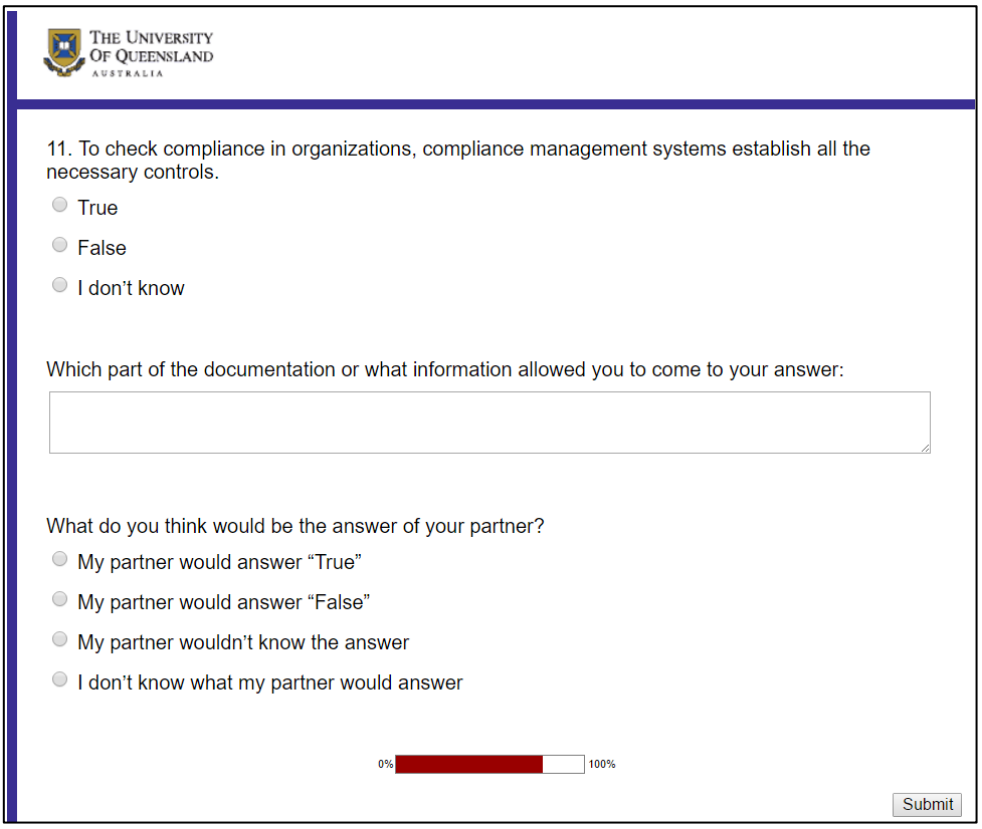


Figure D-90. Screenshot of the Compliance Management Question 11

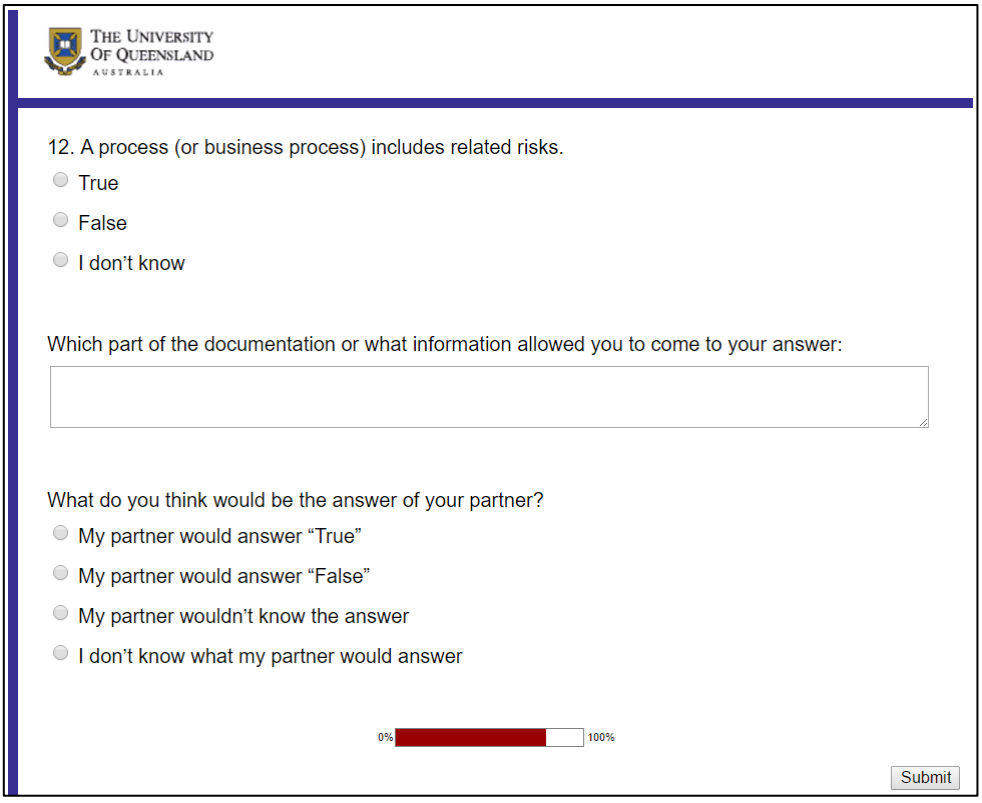


Figure D-91. Screenshot of the Compliance Management Question 12

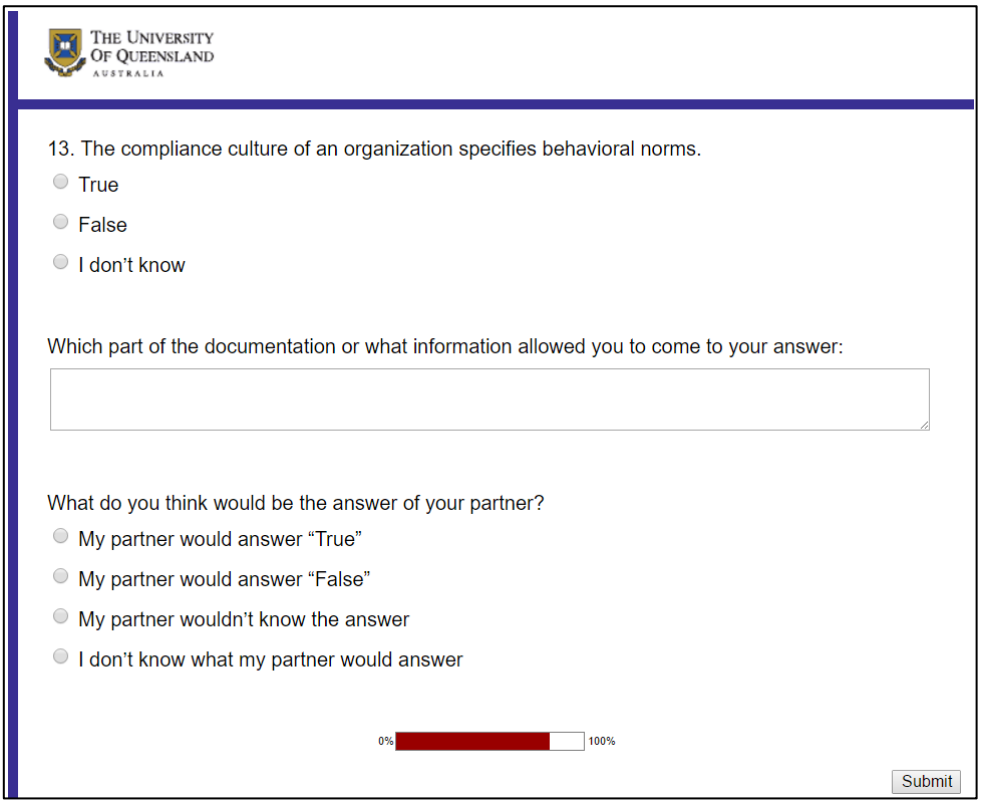


Figure D-92. Screenshot of the Compliance Management Question 13

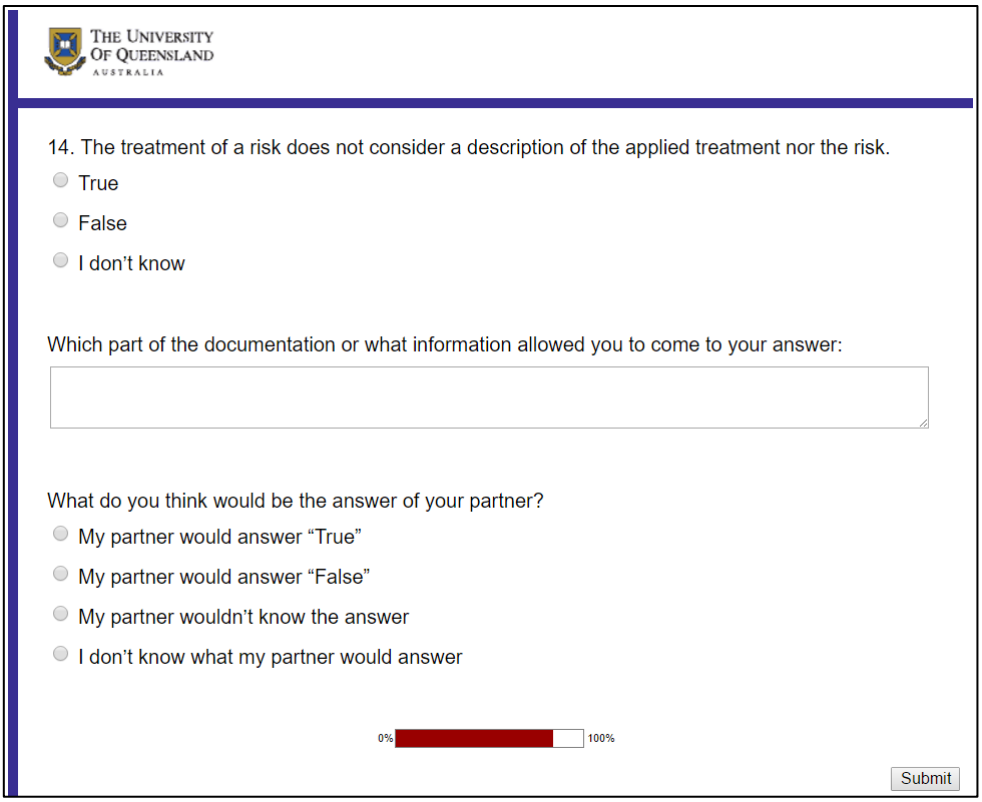


Figure D-93. Screenshot of the Compliance Management Question 14

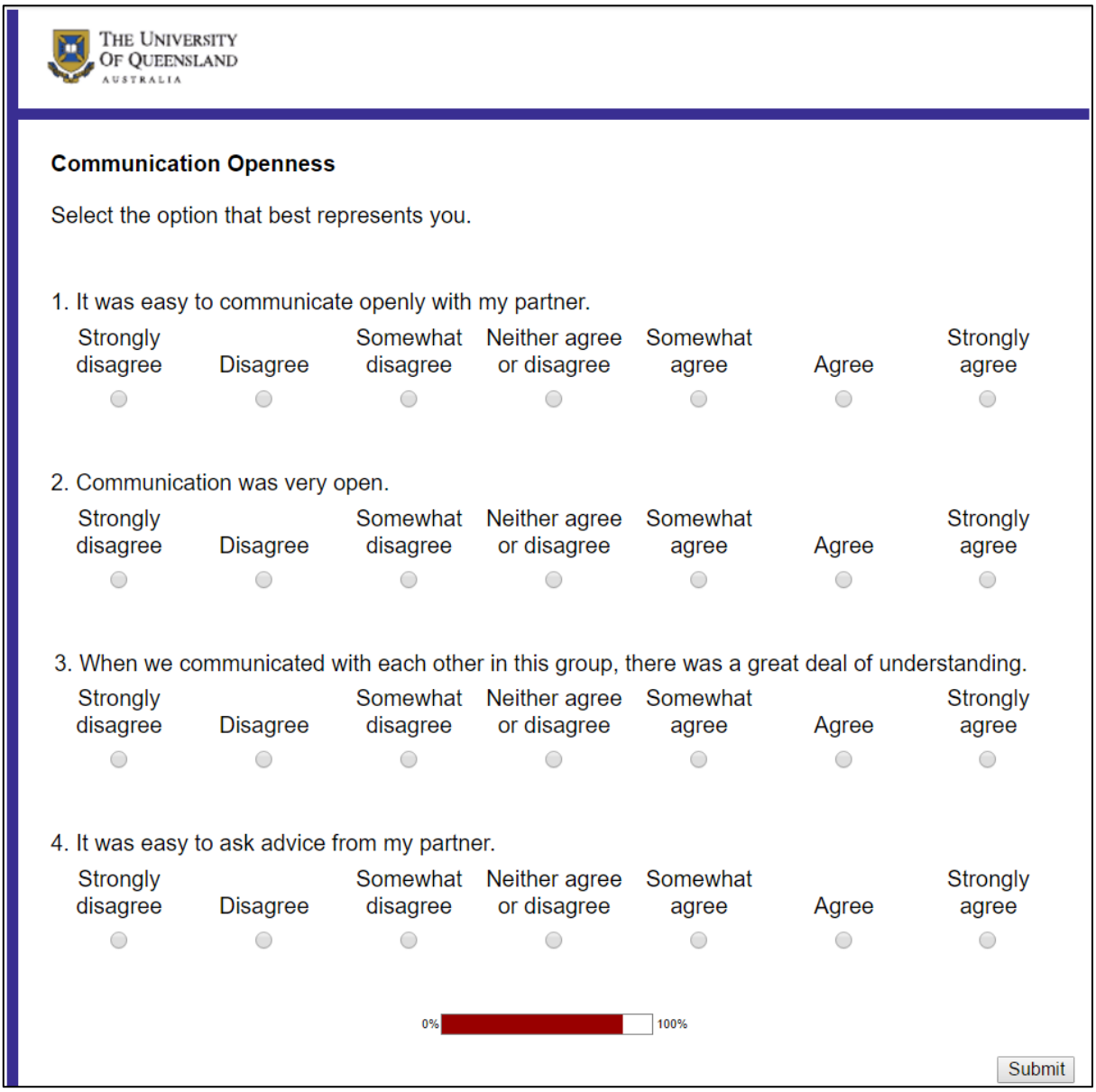


Figure D-94. Screenshot of the Communication Openness Questions

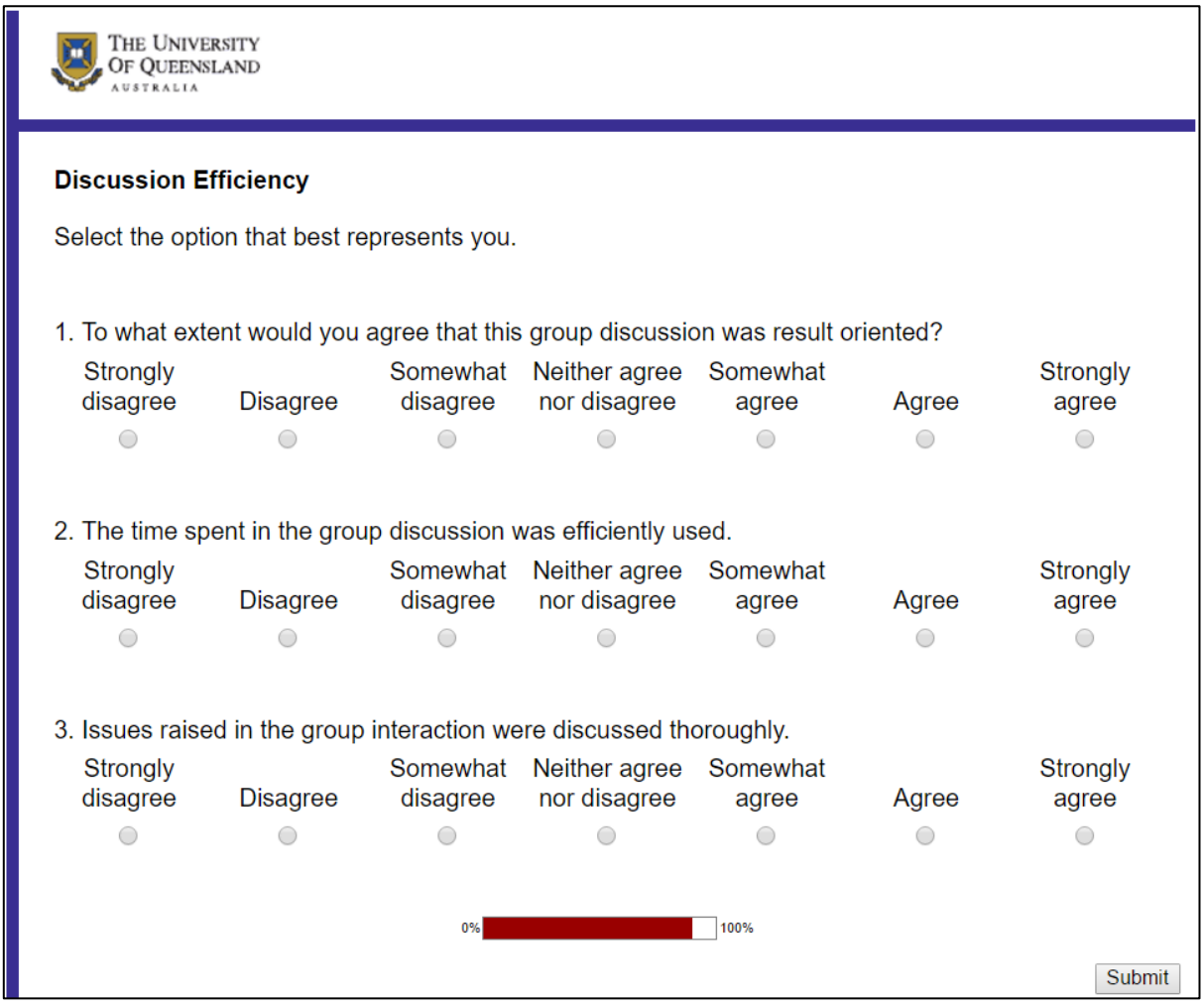


Figure D-95. Screenshot of the Discussion Efficiency Questions

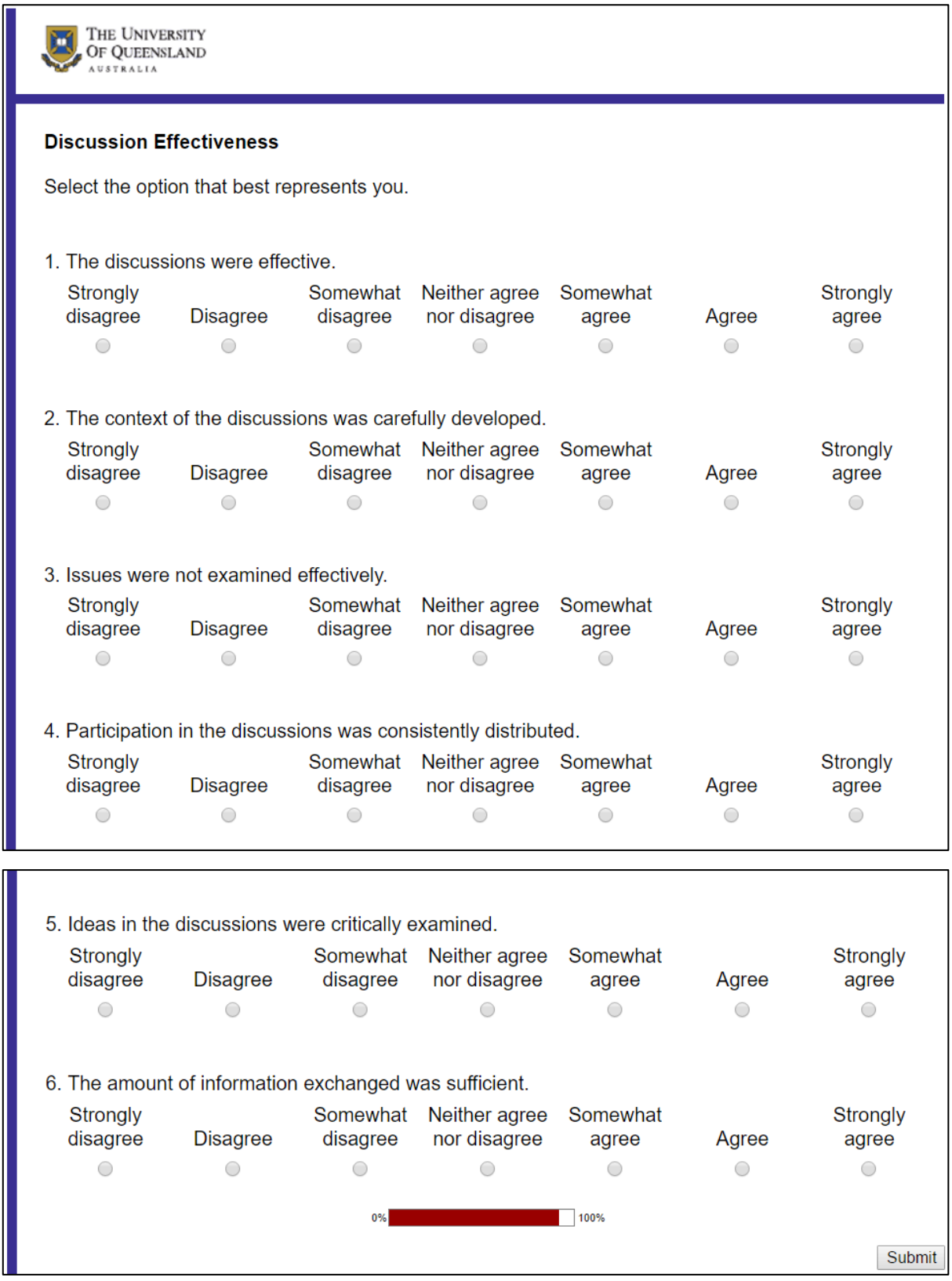


Figure D-96. Screenshot of the Discussion Effectiveness Questions

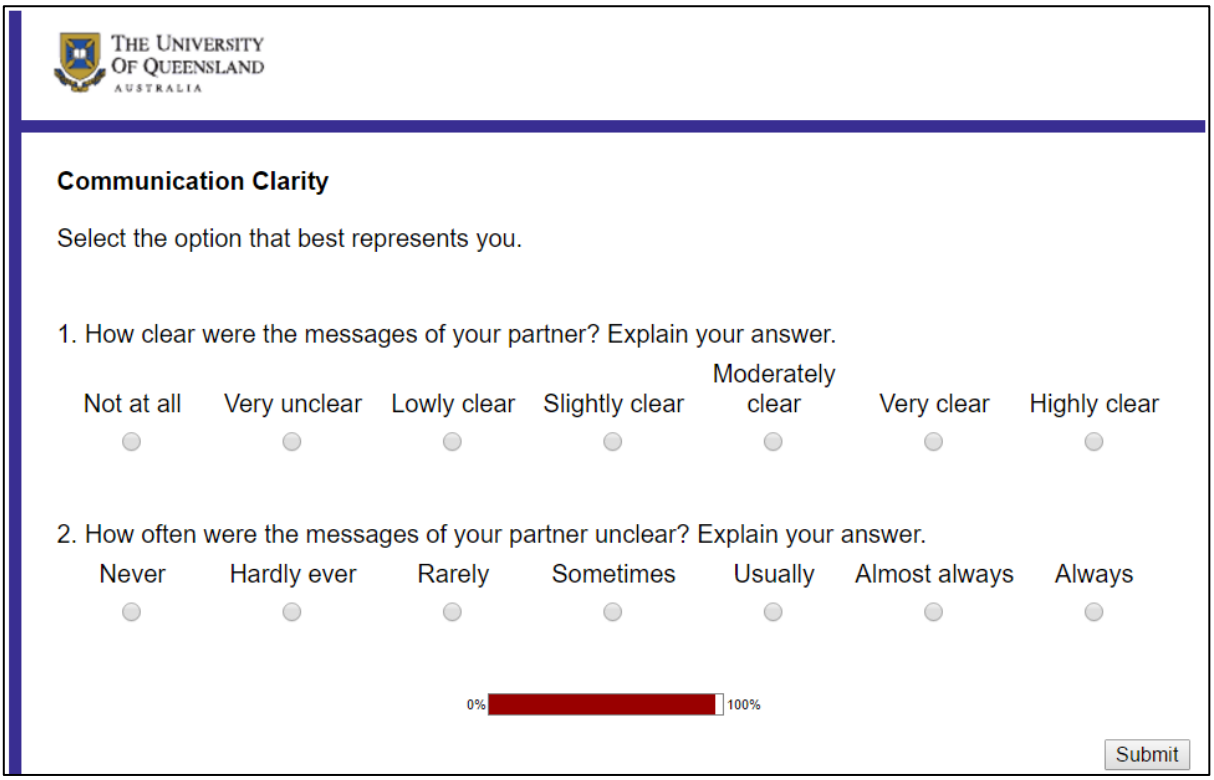


Figure D-97. Screenshot of the Communication Clarity Questions

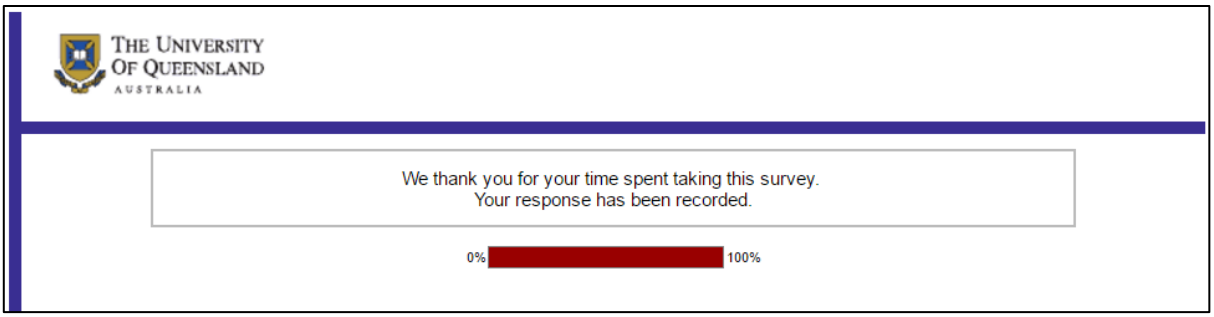
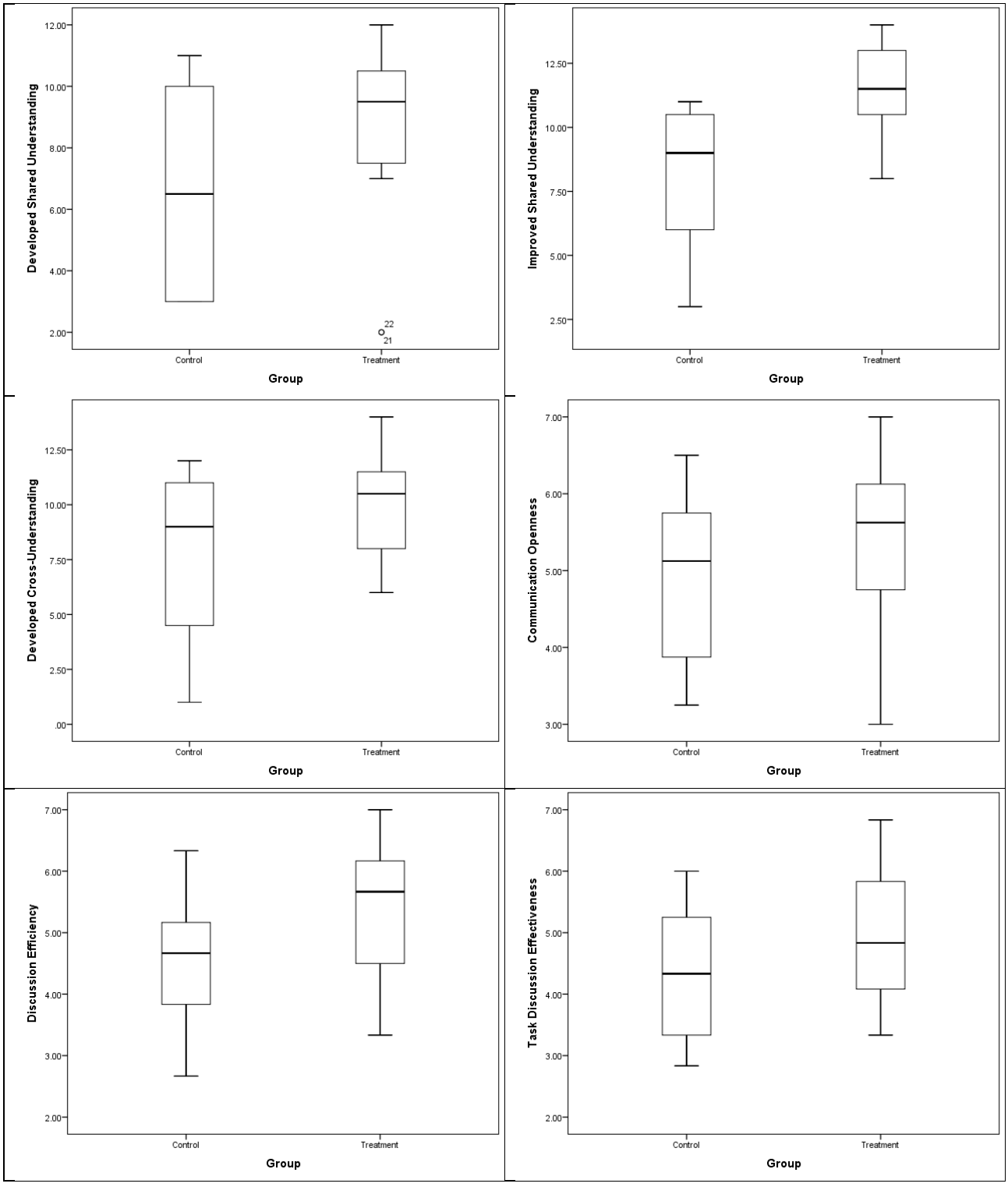


Figure D-98. Screenshot of the End of the Experiment

APPENDIX E. ANALYSIS OF OUTLIERS



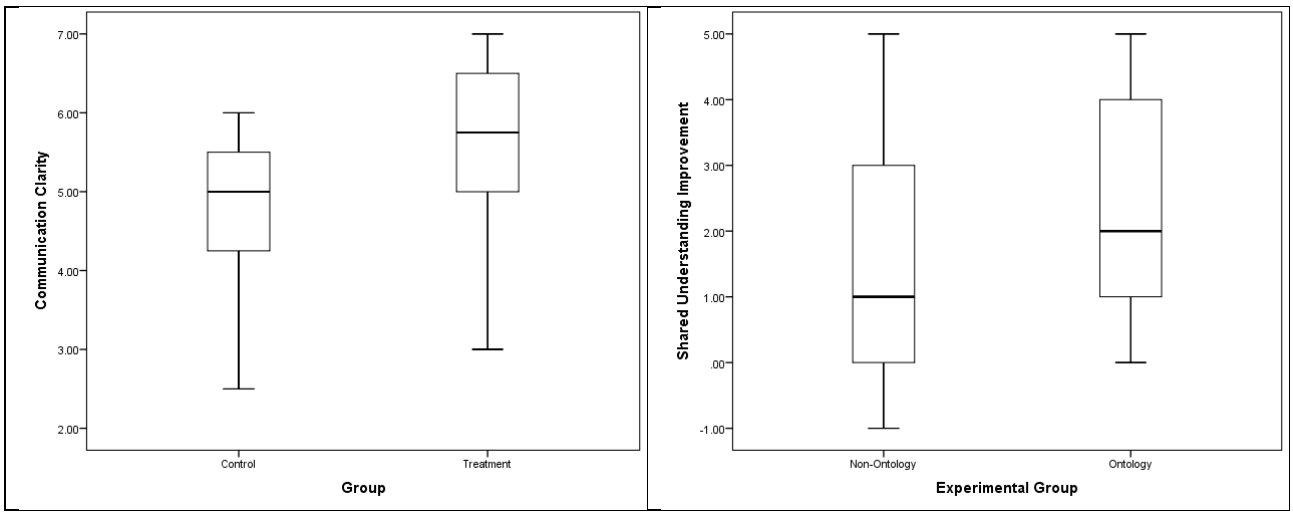


Figure E-1. Dependent Variable Boxplot

APPENDIX F. TEST OF ASSUMPTIONS

F.1 NORMALITY CHECK

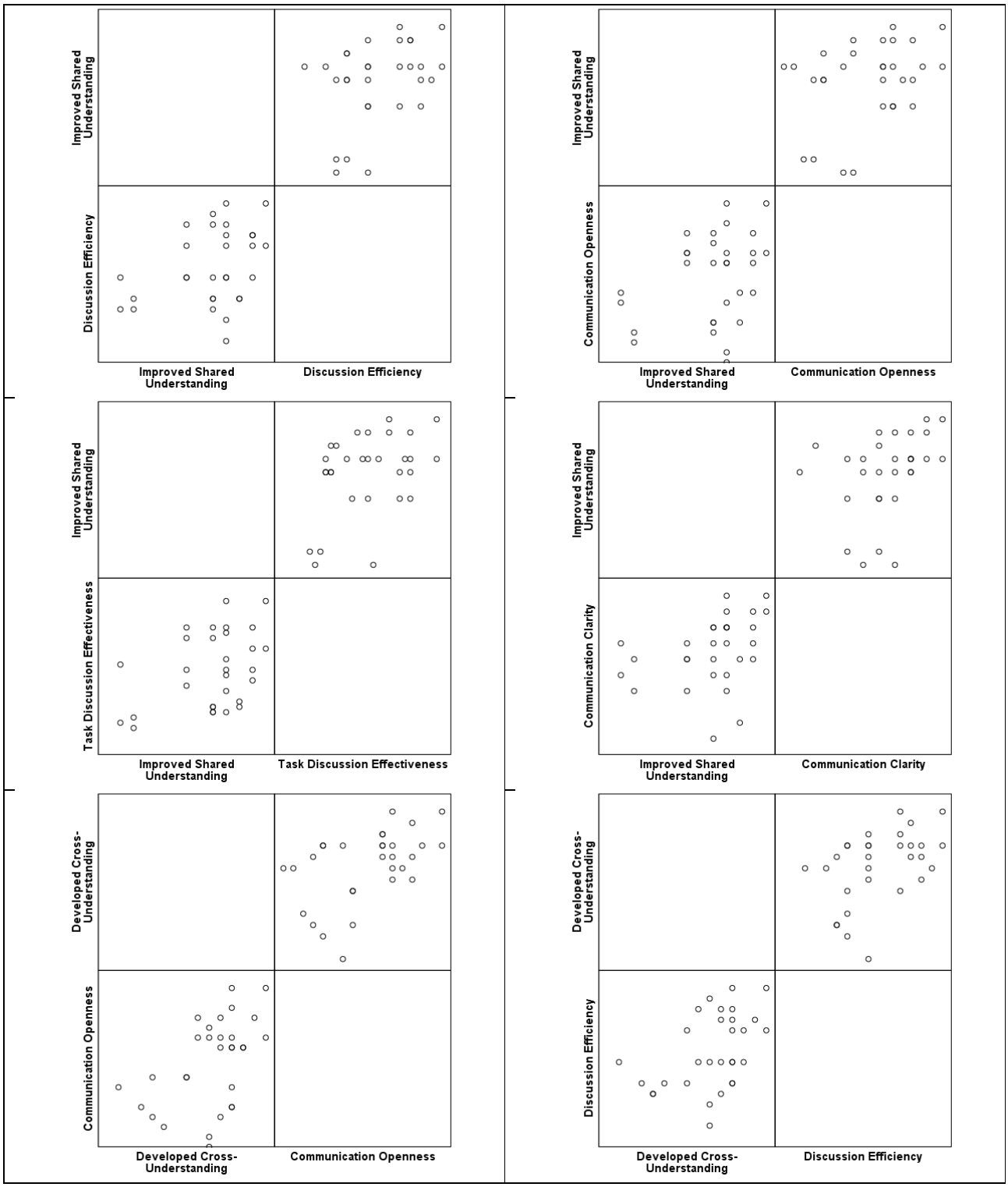
Table F-1. Shapiro-Wilk Test Results

	Group	Statistic	df	Sig.
Developed SU	Non-ontology Usage	0.81	16	**0.00**
	Ontology Usage	0.94	14	**0.38**
Improved SU	Non-ontology Usage	0.82	16	**0.00**
	Ontology Usage	0.91	14	0.16
Developed CU	Non-ontology Usage	0.88	16	**0.04**
	Ontology Usage	0.94	14	0.45
Communication Openness	Non-ontology Usage	0.92	16	0.15
	Ontology Usage	0.96	14	0.64
Discussion Efficiency	Non-ontology Usage	0.92	16	0.19
	Ontology Usage	0.93	14	0.34
Task Discussion Effectiveness	Non-ontology Usage	0.90	16	0.08
	Ontology Usage	0.95	14	0.53
Communication Clarity	Non-ontology Usage	0.91	16	0.11
	Ontology Usage	0.91	14	0.14
SU Improvement	Non-ontology Usage	0.90	16	0.69
	Ontology Usage	0.94	14	0.38

Table F-2. Z-scores for Skewness and Kurtosis

	Experimental Group		Statistic	Std. Error	Z-score
Developed SU	Non-Ontology	Skewness	0.14	0.56	0.24
		Kurtosis	-1.83	1.09	-1.68
	Ontology	Skewness	-0.15	0.60	-0.25
		Kurtosis	-0.91	1.15	-0.79
Improved SU	Non-Ontology	Skewness	-0.83	0.56	-1.46
		Kurtosis	-0.85	1.09	-0.78
	Ontology	Skewness	0.00	0.60	0.00
		Kurtosis	-1.26	1.15	-1.09
Developed CU	Non-Ontology	Skewness	-0.75	0.56	-1.33
		Kurtosis	-0.75	1.09	-0.69
	Ontology	Skewness	-0.12	0.60	-0.20
		Kurtosis	-0.45	1.15	-0.39
Communication Openness	Non-Ontology	Skewness	-0.10	0.56	-0.17
		Kurtosis	-1.50	1.09	-1.37
	Ontology	Skewness	-0.60	0.60	-1.00
		Kurtosis	0.19	1.15	0.16
Discussion Efficiency	Non-Ontology	Skewness	0.32	0.56	0.57
		Kurtosis	-0.43	1.09	-0.39
	Ontology	Skewness	-0.43	0.60	-0.72
		Kurtosis	-0.88	1.15	-0.76
Task Discussion Effectiveness	Non-Ontology	Skewness	0.32	0.56	0.56
		Kurtosis	-1.37	1.09	-1.25
	Ontology	Skewness	0.06	0.60	0.10
		Kurtosis	-1.10	1.15	-0.95
Communication Clarity	Non-Ontology	Skewness	-0.96	0.56	-1.71
		Kurtosis	1.26	1.09	1.15
	Ontology	Skewness	-1.17	0.60	-1.96
		Kurtosis	1.74	1.15	1.51

F.2 LINEARITY ANALYSIS



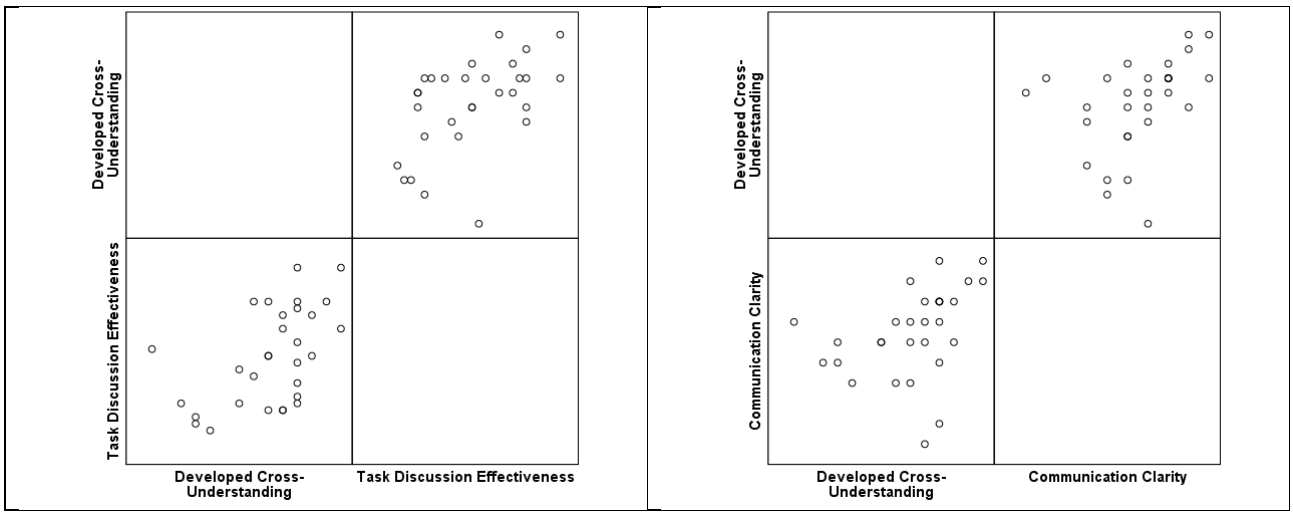


Figure F-1. Linearity Analysis for Dependent Variables

APPENDIX G. MEDIATION ANALYSIS

G.1 MEDIATION OF SHARED UNDERSTANDING IMPROVEMENT: FOUR FACTORS

```
************** PROCESS Procedure for SPSS Release 2.16 *******************

          Written by Andrew F. Hayes, Ph.D.       www.afhayes.com
    Documentation available in Hayes (2013). www.guilford.com/p/hayes3

**************************************************************************
Model = 4
    Y = SUImp
    X = Group
   M1 = CO
   M2 = DE
   M3 = TDE
   M4 = CC

Sample size
         30

**************************************************************************
Outcome: CO

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .2535      .0643     1.1894     1.7776     1.0000    28.0000      .1932

Model
             coeff         se          t          p       LLCI       ULCI
constant     4.8750      .2728    17.8673      .0000     4.3161     5.4339
Group         .5536      .4152     1.3333      .1932     -.2970     1.4041

**************************************************************************
Outcome: DE

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .3847      .1480     1.2239     4.4686     1.0000    28.0000      .0436

Model
             coeff         se          t          p       LLCI       ULCI
constant     4.5833      .2713    16.8967      .0000     4.0277     5.1390
Group         .8929      .4224     2.1139      .0436      .0276     1.7581

**************************************************************************
Outcome: TDE

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .3105      .0964     1.3076     2.7697     1.0000    28.0000      .1072

Model
             coeff         se          t          p       LLCI       ULCI
constant     4.3125      .2897    14.8867      .0000     3.7191     4.9059
Group         .7232      .4346     1.6642      .1072     -.1670     1.6134

**************************************************************************
Outcome: CC

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .3941      .1553     1.0217     4.7035     1.0000    28.0000      .0387

Model
             coeff         se          t          p       LLCI       ULCI
constant     4.8750      .2427    20.0890      .0000     4.3779     5.3721
Group         .8393      .3870     2.1688      .0387      .0466     1.6320
```

```
**************************************************************************
Outcome: SUImp

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .5029      .2529     3.0463     2.2431     5.0000    24.0000      .0828

Model
              coeff         se          t          p       LLCI       ULCI
constant    -1.3197     2.8907     -.4565      .6521    -7.2860     4.6466
CO            .0040      .6053      .0066      .9948    -1.2453     1.2533
DE            .2489      .9128      .2726      .7875    -1.6352     2.1329
TDE           .5646      .9981      .5657      .5769    -1.4954     2.6246
CC           -.1590      .4858     -.3273      .7463    -1.1617      .8437
Group         .4293      .8804      .4876      .6302    -1.3878     2.2464

************************* TOTAL EFFECT MODEL ****************************
Outcome: SUImp

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .2565      .0658     3.2653     1.8805     1.0000    28.0000      .1812

Model
              coeff         se          t          p       LLCI       ULCI
constant     1.5000      .4989     3.0067      .0055      .4780     2.5220
Group         .9286      .6771     1.3713      .1812     -.4585     2.3157

****************** TOTAL, DIRECT, AND INDIRECT EFFECTS ********************

Total effect of X on Y
     Effect         SE          t          p       LLCI       ULCI
      .9286      .6771     1.3713      .1812     -.4585     2.3157

Direct effect of X on Y
     Effect         SE          t          p       LLCI       ULCI
      .4293      .8804      .4876      .6302    -1.3878     2.2464

Indirect effect of X on Y
          Effect    Boot SE   BootLLCI   BootULCI
TOTAL      .4993      .5936     -.5329     1.8954
CO         .0022      .4352    -1.1172      .7695
DE         .2222      .7246    -1.0604     1.9427
TDE        .4083      .6817     -.8181     1.6939
CC        -.1335      .4609    -1.8098      .3326

******************** ANALYSIS NOTES AND WARNINGS ************************

Number of bootstrap samples for bias corrected bootstrap confidence intervals:
    10000

Level of confidence for all confidence intervals in output:
    95.00

NOTE: All standard errors for continuous outcome models are based on the HC3 estimator

------ END MATRIX -----
```

G.2 MEDIATION OF SHARED UNDERSTANDING IMPROVEMENT: TWO FACTORS

```
************** PROCESS Procedure for SPSS Release 2.16 *******************

          Written by Andrew F. Hayes, Ph.D.       www.afhayes.com
    Documentation available in Hayes (2013). www.guilford.com/p/hayes3

**************************************************************************
Model = 4
    Y = SUImp
    X = Group
   M1 = DE
   M2 = CC

Sample size
         30

**************************************************************************
Outcome: DE

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .3847      .1480     1.2239     4.4686     1.0000    28.0000      .0436

Model
             coeff         se          t          p       LLCI       ULCI
constant     4.5833      .2713    16.8967      .0000     4.0277     5.1390
Group         .8929      .4224     2.1139      .0436      .0276     1.7581

**************************************************************************
Outcome: CC

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .3941      .1553     1.0217     4.7035     1.0000    28.0000      .0387

Model
             coeff         se          t          p       LLCI       ULCI
constant     4.8750      .2427    20.0890      .0000     4.3779     5.3721
Group         .8393      .3870     2.1688      .0387      .0466     1.6320

**************************************************************************
Outcome: SUImp

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .4701      .2210     2.9323     2.0007     3.0000    26.0000      .1386

Model
             coeff         se          t          p       LLCI       ULCI
constant    -1.5025     2.3453     -.6406      .5274    -6.3235     3.3186
DE            .6737      .3590     1.8769      .0718     -.0642     1.4116
CC           -.0175      .3821     -.0458      .9638     -.8030      .7680
Group         .3417      .8198      .4169      .6802    -1.3434     2.0269

************************ TOTAL EFFECT MODEL ****************************
Outcome: SUImp

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .2565      .0658     3.2653     1.8805     1.0000    28.0000      .1812

Model
             coeff         se          t          p       LLCI       ULCI
constant     1.5000      .4989     3.0067      .0055      .4780     2.5220
Group         .9286      .6771     1.3713      .1812     -.4585     2.3157

***************** TOTAL, DIRECT, AND INDIRECT EFFECTS ********************

Total effect of X on Y
     Effect         SE          t          p       LLCI       ULCI
      .9286      .6771     1.3713      .1812     -.4585     2.3157

Direct effect of X on Y
```

```
     Effect         SE          t          p       LLCI       ULCI
      .3417      .8198      .4169      .6802    -1.3434     2.0269

Indirect effect of X on Y
          Effect    Boot SE   BootLLCI   BootULCI
TOTAL      .5868      .4875     -.1654     1.8544
DE         .6015      .4059      .0221     1.6703
CC        -.0147      .3703    -1.0469      .5126

******************** ANALYSIS NOTES AND WARNINGS *************************

Number of bootstrap samples for bias corrected bootstrap confidence intervals:
    10000

Level of confidence for all confidence intervals in output:
    95.00

NOTE: All standard errors for continuous outcome models are based on the HC3 estimator

------ END MATRIX -----
```

G.3 MEDIATION OF DEVELOPED CROSS-UNDERSTANDING: FOUR FACTORS

```
************** PROCESS Procedure for SPSS Release 2.16 *******************

          Written by Andrew F. Hayes, Ph.D.       www.afhayes.com
    Documentation available in Hayes (2013). www.guilford.com/p/hayes3

**************************************************************************
Model = 4
    Y = DCU
    X = Group
   M1 = CO
   M2 = DE
   M3 = TDE
   M4 = CC

Sample size
         30

**************************************************************************
Outcome: CO

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .2535      .0643     1.1894     1.7776     1.0000    28.0000      .1932

Model
             coeff         se          t          p       LLCI       ULCI
constant     4.8750      .2728    17.8673      .0000     4.3161     5.4339
Group         .5536      .4152     1.3333      .1932     -.2970     1.4041

**************************************************************************
Outcome: DE

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .3847      .1480     1.2239     4.4686     1.0000    28.0000      .0436

Model
             coeff         se          t          p       LLCI       ULCI
constant     4.5833      .2713    16.8967      .0000     4.0277     5.1390
Group         .8929      .4224     2.1139      .0436      .0276     1.7581

**************************************************************************
Outcome: TDE

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .3105      .0964     1.3076     2.7697     1.0000    28.0000      .1072

Model
             coeff         se          t          p       LLCI       ULCI
constant     4.3125      .2897    14.8867      .0000     3.7191     4.9059
Group         .7232      .4346     1.6642      .1072     -.1670     1.6134

**************************************************************************
Outcome: CC

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .3941      .1553     1.0217     4.7035     1.0000    28.0000      .0387

Model
             coeff         se          t          p       LLCI       ULCI
constant     4.8750      .2427    20.0890      .0000     4.3779     5.3721
Group         .8393      .3870     2.1688      .0387      .0466     1.6320

**************************************************************************
Outcome: DCU

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .6186      .3826     7.5836     2.8668     5.0000    24.0000      .0362
```

```
Model
              coeff         se          t          p       LLCI       ULCI
constant     2.6921     2.9186      .9224      .3655    -3.3318     8.7160
CO           1.1267     1.1684      .9643      .3445    -1.2849     3.5382
DE           -.9352      .8998    -1.0394      .3090    -2.7924      .9219
TDE          1.1125      .9522     1.1683      .2542     -.8529     3.0779
CC           -.1555      .8487     -.1833      .8561    -1.9072     1.5961
Group        2.2427     1.3407     1.6728      .1074     -.5245     5.0098

************************** TOTAL EFFECT MODEL ****************************
Outcome: DCU

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .4306      .1854     8.5768     6.3071     1.0000    28.0000      .0181

Model
              coeff         se          t          p       LLCI       ULCI
constant     7.9375      .8868     8.9509      .0000     6.1210     9.7540
Group        2.7054     1.0772     2.5114      .0181      .4987     4.9120

***************** TOTAL, DIRECT, AND INDIRECT EFFECTS ********************

Total effect of X on Y
     Effect         SE          t          p       LLCI       ULCI
     2.7054     1.0772     2.5114      .0181      .4987     4.9120

Direct effect of X on Y
     Effect         SE          t          p       LLCI       ULCI
     2.2427     1.3407     1.6728      .1074     -.5245     5.0098

Indirect effect of X on Y
          Effect    Boot SE   BootLLCI   BootULCI
TOTAL      .4627      .9009    -1.1527     2.5600
CO         .6237     1.0198     -.3991     3.8536
DE        -.8350     1.0944    -3.8054      .5980
TDE        .8046     1.1641     -.6761     4.1691
CC        -.1305      .8805    -2.3939     1.3795

******************** ANALYSIS NOTES AND WARNINGS *************************

Number of bootstrap samples for bias corrected bootstrap confidence intervals:
    10000

Level of confidence for all confidence intervals in output:
    95.00

NOTE: All standard errors for continuous outcome models are based on the HC3 estimator

------ END MATRIX -----
```

G.4 MEDIATION OF DEVELOPED CROSS-UNDERSTANDING: TWO FACTORS

```
************** PROCESS Procedure for SPSS Release 2.16 *******************

          Written by Andrew F. Hayes, Ph.D.       www.afhayes.com
    Documentation available in Hayes (2013). www.guilford.com/p/hayes3

**************************************************************************
Model = 4
    Y = DCU
    X = Group
   M1 = DE
   M2 = CC

Sample size
         30

**************************************************************************
Outcome: DE

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .3847      .1480     1.2239     4.4686     1.0000    28.0000      .0436

Model
             coeff         se          t          p       LLCI       ULCI
constant    4.5833      .2713    16.8967      .0000     4.0277     5.1390
Group        .8929      .4224     2.1139      .0436      .0276     1.7581

**************************************************************************
Outcome: CC

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .3941      .1553     1.0217     4.7035     1.0000    28.0000      .0387

Model
             coeff         se          t          p       LLCI       ULCI
constant    4.8750      .2427    20.0890      .0000     4.3779     5.3721
Group        .8393      .3870     2.1688      .0387      .0466     1.6320

**************************************************************************
Outcome: DCU

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .5375      .2889     8.0625     3.0944     3.0000    26.0000      .0443

Model
             coeff         se          t          p       LLCI       ULCI
constant    2.9204     3.3061      .8833      .3851    -3.8755     9.7164
DE           .7729      .4663     1.6576      .1094     -.1856     1.7313
CC           .3025      .7058      .4286      .6717    -1.1482     1.7533
Group       1.7614     1.1832     1.4886      .1486     -.6709     4.1937

************************ TOTAL EFFECT MODEL ****************************
Outcome: DCU

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .4306      .1854     8.5768     6.3071     1.0000    28.0000      .0181

Model
             coeff         se          t          p       LLCI       ULCI
constant    7.9375      .8868     8.9509      .0000     6.1210     9.7540
Group       2.7054     1.0772     2.5114      .0181      .4987     4.9120

***************** TOTAL, DIRECT, AND INDIRECT EFFECTS ********************

Total effect of X on Y
     Effect         SE          t          p       LLCI       ULCI
     2.7054     1.0772     2.5114      .0181      .4987     4.9120

Direct effect of X on Y
     Effect         SE          t          p       LLCI       ULCI
```

```
     1.7614     1.1832     1.4886      .1486     -.6709     4.1937

Indirect effect of X on Y
          Effect    Boot SE   BootLLCI   BootULCI
TOTAL      .9440      .6850      .0048     2.8367
DE         .6901      .5542      .0196     2.5799
CC         .2539      .6472     -.6855     2.1057

****************** ANALYSIS NOTES AND WARNINGS ************************

Number of bootstrap samples for bias corrected bootstrap confidence intervals:
    10000

Level of confidence for all confidence intervals in output:
    95.00

NOTE: All standard errors for continuous outcome models are based on the HC3 estimator

------ END MATRIX -----
```