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Investigating Process Oriented and Product Oriented Worked Examples in an Ill-Structured Learning Domain

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Abstract

Cognitive Load Theory (CLT) research has shown that studying worked examples, which provide a step-by-step solution to a problem, can reduce cognitive load and support learning in well-structured learning domains relative to solving conventional problems. Two types of worked examples that have been widely used in CLT research are process oriented worked examples and product oriented worked examples. Process oriented worked examples provide step-by-step solutions to solve a problem, plus statements explaining the rationale for each step. Product oriented worked examples provide the step-by-step solutions to solve a problem without supporting explanations of each of the steps. In this research two studies were conducted to investigate which instructional condition, process oriented worked examples, product oriented worked examples or conventional problem solving, would best support student learning in an ill-structured learning domain focusing on the quality teaching component of substantive communication.

In Experiment 1 a between-subjects design was used to examine the test performance scores, perceived cognitive load and perceived task difficulty of 85 pre-service teachers, who learned about substantive communication. Learning took place in three instructional conditions; studying process oriented worked examples (i.e., Process condition), studying product oriented worked examples (i.e., Product condition) and solving conventional problems (i.e., Control condition). The pre-service teachers were considered novices, because they had limited knowledge of substantive communication and limited teaching experience. Results showed that participants in the Process condition outperformed participants in the Product condition on the test and were suggestive for highest instructional efficiency (i.e., relatively higher test performance scores obtained with relatively lower mental effort investment) of the three instructional conditions. However, the ratings for mental effort and task difficulty were inconclusive across the three instructional conditions. Due to the inconclusive ratings, Study 2 was designed to examine in depth how participants engaged with the instructional conditions.

In Study 2, verbal protocols were used to determine how six experts (i.e., practicing teachers who taught in regional Diocesan schools) and five novices (i.e., pre-service teachers enrolled in their fourth year of the Bachelor of Education degree at a university) engaged with the three instructional conditions used in Experiment 1. Results revealed that both expert and novice participants reported that the Process condition aided their learning. The novice participants found the Process condition useful as they were able to modify misconceptions and make

meaning from the included principled knowledge, whereas the expert participants found the Process condition useful as the principled knowledge enabled them to confirm and validate their prior understanding of substantive communication.

Overall, there were three key findings for Experiment 1 and Study 2. Firstly, Experiment 1 results for novice participants in ill-structured learning domains were consistent with CLT research of worked examples in well-structured learning domains, that is, process oriented worked examples support novice learners in an ill-structured learning domain. Secondly, Study 2 indicated a preference for the Process condition for both novice and expert participants. This aligns with research of novices engaging with worked examples in a well-structured learning environment and is a novel finding for expert learners in an ill-structured learning domain. CLT research has shown that as a learner's expertise increases through the use of worked examples, the worked example becomes redundant or negatively impacts learning outcomes. However, Study 2 found that experts found the Process condition useful as a way to validate their understanding. Thirdly, Study 2 indicated the instructional condition and prior knowledge influenced how each participant engaged and made meaning of substantive communication. The learning approaches adopted by the participants were influenced by their prior knowledge and instructional condition they engaged in.

In summary, the findings from this research suggest that process oriented worked examples are just as valuable for experts as for novices in an ill-structured learning domain. This supports the current CLT research findings for novices presented with process oriented worked examples in a well-structured learning domain. However, previous research about worked examples in well-structured learning domains have shown that process oriented worked examples are not as useful for experts, referred to as the "expertise reversal effect", which was not the case in this research. Future research is needed to further understand the differences and nuances between experts and novices using worked examples in ill-structured learning domains.

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Certification

I, Gerardo Sozio declare that this thesis submitted in fulfilment of the requirements for the conferral of the degree Doctor of Philosophy from the University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. This document has not been submitted for qualifications at any other academic institution.

Gerardo Sozio
November 2022

List of Terms and Acronyms

Terms

The following terms will be defined as follows when used in this research:

Conventional Problem Solving: Conventional problems present students with the known information and specifies what is required to be found (Cooper, 1998) without any support or guidance (Brooks, 2009; Paas, 1992).

Ill-Structured Learning Domain: Content specific domain that includes ill-defined problems that do not have clearly specified problem states or problem-solving operators (Sweller et al., 2011) e.g. English and History. Ill-structured learning domains provide multiple possible pathways to solution and elements of interpretation (Simon, 1973). Problem-solving operators are the steps taken to move between the states of a problem. Sweller et al. (2011, p. 102) provide the following as an example of an ill-defined problem, " 'Discuss the meaning of this passage' provides an example of an ill-structured problem". This is ill-structured because there is no one correct absolute answer.

Mental Effort: "The aspect of cognitive load that refers to the cognitive capacity that is actually allocated to accommodate the demands imposed by the task" (Paas et al., 2003b, p. 64).

Principled Knowledge: "The purpose of the steps in a procedure" (van Gog et al., 2008, p. 6). Van Gog et al. (2004) stated that the principled knowledge included in process oriented worked examples improve understanding as learners are "challenged to invest germane effort in studying the why and how of information" (van Gog et al., 2004, p. 96). In this research, the process oriented worked example provided strategic information (how to solve the problem) and principled knowledge i.e., the why (Brooks, 2009), the purpose of the steps in solving the problem.

Process Oriented Worked Example: Process oriented worked examples provide step-by-step solutions to solve a problem, and also include statements explaining each of steps i.e., they explain why steps are taken during problem solving (Van Gog et al., 2008). Brooks (2009) writes that "process-oriented worked examples provide learners with principled knowledge ("why") and strategic information" (Brooks, 2009, p. 11).

Product Oriented Worked Example: Product oriented worked examples provide only the step-by-step solutions to solve a problem without supporting explanations of each of the steps i.e., they do not explain why certain steps are taken during problem solving (Van Gog et al., 2008).

Schema: *"*Can be defined as a cognitive construct that permits us to classify multiple elements of information into a single element according to the manner in which the multiple elements are used" (Sweller et al., 2011, pp. 22-23).

Substantive Communication: Lessons with high levels of substantive communication involve "sustained interaction about the substance of the lesson" (New South Wales Department of Education and Training (NSW DET), 2006, p. 22). Substantive communication is one of the elements of the New South Wales Quality Teaching Model. In classes with high levels of substantive communication, there is sustained interaction, communication focused on the substance of the lesson and the interaction is reciprocal (NSW DET, 2006).

Strategic Information "The heuristics and/or a systematic approach to problem solving that is employed" (van Gog et al. 2008, p. 213). In this research, the product oriented worked examples provided strategic information i.e., the steps demonstrating how to solve the problem.

Task Difficulty: Can be described as "how difficult the task is" (Hsu et al., 2019, p. 1).

Well-Structured Learning Domain: Content specific domain that includes well-defined problems that have clearly specified problem states and required problem-solving operators (Sweller et al., 2011) e.g. Mathematics and Science. Problem-solving operators are the steps taken to move between the states of a problem. In mathematics, the rules of solving algebraic equations can be considered as problem solving operators (Sweller et al., 2011). This is well-structured because there are clearly defined answers to the problem.

Worked Example: A worked example provides a step-by-step solution to a problem. Most worked examples provide a problem statement and procedure for solving the problem. The steps guide the learner on how to solve the problem and also support the development of a problem-solving schema by having a focus on problem states and solution steps (Cooper & Sweller, 1987).

Acronyms

The following provides the acronyms used in this research:

ANOVA: Analysis of Variance

CLT: Cognitive Load Theory

ECL: Extraneous Cognitive Load

GCL: Germane Cognitive Load

ICL: Intrinsic Cognitive Load

IRE: Initiate-Respond-Evaluate

LTM: Long-term memory

NSW DET: New South Wales Department of Education and Training

NSW QTM: New South Wales Quality Teaching Model

PDHPE: Physical Development, Health and Physical Education

SM: Sensory Memory

WM: Working Memory

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Chapter 1

INTRODUCTION

The purpose of this research was to investigate the efficacy of process oriented and product oriented worked examples within an ill-structured learning domain. Ill-structured learning domains provide multiple possible pathways to solution and elements of interpretation (Simon, 1973). Cognitive Load Theory (CLT) research on the use of worked examples has focused mainly on well-structured learning domains. Well-structured learning domains are content specific domains that include well-defined problems that have clearly specified problem states and required problem-solving operators (Sweller et al., 2011). Ill-structured learning domains have received little attention; thus the focus of this research was to address this gap in the CLT research by investigating what type of worked example best supported participant learning in an ill-structured learning domain. This chapter provides a background to this research, the significance of the research, the research questions and hypotheses that guided this research, the research methodology and an overview of the structure of this thesis.

1.1 BACKGROUND

This research was underpinned by CLT, an instructional theory originating in the 1980s (Sweller et al., 1998; Paas et al., 2003a). CLT frames learning in terms of an information processing system involving working memory (WM) and long-term memory (LTM). CLT states that for learning to be optimised, knowledge needs to be processed in WM, then stored in LTM, then accessed and transferred back into WM to make sense of, and process new information. WM has a very limited capacity (Clark et al., 2006) and is used to process information, which is then transferred into LTM. For this to occur, limited WM resources need to be optimized. Instructional designs based on CLT principles enable improved processing abilities for learners through optimising WM capacity (Chandler & Sweller, 1991; Eysenck & Clavo, 1992; Paas et al., 2003; Sweller et al., 2019).

Cognitive Load Theory (CLT) states that there are three different forms of load imposed when learners process information in WM (Sweller et al., 2011). These loads are additive and are categorised as intrinsic cognitive load (ICL), extraneous cognitive load (ECL) and germane cognitive load (GCL). ICL is related to the complexity of the material and is dependent on the number of elements the learner is required to process simultaneously to understand the information and is dependent on the learner's prior knowledge (Kalyuga et al., 2003). When information has a high ICL, it has corresponding high-level element interactivity and high load on limited working memory's resources. Clark et al. (2006, p. 344) describe element interactivity as "the extent to which multiple content components must be held and/or processed simultaneously in working memory in order to be learned". For instance, Clark et al. (2006) posit that learning words in a foreign language is relatively low in element interactivity as each word can be memorized independently, thus placing a limited burden on WM. Alternatively, creating a sentence in a foreign language requires words to be ordered to convey meaning and follow grammatical rules, thus more elements (words, grammatical rules) need to be processed simultaneously in WM, placing a burden on limited WM resources. Chinnappan and Chandler (2010) present the example that learning to memorise a formula, such as the formula for the area of a circle ($A = \pi r^2$), would impose a low intrinsic load on the learner (Chinnappan & Chandler, 2010). However, they add that applying the formula "requires the learner to relate and compare parts of the formula (specifically *r*, area) with other elements in the problem" (Chinnappan & Chandler, 2010, p. 8), and would impose a high intrinsic load on the learner.

Extraneous cognitive load (ECL) is related to how instructional materials are presented (Sweller et al., 2011; Sweller et al., 2019) and is caused when instructions are presented in such a way that the learner is forced to undertake cognitive activities that are not related to learning. This in turn increases element interactivity, which places an additional burden on limited WM resources (Sweller et al., 2019; Sweller, 2010; van Merriënboer & Sweller, 2005). Reducing ECL is particularly important when ICL is high as the two loads are additive. If the ICL for acquiring particular knowledge is low, then the level of ECL may not affect learning. In contrast when ICL is high, and there is high element interactivity, it is important that ECL is reduced.

The third load, GCL has been defined as the load dedicated to schema construction and automation of schemas and can increase when the intrinsic and extrinsic cognitive loads are reduced (Sweller et al.,1998). Current research in the area of GCL is contentious. Some cognitive load theorists argue that GCL redistributes WM resources from extraneous tasks to aspects intrinsic to the learning task, as opposed to other cognitive load theorists assuming GCL imposes its own cognitive load (Sweller et al., 2019; Leppink, 2020). This current research focuses on learners engaging with different worked examples and how the type of worked example may support learning by reducing ECL and providing additional information (ICL) to support schema construction and learning.

Cognitive Load Theory (CLT) research has shown that in comparison to solving conventional problems, studying worked examples can support learning through reducing ECL and increasing GCL to improve learning (Paas & van Gog, 2006). There are different types of worked examples. These include process oriented worked examples, product oriented worked examples, worked example problem pairs and completion examples. Product oriented worked examples present a problem solution and process oriented worked examples include the rationale behind the presented solution (Van Gog et al., 2008). Product oriented worked examples include only the procedure for obtaining a final product and provide step-by-step solutions without explanations of the rationale behind these steps. In contrast, process oriented worked examples which also include procedure will have an added explanation for each of the steps (Sweller et al., 2011). The commonality between the different types of worked examples is that they provide the solution steps required to reach a problem goal (Van Gog et al., 2011). Providing the steps to solution aims to support the learner in developing problem-solving schemas which are stored in LTM. Once stored in LTM, the stored schema can be accessed to solve problems and enhance automation (Cooper & Sweller, 1987; Sweller et al., 2011). Further details on worked examples are discussed in Chapter 2.

As stated, even though there are a range of worked examples, this research focused on process oriented and product oriented worked examples. Considering the definition of a process oriented and product oriented worked example, it may appear obvious that a process oriented worked example would be more effective than a product oriented worked example. However, research suggests that this depends on the prior knowledge of the learner as to which form of worked example is more effective (Kalyuga et al., 2001). For example, previous research conducted by van Gog et al. (2007) in the area of electrical circuits troubleshooting found that process oriented worked examples led to better test performance. However, as the training continued the process information became redundant and imposed extraneous load. This was referred to as an expertise-reversal effect (van Gog et al., 2007).

Research on CLT has mainly focused on the use of worked examples in well-structured learning domains. Worked examples provide a scaffold for the participant to search and match information to make meaning (Chandler & Sweller, 1991). Worked examples have been shown to be effective in supporting learners by promoting a forward working strategy when problem solving and reducing the cognitive load associated with a task. In particular, worked examples have been shown to support novice learners, who may lack "domain specific schemas necessary to handle the multiple elements associated with a complex task or problem." (Brooks, 2009, p. 87). There has been less research undertaken examining the use of worked examples in the humanities and in ill-structured learning domains (Sweller et al., 2011, p.102). Sweller et al. (2011) state "The bulk of research on the worked example effect has used well-structured problems from mathematics or science domains rather than ill-structured problems" (Sweller et al., 2011, p. 104). A problem in a well-structured content domain is "one in which we can clearly specify the various problem states and the problem solving operators required to move from one state to another" (Sweller et al., 2011, p. 104). A problem within an ill-structured content domain does not clearly specify the problem state or the problem solving operators (Sweller et al., 2011). An example of a well-structured problem is solving an algebraic equation in mathematics and an example of an ill-structured problem is writing a poem.

Research on the use of worked examples in well-structured learning domains has shown that novice participants engaging with process oriented worked examples outperform novice participants presented with product oriented worked examples. This is due to a process oriented worked example providing participants with the principled knowledge (why) and strategic information (how) to assist in solving related problems (Ohlsson & Rees, 1991, Van Gog et al., 2008). Van Gog et al. (2004) stated that the principled knowledge included in process oriented worked examples improve understanding as learners are "challenged to invest germane effort in studying the why and how of information" (van Gog et al., 2004, p. 96). Further, novice participants presented with product oriented worked examples will outperform novice participants engaging in conventional problem solving due to the product oriented worked example providing participants with the strategic information (how) to assist in solving related problems (Ohlsson & Rees, 1991, Van Gog et al., 2008). However, research has shown that as learners' expertise increases, further use of worked examples may negatively impact learning outcomes (Kalyuga et al., 1999; Leslie et al., 2012; Pachman et al., 2013; Yeung et al., 1998). As stated above, this is referred to as the "expertise reversal effect".

This research was conducted to further the limited research on the use of worked examples in an ill-structured learning domain. The context of the research was the New South Wales Quality Teaching Model (NSW QTM), with a focus on substantive communication, one of the six elements within the Intellectual Quality Dimension (the other two Dimensions being Quality Learning Environment and Significance). In classes with high levels of substantive communication, there is sustained interaction, communication focused on the substance of the lesson and the interaction is reciprocal (NSW DET, 2006). This model is considered as an ill-structured learning domain as learning about the characteristics of substantive communication does not have clearly specified problem states or problem-solving operators. The researcher designed process oriented and product oriented worked examples and focused specifically on one element of the model, substantive communication. The NSW QTM element of substantive communication has a high ICL and a corresponding high level element interactivity. This is due to the complex nature of the material to be learned, the complex and multiple interactions that occur in a classroom and the interacting components and characteristics of the NSW QTM that need to be considered when making a judgement on the level of substantive communication in a classroom. In addition, even though the NSW QTM element of substantive communication has a high ICL for both novices and experts, it would be more profound for novices due to their low prior knowledge and lack of experience in teaching.

1.2 RESEARCH AIMS AND SIGNIFICANCE

The research presented in this thesis examined the use of process oriented worked examples, product oriented worked examples and conventional problem solving with novice and expert participants within an ill-structured learning domain. Further, this research investigated the thought processes of both novice and expert participants engaging within the different instructional conditions to better understand how they engaged and made meaning from process and product oriented worked examples in an ill-structured learning domain. The study employed both a quantitative and qualitative approach; the quantitative approach contributed to the empirical base of the effectiveness of worked examples presented in ill-structured learning domains and the qualitative approach aimed to investigate what participants were doing when engaging with the instructional material.

The overall aim of the PhD study was to investigate which instructional condition, process oriented worked examples, product oriented worked examples or conventional problem solving, supported participants best in identifying and applying knowledge of the New South Wales Quality Teaching Model element of substantive communication. Following are the aims of Experiment 1 and Study 2.

The aim of Experiment 1 was three-fold:

1. To investigate participants' test performance scores for the three instructional conditions.
2. To investigate participants' perceived cognitive load for the three instruction conditions.
3. To investigate participants' perceived task difficulty for the three instructional conditions.

The aim of Study 2 was to take a more exploratory qualitative approach to investigate:

1. How experts and novices engaged with the different instructional conditions.
2. How experts and novices made meaning from each instructional condition.

This research is significant due to the limited research on the use of worked examples in an ill-structured learning domain.

1.3 RESEARCH QUESTIONS AND HYPOTHESES

As stated in Section 1.2, the overall aim of the PhD study was to investigate which instructional condition, process oriented worked examples, product oriented worked examples or conventional problem solving, supported participants best in identifying and applying knowledge of the New South Wales Quality Teaching Model element of substantive communication. The following section presented the research questions and hypotheses that guided this research.

The four research questions and associated hypotheses for Experiment 1 were:

Research Question 1: When learning about the characteristics of substantive communication, do participants presented with process oriented worked examples achieve higher test performance scores during the *test phase* than participants presented with product oriented worked example, and do participants presented with product oriented worked examples achieve higher test performance scores during the *test phase* than participants engaging in conventional problem solving?

Hypothesis 1

When learning about the characteristics of substantive communication, participants presented with the process oriented worked example will achieve higher test performance scores during the *test phase* than participants presented with the product oriented worked example.

Hypothesis 2

When learning about the characteristics of substantive communication, participants presented with the product oriented worked example will achieve higher test performance scores during the *test phase* than learners engaging in conventional problem solving.

Research Question 2: When learning about the characteristics of substantive communication, do participants presented with process oriented worked examples or participants who undertake conventional problem solving, report higher perceived cognitive load and higher perceived task difficulty during the *learning phase* than participants presented with product oriented worked examples during the *learning phase*?

Hypothesis 3

When learning about the characteristics of substantive communication, participants presented during the *learning phase* with the process oriented worked example or participants who undertake conventional problem solving, will report higher perceived cognitive load than participants presented with the product oriented worked example.

Hypothesis 4

When learning about the characteristics of substantive communication, participants presented during the *learning phase* with the process oriented worked example or participants who undertake conventional problem solving, will report higher perceived task difficulty than participants presented with the product oriented worked example.

Research Question 3: When learning about the characteristics of substantive communication, do participants presented with process oriented worked examples report lower perceived cognitive load and lower perceived task difficulty during the *test phase* than participants presented with product oriented worked examples?

Hypothesis 5

When learning about the characteristics of substantive communication, participants presented with the process oriented worked example will report lower perceived cognitive load during the *test phase* than participants presented with the product oriented worked example.

Hypothesis 6

When learning about the characteristics of substantive communication, participants presented with the process oriented worked example will report lower perceived task difficulty during the *test phase* than participants presented with the product oriented worked example.

Research Question 4: When learning about the characteristics of substantive communication, do participants presented with process oriented or product oriented worked examples report lower perceived cognitive load and lower perceived task difficulty during the *test phase* than participants engaging in conventional problem solving?

Hypothesis 7

When learning about the characteristics of substantive communication, participants presented with the process oriented or product oriented worked example will report lower perceived cognitive load during the *test phase* than participants engaging in conventional problem solving.

Hypothesis 8

When learning about the characteristics of substantive communication, participants presented with the process oriented or product oriented worked example will report lower perceived task difficulty during the *test phase* than participants engaging in conventional problem solving.

Two exploratory questions guided Study 2. These are presented below:

Research Question 1: When learning about the characteristics of substantive communication, how do novice and expert participants engage with and make meaning from the three different instructional conditions; process oriented worked examples, product oriented worked examples or conventional problem solving within an ill-structured learning domain?

Research Question 2: When learning about the characteristics of substantive communication, how do novice and expert participants who have engaged with one instructional condition perceive the other two instructional conditions?

1.4 RESEARCH METHODOLOGY

This research comprised two studies: Experiment 1 a quantitative and randomly controlled experiment which used a between-subject design and Study 2 which was predominantly a qualitative exploratory study, with limited quantitative data collected. Each investigated what type of worked example best supported participants learning and applying the characteristics of substantive communication, an element of the NSW QTM, in an ill-structured learning environment. The characteristics of classrooms with high levels of substantive communication include sustained interaction during the lesson, communication focused on the substance of the lesson and interaction that is reciprocal (NSW DET, 2006). Experiment 1 used a quantitative research approach to investigate the effectiveness of process oriented and product oriented worked examples for pre-service teachers' (novices) learning about the characteristics of substantive communication. Study 2 built on the findings of Experiment 1 by using a qualitative approach to investigate the thought processes of pre-service teachers (novices) and practicing teachers (experts) learning about the characteristics of substantive communication using process oriented and product oriented worked examples.

Further, even though Experiment 1 provided significant results for test performance scores, the results for the perceived mental effort and perceived task difficulty ratings of the participants were inconclusive. These inconclusive results gave scope to investigate in more depth what participants were doing when engaging with worked examples in an ill-structured learning domain. As stated there has been limited research in the use of worked examples in ill-structured learning domains, including what they look like and how people engaged with them. Hence, Study 2 allowed an in-depth exploration of what participants, novices and experts, were doing when engaging with worked examples in an ill-structured learning domain.

Experiment 1 used a between-subjects design to examine test performance scores, perceived cognitive load and perceived task difficulty of participants when learning about and completing NSW QTM substantive communication tasks. A one-way Analysis of Variance (ANOVA) between instructional conditions was conducted for each of the dependent variables in Experiment 1. The independent variables were the instructional design conditions (process oriented worked examples, product oriented worked examples and conventional problem solving) and the dependent variables included the test performance scores (performance on test items), perceived mental effort and perceived task difficulty ratings. Mental effort is defined as "the aspect of cognitive load that refers to the cognitive capacity that is actually allocated to accommodate the demands imposed by the task" (Paas et al. 2003, p. 64) and task difficulty can be described as "how difficult the task is" (Hsu et al., 2019, p. 1). Further analysis of data by means of Cohen's *d* test was performed and the relationship between performance and mental effort (i.e., Instructional Efficiency) was used to compare the effects of the three instructional conditions on learning (van Gog & Paas, 2008).

The participants for Experiment 1 were pre-service teachers (novices) enrolled in either their first year of a two-year post-graduate Masters of Teaching programme (this programme offers both primary and secondary school focus) or their final year of a four-year Bachelor of Primary Education programme at an Australian regional university. Experiment 1 was conducted in three phases: introductory phase, learning phase and test phase. The experimental materials were developed by the researcher, who had expert knowledge of the NSW QTM, in consultation with PhD supervisors, international expert CLT researchers and three Education Officers from a regional Catholic Education Diocese. In Experiment 1, during the introductory and learning phases, participants were presented with training based on their instructional condition on the NSW QTM with a specific focus on the element of substantive communication. Immediately after the learning phase, participants completed a series of test items during the test phase. During both the learning phase and test phase, participants were asked to rate their perceived mental effort and perceived task difficulty. Following this, participants completed an evaluation of their experience, evaluating whether they enjoyed learning in their allocated instructional condition and if they found this type of instruction engaging.

To investigate the thought processes of novice and expert participants engaging with the instructional conditions, Study 2 was conducted. Study 2 was a small-scale qualitative study which investigated the thought processes of both novices (pre-service teachers enrolled in their fourth year of the Bachelor of Education degree) and experts (practicing teachers) by asking questions to ascertain how they engaged with and made meaning from the three different instructional conditions.

Study 2 was conducted in three phases. Initially, participants engaged with one instructional condition similar to Experiment 1. At the conclusion of the first phase, the participants were asked a series of questions to investigate how they engaged and made meaning from the presented material. During Phase 2, participants were introduced to the remaining two instructional conditions and were asked how they perceived and how they engaged and made meaning from each instructional condition. The third phase of Study 2 involved participants discussing how they could use worked examples in their own teaching practice.

1.5 THESIS STRUCTURE

The structure of the thesis is as follows:

In Chapter One, the background and significance of the research are presented followed by the research questions and hypotheses that guided this research, the research methodology, the limitations and an overview of the structure of this thesis.

In Chapter Two, the literature review related to this research is presented. The chapter provides an overview of CLT and instructional design, including information on the human cognitive architecture, WM, information processing system and different types of cognitive load. Approaches on how the principles of CLT can enhance learning is presented, including cognitive load effects related to the current research and specifically the worked example effect, including process oriented and product oriented worked examples. Information on cognitive load measures, ill-structured learning domains, the NSW QTM and the element of substantive communication are also discussed.

In Chapter Three, an overview of Experiment 1 and Study 2 is presented. The chapter includes the research aim, overarching questions, research questions, related hypotheses and a description of Experiment 1 and Study 2.

In Chapter Four, Experiment 1 is presented and includes experiment aims, hypotheses, the methodology and instructional materials used. The quantitative results to the experiment are analysed and the summary of key findings, limitations and discussion for Experiment 1 are presented.

In Chapter Five, Study 2 is introduced and includes the research aim, two research questions that guided this experiment, the methodology, participant information and the instructional materials used. A discussion of the data collected and analysis for Study 2 are presented

In Chapter Six, an analysis of the qualitative data collected from the novice participants during the three phases of Study 2 is presented. The analysis of the qualitative data answers Research Question 1 (in relation to novices) and Research Question 2 from Study 2. The chapter initially presents and analyses novice participants' responses from each instructional condition. This is then followed by a discussion on how each participant engaged and made meaning from the worked examples. Test performance scores, perceived mental effort and perceived task difficulty ratings during the learning phase are presented and discussed. The chapter concludes with an analysis of the responses from Phases 2 and 3 of Study 2, a presentation of emergent themes and an overall summary of key findings.

In Chapter Seven, a discussion of the qualitative data collected from the expert participants during the three phases of Study 2 is presented, and is structured as Chapter Six. The analysis of the qualitative data answers Research Question 1 (in relation to experts) and Research Question 2 from Study 2.

In Chapter Eight, an overview of the methodology, results, main findings and answers to the research questions for Experiment 1 and Study 2 are provided. In addition, the theoretical contributions for CLT, implications for practice, limitations, further areas for research and the conclusion are presented.

Chapter 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter presents a review of literature about Cognitive Load Theory (CLT), with a specific focus on CLT effects of worked examples, expertise reversal, split attention and redundancy, all of which inform the design of instructions in Experiment 1 and Study 2. The chapter firstly presents a discussion of human cognitive architecture, CLT and CLT effects. This is followed by a review of cognitive load measures and the use of worked examples in ill-structured and well-structured learning domains. The chapter concludes with an overview of the New South Wales Quality Teaching Model (NSW QTM), the information presented within the instructional materials. This literature review forms the basis of identifying a gap in research examining the use of process oriented and product oriented worked examples in an ill-structured learning domain.

2.2 HUMAN COGNITIVE ARCHITECTURE

Human cognitive architecture refers to the organisation of memory stores and is comprised of sensory memory (SM), working memory (WM) and long-term memory (LTM) (Atkinson & Shiffrin, 1968). Information enters the memory system for initial processing through SM and is then further processed in WM before being transferred to LTM. Information enters WM in two ways, from the SM, which "consists of the short-term storage of sensory stimuli to guide behaviour" (Pasternak & Greenlee 2005, p. 97) or through LTM by the retrieval process. The process of transferring from LTM to WM involves information being stored in LTM as schemas and being retrieved and utilised at a later time in the WM (Kalyuga, 2006). The following sections provide a discussion on WM, LTM and schemas, automation, CLT and learning and the different types of cognitive load.

2.2.1 Working Memory

Working memory (WM) is the centre of human information processing and central for successful learning, but is limited in capacity (Sweller, 1999). George Miller (1956) showed that WM capacity is limited to processing 7 ± 2

chunks or elements of information simultaneously. Recent studies have suggested that WM may be limited to only three to five elements of information (Cowan, 2001), with an element being "anything that needs to be learned or processed" (Sweller et al., 2011, p. 65). As the number of interacting elements increases and subsequently need to be processed simultaneously, WM load increases.

Baddeley (1986) proposed a model of WM consisting of the following components: the central executive, the visuospatial sketchpad and the phonological loop. The central executive manipulates cognitive processes and supports the integration and organisation of information from the phonological loop, the visuospatial sketchpad and LTM (Baddeley, 1986). The visuospatial sketchpad processes visual and spatial information and the phonological loop supports the acquisition of language (Baddeley & Hitch, 2010). Baddeley (2000) proposed a fourth component, the episodic buffer, which is controlled by the central executive and is assumed to be a temporary store of limited capacity. The episodic buffer binds information from LTM, the phonological loop and the visuospatial sketchpad into a unitary episodic representation (Baddeley, 2000), and is linked to the processing of information from LTM. Figure 2.1 demonstrates Baddeley's revised multi-component WM model (Baddeley, 2003).

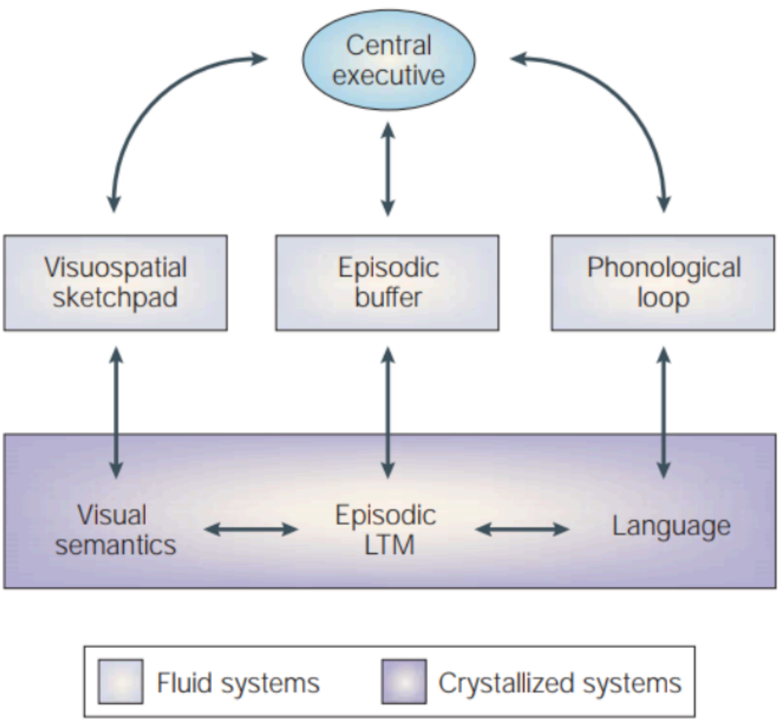

Figure 2.1: Baddeley's revised working memory model (Baddeley 2003, p. 835).

2.2.2 Working Memory, Long-Term Memory and Schemas

When dealing with novel information, WM capacity is limited, and information can only be stored for a limited duration (Peterson & Peterson, 1959). In contrast, there are "no known limits when familiar, organised information from long-term memory is processed" in WM (Sweller, 2019, p. 5). LTM is an unlimited store of knowledge and skills (Kirschner, 2002), with the knowledge and skills organised into schema (Sweller et al., 2011). Schema can be defined as "cognitive constructs that incorporate multiple elements of information into a single element with a specific function" (Paas et al., 2003a, p. 2). LTM supports schema development so that multiple elements of information may be treated as a single element in WM (Sweller et al., 2011). For example, a single word may be viewed as separate letters (elements) by a novice learner. However, an expert learner would view the word as a single element. For instance, a young child may view the word "CAT" as three different elements i.e., the letters C, A and T, whereas an older child who can read, would view this as one element, the word CAT.

Plass et al. (2010, p. 32) state that LTM is not a "repository of isolated, near-random facts but, rather, the central structure of human cognition". This is due to the schemas stored in LTM, which are crucial for chunking information in WM. It is the chunking process in LTM, as demonstrated in the above "CAT" example, that leads to expertise as the number of elements needed to be processed in WM is reduced, decreasing the load on WM and enabling the schema to be accessed with less conscious processing and minimal effort (Sweller et al., 2011). Sweller et al. (2011) state LTM schema construction is central for developing expertise and that expert learners have access to higher-level schemas that supports them to solve more difficult problems. Simply stated, a novice has not acquired the schemas of an expert.

If WM is overloaded, which occurs when the WM capacity of the learner is exceeded (Gerjets et al., 2009), information being taught may not be effectively encoded in LTM and can impact learning (Martin, 2016). To optimise learning, the aim is to balance a high load within WM limits so as not to cause an overload, which involves "thinking about the complexity of your content and how you can make it accessible without oversimplifying it" (Garnett, 2020, p. 15).

Figure 2.2 shows the processing of incoming information through the memory stores. The information is initially stored in SM for a limited time and then if attended to, is transferred to WM for processing before being encoded to LTM. The figure also shows the inter-connected relationship between LTM and WM with encoding and retrieval and the use of rehearsal within WM. Rehearsal is the process that involves repetition to maintain information in WM so it is not lost and can be transferred to LTM. Encoding transfers new information from WM into LTM and seeks to "relate it to existing knowledge" (Garnett, 2020, p. 8); this commences the process of schema development. Retrieval is the ability to access information, schemas from LTM when required to WM, where it can then be processed (Kalyuga, 2006). The output of the information processing system is the action undertaken based on LTM knowledge including the ability to recall, understand and transfer information. For example, a child may see an animal in the field. The visual image is first transferred to SM where it is held for a limited time and if it is attended to, transferred into WM. When in WM, the visual image of the animal is then held for up to twenty seconds; whereby the stimulus in WM is compared to schemas (knowledge on animals) held in LTM. It is this "matching" process between the visual stimulus in WM and schemas (knowledge about animals/cows) in LTM that facilitates the retrieval of the information into WM and output, where a child may classify the animal as a cow. Once this process occurs a number of times with labelling different animals, the schema held in LTM develops, becomes more complex and integrated; that is, it holds more animals and eventually becomes automated. Automation is discussed in the next section.

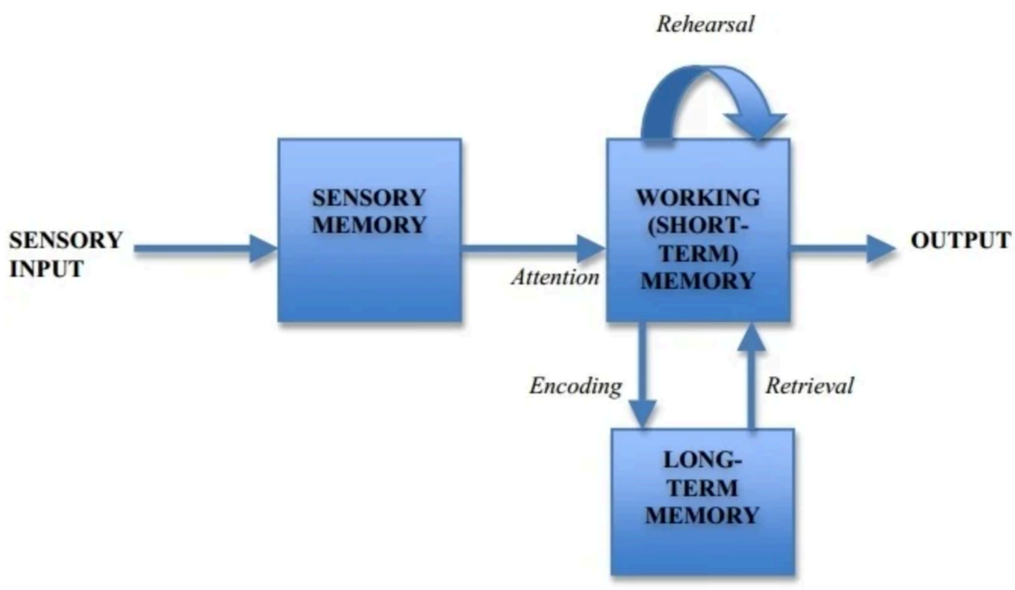

Figure 2.2: Information Processing Model (Pappas, 2014).

2.2.3 Automation

Schema construction and automation are important learning processes to enable the transfer of acquired knowledge and skills and develop expertise (Paas et al., 2003). Automation occurs when schemas are processed unconsciously in WM. New schema acquisition needs to be consciously processed, and at times, with effort (Sweller et al., 2011). The combination of interacting elements (e.g., C, A, T) of information into fewer schema (e.g., CAT), results in fewer elements needing to be processed simultaneously. Problem solving using automated schemas is efficient and effective as there is less load on WM (Kotovsky et al., 1985) and this frees up WM to process new information (Laberge & Samuels, 1974). With continual practice, schemas require less conscious processing, and can be used automatically with minimal effort and with minimal load on WM (Sweller et al., 1998, p. 256; Sweller et al., 2011, p.23).

Plass et al. (2010, p. 34) state "the automation of lower level schema is essential for the construction of higher level schemas". They give the example of reading a word demonstrating that when humans initially learn to read, they need to consciously process each letter before saying the word (Sweller et al., 2011). Thus, learning requires both the formation of schemas in LTM and their automation, and it is these two cognitive processes that are essential for developing expertise.

2.3 COGNITIVE LOAD THEORY

Cognitive Load Theory (CLT) is based on an understanding of human cognitive architecture components of WM, LTM and the relationship between them (Sweller, van Merriënboer & Paas, 2019). This includes understanding that WM is limited in capacity and duration when dealing with novel information and unlimited when WM is dealing with information, organised in schemas from LTM (Sweller et al., 2019). CLT provides an understanding of methods to support the development and automation of schemas, how to reduce load on WM and how to optimise limited WM resources to maximise learning.

Cognitive Load Theory (CLT) posits that learning is the development and automation of schemas in LTM (Leppink, 2020). Leppink (2020) adds that learning can only occur if information is processed within the narrow limits of WM and through the minimisation of processing information that does not contribute to learning. Zambrano, Kirschner, Sweller and Kirschner (2019) add that if little knowledge is stored in LTM and if tasks are complex, learners may experience cognitive overload and learning and performance will be impacted. CLT provides guidelines for instructional design to support learning by providing strategies to reduce the cognitive load on WM.

When considering instructional implications, CLT views knowledge as being either biologically primary or biologically secondary (Geary, 2008, 2012; Sweller et al., 2011). Humans have evolved to acquire biologically primary knowledge and learn the associated generic-cognitive skills, skills that cannot be taught (Tricott & Sweller, 2014). Examples of biologically primary knowledge include learning to listen, speaking a native language and recognising faces (Sweller et al., 2011). Biologically secondary knowledge is knowledge that is not automatically acquired by humans and is largely domain-specific and needs to be explicitly taught (Kirschner et al., 2006; Tricott & Sweller, 2014). An example of biologically secondary knowledge is learning to solve an algebraic equation. CLT instructional design principles focus on biologically secondary information, that is, developing and automating schemas, as educational areas deal predominantly with this type of information.

The function of WM and its ability to process familiar information stored in LTM has specific instructional consequences to enhance learning biologically secondary knowledge (Sweller et al. 2011), that is, knowledge that is not automatically acquired by humans, as stated previously needs to be explicitly taught. This current research investigated the use of process oriented and product oriented worked examples to learn specific knowledge about quality teaching practices, that can be classified as biologically secondary knowledge.

2.3.1 Types of Cognitive Load

Cognitive Load Theory (CLT) assumes knowledge acquisition is reliant on the efficiency of the use of available cognitive resources (Park et al., 2020). The amount of cognitive load is determined by three components: intrinsic cognitive load (ICL), extraneous cognitive load (ECL) and germane cognitive load (GCL) (Paas, 1998; Sweller et al., 2011). The following discusses the three different components of cognitive load.

2.3.1.1 Intrinsic Cognitive Load (ICL)

Intrinsic Cognitive Load (ICL) is determined by the complexity of the content to be learnt (Sweller, 1994, 2010; Sweller & Chandler, 1994) and the prior knowledge of the learner (Gerjets et al., 2004; Sweller et al, 2019; Wong et al., 2020). When information to be learnt is complex and the learner's prior knowledge is limited, information is deemed to be high in element interactivity (Sweller & Chandler, 1994, 1996). High element interactivity results in increased levels of cognitive load (Brooks, 2009). Element interactivity can be defined as "elements that must be processed simultaneously in working memory because they are logically related" (Sweller et al. 2011, p. 58). When learners can link new information to existing schemata, they can chunk elements, reducing element interactivity and load. Experiment 1 investigated the types of worked examples that best supported novice participants learn about quality teaching practices through tasks that were deemed to be high in element interactivity, due to the participants' limited prior knowledge. Study 2 involved expert and novice participants and investigated the impact of how prior knowledge influenced participant engagement and meaning making when engaging with process oriented worked examples, product oriented worked examples and conventional problem solving.

2.3.1.2 Extraneous Cognitive Load (ECL)

Extraneous Cognitive Load (ECL) is imposed on WM as a result of the manner in which information is presented to learners (Sweller et al., 2011; Sweller et al., 2019). Ineffective instructional procedures can increase the load on WM through the learner having to engage with multiple pieces of information based on how the instructions are presented (Sweller et al., 2019; Sweller, 2010; van Merriënboer & Sweller, 2005). For example, presenting spoken and written information simultaneously during a presentation can increase ECL, as information presented is duplicated, therefore redundant. Information on the redundancy effect is included in Section 2.5.2.

There are a number of effects that can be implemented that will optimise the instructional design and minimise ECL, allowing learners to invest greater effort into the learning process (Klepsch et al., 2017). This current research focused on the worked example effect which has been shown to reduce ECL by focusing on problem states and steps to solution to support learning (Plass et al., 2010). Other relevant effects to the current research include the redundancy effect and the split attention effect, which are discussed in Section 2.5.

2.3.1.3 Germane Cognitive Load (GCL)

Germane Cognitive Load (GCL) has been defined as the load that supports learning, where WM resources are devoted to dealing with ICL, as opposed to ECL (Sweller et al., 2019). The latest research into the different cognitive loads has indicated a reduction in total load "following a reduction in extraneous load" (Sweller et al. 2019, p. 264). Otherwise, if GCL were to replace ECL when ECL is reduced, then the total load would be maintained (Sweller et al., 2019). Hence, it is assumed that “germane cognitive load redistributes working memory resources from extraneous activities to activities directly relevant to learning by dealing with information intrinsic to the learning task” (Sweller et al., 2019, p. 264). In summary, current research assumes that GCL redistributes from extraneous to intrinsic aspects of a task as opposed to imposing its own cognitive load.

Furthermore, Leppink (2020) adds that there are some cognitive load theorists who state that there are three types of cognitive load: intrinsic, extraneous and germane, where germane load is “load arising from the deliberate engagement in learning” (Leppink, 2020, p. 5). Yet, Leppink also writes that there are others who state that GCL is not an independent type of cognitive load, but “part of the *intrinsic* load that results in learning” (Leppink, 2020, p. 5). Despite the contention in this field, this current research does not specifically investigate GCL.

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The three types of cognitive load can be explained by learning how the heart circulates blood. Figure 2.3 below shows the specialized set of working parts of the human heart (Saunders, 2014) including connections to other parts of the human body. In this learning context, ICL is the load placed on a learner’s WM resources as they understand how the different elements within the heart are interconnected and work together to circulate blood. ECL is the load placed on a learner’s WM based on how the information is presented, that is, the instructional design. In the diagram below, textual information is integrated into the diagram rather than explanatory text below the diagram. Different instructional conditions place different loads on learners’ WM. GCL is the load placed on a learner’s WM when the learner purposely engages with instructional material to develop schema of how the heart circulates blood.

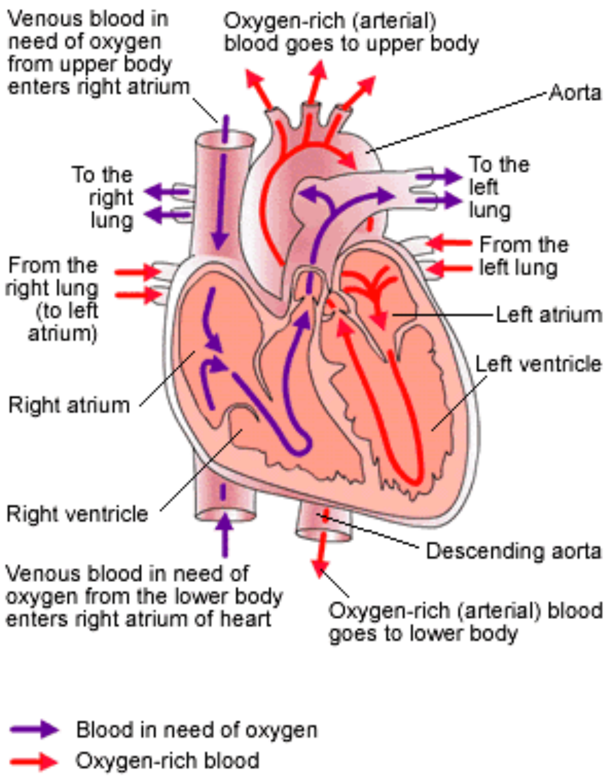

Figure 2.3: The specialized set of working parts of the human heart (Saunders, 2014).

2.3.2 Strategies to Improve Learning by Considering Types of Cognitive Load

To optimise learning, supportive cognitive load needs to be maximised (intrinsic and germane) and irrelevant cognitive load (extraneous) needs to be minimised (Kirschner, 2018). Strategies to support the maximisation of cognitive load to assist learning and minimisation of irrelevant cognitive load include appropriate management of ICL, minimisation of ECL sources and maximisation of GCL resources (Young, Irby, Barilla-LaBarca, Cate & O'Sullivan, 2016). The following provides an overview of some CLT strategies that have been empirically found to reduce the ICL of content to be learnt. These include:

1. Presenting content in a simple to complex order (van Merriënboer et al., 2003).
2. Using a "part-whole" approach, where individual parts of content are presented before presenting the complete task (Bannert 2002; Pollock et al., 2002).
3. Using a "whole-part" approach, where the high-element interactivity materials are presented "in their

full complexity right from the beginning, but use learning tasks that focus the learner's attention on particular subsets of interacting elements" (van Merriënboer et al., 2006, p. 348).

The first two approaches reduce the cognitive load as they both introduce single and simpler elements before gradually introducing the more complex elements (van Merriënboer & Sweller, 2005), thus reducing element interactivity. However, the third approach promotes a germane load inducing method by presenting the high-element interactivity materials in full and then focusing on particular "subsets of interacting elements" (van Merriënboer et al., 2006, p. 348). This can be achieved through the use of worked examples which "focus the learner's attention on elements that represent correct solutions steps only" (van Merriënboer et al., 2006, p. 348). The current research adopts the third approach, initially the full content was presented to the participants in the form of a PowerPoint presentation which included information on the NSW QTM. Following the initial presentation and the learning phase, the participants were presented three tasks to complete, ordered from simpler to more complex tasks.

2.3.3 Cognitive Load Theory and Engagement

Martin (2016) suggests that reducing cognitive load through instructional approaches can enhance learning experiences and achievement. He investigated how implementing instructional approaches that promote reduction in cognitive load, referred to as Load Reduction Instruction (LRI), can enhance engagement in learning. Enhanced engagement impacts behaviour, emotion and cognition (Fredricks et al., 2004), leading to improved student interest and commitment to learning, achievement motivation and self-regulated learning (Fredricks et al., 2004). Furthermore, he also investigated how implementing instructional approaches that promote reduction in cognitive load (LRI), can enhance engagement and promote automaticity that "frees up working memory" capacity that can be applied to completing a task.

In addition to instructional approaches, prior knowledge can have an important impact on engagement (Rodrigues, 2007; Pecore et al., 2017) by reducing cognitive load (van Riesen et al., 2019) and can be considered as a variable of cognitive load that influences engagement (Dong et al., 2020). Study 2 in this research investigated how novice and expert participants engaged with the instructional material provided by the worked example to make meaning of substantive communication.

2.3.4 Cognitive Load Theory Effects

Cognitive Load Theory (CLT) has been instrumental in generating a number of instructional designs, CLT effects, to facilitate learning (Sweller et al., 2011). The following section presents an overview and research on the worked example effect. Following this, an overview of other CLT effects that inform this current research is provided, including the expertise reversal effect, the split attention effect and the redundancy effect.

2.3.5 Worked Example Effect

Initial evidence of the worked example effect, conducted in the well-structured learning domain of mathematics, was identified within research conducted by Sweller and Cooper (1985). Section 2.3.5.1 includes details of this research. Mathematics is considered well-structured as it is a content specific domain that includes well-defined problems that have clearly specified problem states and required problem-solving operators (Sweller et al., 2011) (See Section 2.7 for a discussion on well-structured and ill-structured learning domains). Worked examples include a problem state, a goal state and provide a step-by-step solution from the problem to the goal state (Sweller et al., 2011; Sweller & Cooper, 1985). The worked example effect is a cognitive-load effect that has been shown to reduce extraneous load by focusing on problem states and steps to solution (Plass et al., 2010). Central to the worked example effect is supporting learners to work from the problem state to the goal state using a scaffolded forward problem-solving strategy. This forward step by step strategy is one that experts use when solving problems (Simon & Simon, 1978). Simon and Simon (1978) compared expert and novice participants in solving physics problems and found that experts used a "working forward" method when solving problems. As the worked example effect promotes a forward working strategy, it models for novices an expert like approach to solving problems and reduces cognitive load by learners moving forward and not back, preventing learners from using a means-ends problem solving strategy (Plass et al., 2010). A means-ends strategy is one where the problem solver starts by envisaging the ultimate goal and then determines the best strategy to achieve the goal, usually working back and forward between the problem state and the goal state. However, this strategy places a burden on limited WM resources. The use of worked examples prevents learners from using a means-ends problem solving strategy, hence, reducing load on WM. Figure 2.4 presents a worked example created by Cooper (1998), showing the steps required to make "*a*" the subject of a given algebraic expression.

$$
\begin{aligned}
ac + e &= g \\
ac &= g - e \\
a &= \frac{g-e}{c}
\end{aligned}
$$

Figure 2.4: Worked Example: How to make "*a*" the subject of an algebraic equation (Cooper, 1998).

The learning by example strategies method has been used for many years, dating back to the 1950s (Atkinson, Derry, Renkl & Wortham, 2000). The use of worked examples to support learning has been shown to support the development of problem-solving schemas stored in LTM (Sweller at al., 2011). Once stored in LTM, the stored schema can be accessed to solve problems (Cooper & Sweller, 1987) and enhance automation, leading to improved problem solving performance (Sweller et al., 2011). Worked examples assist in reducing ECL and element interactivity and increase GCL to improve learning (Miller et al., 2021; van Merriënboer & Sweller, 2010). Research has shown that novice learners who study worked examples, perform better on tests than learners not presented with worked examples (Carroll 1994; Cooper & Sweller 1987). In summary, the worked example effect has been shown to prevent learners from using a means-ends problem solving strategy (Plass et al., 2010). The worked example is effective in supporting learners by promoting a forward working strategy when problem solving and reducing the cognitive load associated with a task. In particular, worked examples have been shown to support novice learners, who may lack "domain specific schemas necessary to handle the multiple elements associated with a complex task or problem." (Brooks, 2009, p. 87).

2.3.5.1 Research on Worked Examples

Sweller and Cooper (1985, 1987) conducted two investigations of worked examples in the well-structured learning domain of mathematics. The first experiment involved a group of Year 9 students learning algebraic problem solving. The students were divided into two groups, a worked example group and a conventional problem solving group. The results showed that while the worked example group performed better on similar type problems, the results for the transfer problems were similar between the two groups, indicating a failure to find "evidence of transfer" (Sweller et al. 2011, p. 101). In a follow up experiment, Cooper and Sweller (1987) provided extra learning time during the acquisition and test phase. The results showed students learning by worked examples demonstrated better performance results as well as evidence of transfer. From this experiment, it was concluded that "in any complex domain, significant acquisition time is required to automate the required problem solving operators to demonstrate transfer" (Sweller et al. 2011, p. 101). This current research progresses on from these early worked example studies in that the research investigated participants being presented with worked examples or engaging in conventional problem solving in an ill-structured learning domain.

Paas and van Merriënboer (1994) found evidence for the worked example effect in the well-structured learning domain of geometry. The research "examined the effects of practice-problem type, variability of practice, and combinations of these variables with regard to their effects on training performance, transfer performance, and cognitive load" (Paas & van Merriënboer 1994, p. 130). Four instructional conditions were formed: low-variability conventional, high-variability conventional, low-variability worked example and high-variability worked example (Paas & van Merriënboer, 1994). The problems in the low-variability condition were similar, with different values used in each of the problems. In contrast, the high-variability problems included different values and problem formats. During the worked example instructional conditions, participants were presented with worked examples and were able to immediately study the solutions. The conventional instructional conditions required participants to solve conventional practice problems, which once completed, participants were able to study the solutions. Findings showed that students presented with the high-variability worked example instructional condition benefitted most and invested less time and mental effort compared to participants who initially attempted to solve the conventional problems prior to studying the worked examples (Paas & van Merriënboer, 1994). Thus, the research showed the advantages of worked examples presented to novice learners in a well-structured learning domain.

Another investigation conducted by Halabi et al. (2005) examined the effectiveness of worked examples compared to problem solving instructional strategies when learning accounting using Computer-Based-Learning materials, a well-structured learning domain. It involved students who were enrolled in an Australian university, with approximately half of the students demonstrating prior knowledge. The experiment involved participants assigned to either a problem-solving or a worked example instructional condition. Participants of the problem solving instructional condition received a copy of the correct answers, after solving each of the eight assigned tasks. Students assigned to the worked example instructional condition were presented with solutions to the first three tasks, and completed the remaining tasks. Participants in both instructional conditions rated their mental effort after each task. Following this, a diagnostic test was administered to the students on the tutorial topic (Halabi et al., 2005). Based on the Instructional Efficiency measures, the results showed that worked examples were more effective than problem solving instructional strategies due to the lower level of effort required by the participants to answer the questions. The results also indicated no difference in the Instructional Efficiency measures between the use of worked examples and problem solving instructional strategies for students with high prior knowledge. This investigation demonstrated the benefits of the use of worked examples in a well-structured learning domain for participants with low prior knowledge, with worked examples being less effective with high prior knowledge participants. This current research builds on the Halabi et al. (2005) research as it investigated the impact of prior knowledge on the effectiveness of different types of worked examples in an ill-structured learning domain.

2.3.5.2 Research on Process Oriented and Product Oriented Worked Examples

Process oriented worked examples support novice participants with their learning, as not only do they contain the solution steps (strategic information), they also state the rationale of the steps (principled knowledge) (Van Gog et al., 2008). This is unlike product oriented worked examples which do not state the rationale or the "why" of the steps to solution (Van Gog et al., 2006). Van Gog et al. (2008) stated that process oriented worked examples promote learners' construction and automation of cognitive schemata enabling better performance than product oriented worked examples (see Section 2.2). Van Gog et al. (2004) stated that the principled knowledge included in process oriented worked examples improves understanding as learners are "challenged to invest germane effort in studying the why and how of information" (van Gog et al., 2004, p. 96). Ohlsson and Rees (1991) also state that process oriented worked examples are beneficial for novice learners due to the inclusion of principled knowledge (why) and strategic information (how) to assist in solving related problems. Figure 2.5 shows a process oriented worked example for solving an algebraic equation. The principled knowledge i.e., the why, the purpose of the steps in solving the problem, is represented by the statements contained inside the brackets describing and providing reasons for each step. The below process oriented worked example, product oriented worked example and conventional problem solving task, included in Figures 2.5, 2.6 and 2.7, were developed by the researcher.

Solve 2(x+4) = 18.

2x+8 = 18	(The distributive law has been used to expand the brackets)
2x = 10	(Subtract 8 from both sides, as this maintains a balanced equation)
x = 5	(Divide both sides by 2, as this maintains a balanced equation, and solves for x)

Figure 2.5: Example of a process oriented worked example.

Figures 2.6 shows a product oriented worked example for solving an algebraic equation. The product oriented worked example provides the learner with the procedural steps to perform the task (Brooks, 2009). The strategic information is represented by the steps demonstrating how to solve the problem.

Solve $2(x + 4) = 18$.

$$2x + 8 = 18$$

$$2x = 10$$

$$x = 5$$

Figure 2.6: Example of a product oriented worked example.

Figures 2.7 shows an example of a conventional problem solving task. The conventional problem solving task provides learners with only the question and correct answer to the problem (Brooks, 2009).

Solve $2(x + 4) = 18$.

$$x = 5$$

Figure 2.7: Example of a conventional problem solving task.

A number of key studies in the area of process oriented and product oriented worked examples have been conducted. These studies are summarised below and show how the process oriented or product oriented worked examples have supported learners with different levels of expertise in a variety of domains.

Kalyuga et al. (2001, p. 5) conducted an experiment investigating "interactions between levels of learner knowledge in a domain and levels of instructional guidance". Novice mechanical trade apprentices were presented with either a series of worked examples or problems to solve with less guidance allowing participants to investigate the material on their own (Kalyuga et al., 2001). The tasks presented were classified as either simple or complex. Participants were learning how to calculate different features of a circle, such as the circumference of a circle. This can be classified as a well-structured learning domain as the tasks have clearly specified problem states and required problem-solving operators (Sweller et al., 2011). The researchers hypothesised that guided worked examples would better support novice learners than "an exploratory procedure" (Kalyuga et al., 2001, p. 5) with complex tasks. Findings confirmed the hypothesis with participants interacting with the worked examples performed better and scored lower ratings of mental effort on the more complex tasks. As the participants gained experience, the group presented with the problems to solve with less guidance, outperformed the group presented with worked examples. Kalyuga et al. (2001) stated that learners with high prior knowledge may have found the principled knowledge (why) contained in the process oriented worked example redundant, leading to an increase in their cognitive load. Further, results showed that as the participant knowledge and experience grew, the worked examples became redundant (Kalyuga et al., 2001).

In other research, Hoogveld et al. (2003) used process oriented and product oriented worked examples to train teachers to apply an instructional systems design methodology, a well-structured learning domain. The participants all indicated they had some experience in the field of the instructional design. Two instructional conditions were formed. Participants of the first instructional condition were presented with process oriented worked examples and participants of the second instructional condition were presented with a combination of product oriented worked examples and conventional problems. Findings showed that the combination of product oriented worked examples and practice with conventional problems was more effective in training teachers compared to using process oriented worked examples. Hoogveld et al. (2003, p. 295) suggested that the process oriented worked examples may have "exceeded the available cognitive capacity of the teachers" as the additional information may have caused cognitive overload. The findings are similar to those of Kalyuga, et al. (2001), which show that in well-structured learning domains, there is evidence that process oriented worked examples are ineffective due to the added burden the extra information adds to WM. In addition, evidence showed worked examples are ineffective due to participants with prior knowledge disregarding the extra information presented by the WE, as the information is redundant.

Darabi and Nelson (2004) conducted an investigation involving chemical engineering students presented with instructional strategies for trouble shooting plant malfunctions, a well-structured learning domain. The students were divided into three groups based on an instructional condition. The first group was presented with process oriented worked examples, the second group with product oriented worked examples and the third group engaged in conventional problem solving. Following the instruction, students were required to complete near and far transfer problems. Near transfer problems require participants to apply learnings to similar tasks presented previously (a similar context) and far transfer problems require participants to apply learnings to a new situation (a dissimilar context) (Trumbo et al, 2016). The results indicated no statistical significance between the instructional conditions. The researchers argued that the process oriented worked examples were ineffective due to the prior knowledge of the students, which supported the expertise reversal effect. Further, the researchers stated that due to the prior knowledge of the participants, the findings were also consistent with the redundancy effect, which refers to the presence of unnecessary information adding to extraneous load (Lovell, 2020). Further information on the redundancy effect is included in Section 2.5.2.

Van Gog et al. (2008) investigated the use of the following worked example instructional conditions: product-product, product-process, process-product or process-process. The product-product instructional condition involved participants being presented with product oriented worked examples during two sessions. The process-product instructional condition involved participants being presented with process oriented worked examples during the first training session and product oriented worked examples during the second session. Similar conditions were presented for the remaining two instructional conditions. As per the findings of Darabi and Nelson (2004), the researchers hypothesised that process information might be initially beneficial, but may become redundant as training progressed (Van Gog et al., 2008). Learners were presented with two training sessions on troubleshooting and parallel circuits principles, a well-structured learning domain. The findings revealed that the performances attained with the initial use of process oriented worked examples were similar with the other instructional conditions, but attained with "lower investment of mental effort (van Gog et al., 2008, p. 219). Further, as learners acquired knowledge, the process information became redundant (Van Gog et al. 2008). For the second test, the findings showed higher efficiency results for the use of product oriented worked examples, with higher performances attained with "equal investment of mental effort" (van Gog et al., 2008, p. 219). These findings demonstrated an expertise reversal effect and that the extraneous load of a task can be reduced by considering the instructional support provided for the learner. The researchers concluded that the use of process oriented worked examples in the initial stages could be more efficient than the use of product oriented worked examples (Van Gog et al., 2008).

Building on the work from Hoogveld et al. (2003), Brooks (2009) investigated the effectiveness of process oriented worked examples and product oriented worked examples on problem solving and learning attitude in the well-structured learning domain of microeconomics (Brooks, 2009). The research also considered learners' prior knowledge. Participants were classified as either low prior knowledge or high prior knowledge and were allocated to one of three instructional conditions: process oriented, product oriented or conventional problem solving. Participants were presented with a lecture on the impact of taxes on market activity (Brooks, 2009). Findings showed that learners presented with the process oriented and product oriented worked examples performed better than learners engaging in conventional problem solving. Brooks (2009) hypothesised that low prior knowledge participants presented with process oriented worked examples would outperform participants presented with product oriented worked examples or who engaged in conventional problem solving. The findings did not support this as there were no significant differences between the three instructional conditions. Further, performances of high prior knowledge participants who engaged in conventional problem solving performed better than high prior knowledge participants presented with worked examples. Similar to the findings of Van Gog et al. (2008), this indicated the presence of an expertise reversal effect, which states that the use of worked examples becomes less effective as learners gain expertise and develop schema through the continued use of worked examples. Further details are discussed in Section 2.4.

In support of the findings of the research by Van Gog et al. (2008), Leppink and van den Heuvel (2015) stated that learning instruction should commence with high support and gradually fade as "learners become more proficient" (Leppink & van den Heuvel, 2015, p. 119) and learner germane load is increased. Schilling (2017, p. 27) also stated that by "withdrawing from total guidance" provided by worked examples, infant schemas can be utilised to process information, hence "avoiding extraneous load from excessive cognitive processing" and avoiding an expertise reversal effect (Schilling, 2017, p. 27). This can be compared to the use of process oriented worked examples providing greater guidance in the early stages of learning, and then gradually reducing the guidance with the use of product oriented worked examples as learners become more proficient (Brooks, 2009).

The inclusion of principled knowledge in process oriented worked examples results in participants engaging with them for a longer period of time compared to product oriented worked examples. Recent studies have demonstrated that time for completing tasks may be a form of ECL (Barrouillet & Camos, 2012; Puma, Matton et al., 2018) as longer periods of time required for learners to engage with the content requires them to process information in their WM for longer (Barrouillet & Camos, 2012; Puma et al., 2018). In previous CLT research such as the Modality Effect (Rummer et al., 2011) and Transient Information Effect (Wong et al., 2012), the length of instruction has also been shown to hinder learning and may be considered a form of ECL or ICL due to high element interactivity.

In summary, process oriented worked examples have been shown to be effective with novice learners, particularly in well-structured learning domains. Research has also demonstrated that as a learner gains expertise, the effectiveness of the process oriented worked example reduces, known as the expertise reversal effect. Further, the length of instruction may also hinder learning through imposing a load on WM. This current research builds on the above findings by investigating the effectiveness of process oriented and product oriented worked examples with novice and expert participants in an ill-structured learning domain. Additionally, this current research included a qualitative approach to investigate the thought processes of participants while engaging in the different instructional conditions.

2.4 EXPERTISE REVERSAL EFFECT AND WORKED EXAMPLES

Central to CLT is element interactivity, which is determined by the difficulty level of the learning materials and information to be learnt (Chen & Kalyuga, 2020) (see Section 2.3.1.1). Element interactivity "refers to the number of interconnected elements in a learning task that must be processed simultaneously in working memory for meaningful learning" (Chen & Kalyuga, 2020, p. 611). A learner's prior domain-specific knowledge affects the level of element interactivity in a learning task (Chen et al., 2017; Chen et al., 2020). Learners with a low level of expertise engaging in a task may encounter more interactive elements than more knowledgeable learners (Chen et al., 2020). In addition, Chen and Kalyuga (2020) state that a task high in element interactivity for novice learners, involving many interactive elements, may present a small number of elements for expert learners, due to available schemas in their LTM enabling the chunking of multiple elements into a "single unit" (Chen & Kalyua, 2020, p. 612). Hence, reducing the level of element interactivity and load on WM (Chen et al., 2020). Chen and Kalyuga (2020) provide an example of solving the equation $5x + 6 = 11$. For a novice learner, this task may represent many interactive elements, whereas for an expert learner, the task may involve one or two elements, enabling them to solve the equation almost immediately (Chen & Kalyuga, 2020). As a novice learner gains familiarity within a domain, less attention needs to be devoted to the necessary cognitive processes, resulting in automation (Saw, 2017). As stated in Section 2.2.3, automation occurs when stored information in schemas is processed without conscious effort (Stoica et al., 2011; Sweller, 1994), enabling cognitive resources for other activities (Saw, 2017).

Worked examples can be used to support novice learners gain familiarity within a domain, leading to a reduction in cognitive load (Saw, 2017). As discussed previously in Section 2.3.1, a worked example explicitly provides steps to solution, reducing ECL supporting schema construction and automation (Sweller et al., 2011, 1998). However, as the expertise of the learner increases and the level of element interactivity decreases, the use of the worked example may lose effect for expert learners (Kalyuga, 2007). Research has shown that as learners' expertise increases through the use of worked examples, the worked example negatively impacts learning outcomes (Kalyuga et al., 1999; Leslie et al., 2012; Pachman et al., 2013; Yeung et al., 1998). This is referred to as the "expertise reversal effect". As a result, instructional design needs to consider learners' prior knowledge or expertise (Kalyuga, 2007).

Longitudinal studies involving learners with prior knowledge and worked examples have confirmed the expertise reversal effect. Kalyuga, Chandler, Tuovinen and Sweller (2001, p. 584) showed that the advantage of the worked example format "disappeared" the longer apprentice participants learning about relay circuits were exposed to the training materials and gaining expertise. Kalyuga and Sweller (2018) stated that explicit guidance can support novice learners engaging in tasks imposing high WM load, but also that instructional methods that are effective for learners considered as novices may be detrimental for learners with more experience (Kalyuga & Sweller, 2018). An investigation by Armougum et al. (2020) examined the expertise reversal effect involving train travellers in a virtual reality environment. Results showed that worked examples interfered with experts and showed an expertise reversal effect raising cognitive load with the generation of new schemas (Armougum et al., 2020).

2.5 OTHER COGNITIVE LOAD THEORY EFFECTS

This section provides a summary and discussion of two other CLT effects relevant to the current research; the split attention effect and the redundancy effect. Both effects were considered in the design of the instructional material used in this research study.

2.5.1 Split Attention Effect

Split attention occurs when learners are required to process multiple sources of information simultaneously to make meaning. This can occur when information presented separately through a diagram and text both need the learner to use a search and match strategy to process the information simultaneously for a learner to make meaning (Chandler & Sweller, 1991). This will place a high cognitive load on the learner's WM as the learner will need to process both sources of information at the same time. To minimise the split attention, the diagram and text can be integrated into one source, so that the learner does not need to mentally integrate the two (Ayres, 2010; Cerpa et al., 1996; Owens & Sweller 2008; Tarmizi & Sweller 1988; Ward & Sweller, 1990). Suek (2018) presented a strategy in teaching simple and progressive tense in a manner which minimises split attention. The strategy involved displaying a tense timeline diagram supported with text describing the timeline (Suek, 218). This relates to the current research as the split attention effect was considered in the development of the instructional materials, including the design of the worked examples. See Appendix Q for a pertinent example of an annotated process oriented worked example used in this research.

2.5.2 Redundancy Effect

The redundancy effect occurs when unnecessary visual or auditory elements are presented in learning content and causes additional ECL on WM, thus impacting learning (Sweller et al., 2011). Sweller et al. (2019) add that this effect occurs as a result of participants investing effort into learning from two identical sources. This needs to be considered due to limited WM, as humans have the capacity to process a finite amount of information in visual and auditory channels (Mayer & Moreno, 2003). Moreover, redundancy can be influenced by the expertise of learners. As learners acquire expertise in a learning domain, previously essential information for learning may become non-essential and redundant.

Kalyuga et al. (1999) conducted an experiment which presented electrical diagrams to students on a computer screen accompanied with an audio message. A second condition also included the audio message written as text on the screen. The first condition was regarded as the non-redundant group and the second as the redundant group. Task results demonstrated that students in the non-redundant group outperformed students of the redundant group, hence demonstrating the redundancy effect.

Morrison et al. (2015) conducted an investigation with university undergraduate students which examined the effects of redundancy when "learning from realistic science materials" (Morrison et al., 2015, p. 423). Four instructional conditions were formed; (i) a redundant group; who were provided with text accompanied by representations, (ii) an integrated redundant group; who were provided with text integrated within the representations, (iii) an integrated nonredundant group; who were presented with the representations only and (iv) the text group; who were presented with only text, and no representations. Morrison et al. (2015) administered a questionnaire to measure cognitive load and attitude and an achievement test consisting of multiple-choice questions. Findings showed no significant difference in perceived mental effort and material difficulty between the instructional conditions, with the text group rating the highest of the four instructional conditions. Morrison et al. (2015, p. 433) state in relation to achievement, “the variations in performance across low- and high-level items with the integrated redundant group approached significance”. Further, contrary to previous research, the presence of text and representations supported learning for low-level items. The researchers suggested that “text paired with redundant diagrams may facilitate lower-level” learning (Morrison et al., 2015, p. 434) and that a “single source of information” (Morrison et al., 2015, p. 434) may be more beneficial for complex learning.

Mason et al. (2016) redesigned a twelve-week Database Systems course for Information Technology students, a well-structured learning domain. This was due to low performances attained by students, low student satisfaction and the high complexity of the course instructional materials. Worked examples were redesigned through considering CLT principles in removing redundancy and split attention effects, as well as the inclusion of sub-goals and re-sequencing of content (Mason et al., 2016). Sub-goals are similar to faded worked examples, in that they support learners “step their way through a problem space to solution” (Mason et al., 2016, p. 72), with the number of sub-goals used reducing as learners progress with their learning. Findings showed significant improvement of student performance and student satisfaction as a result of the redesign of the course. This current research also considered CLT principles in removing split attention and redundancy effects when designing the process oriented and product oriented worked examples for novice and expert participants, in an ill-structured learning domain.

2.6 COGNITIVE LOAD MEASUREMENTS

Researchers have examined different forms of measurement that can be undertaken to understand the cognitive load on WM. Cognitive load on WM is necessary for learning to occur. The following discussion provides an overview of how cognitive load on WM has been measured.

2.6.1 Measurements of Cognitive Load

CLT acknowledges that WM is central to learning. Based on this, it is important to understand the cognitive load on WM when someone is learning. Yet, the measurement of cognitive load has been regarded as a difficult task (Skulmowski & Rey, 2017). As such, the measurement of cognitive load, which has been referred to as perceived mental effort, has been an important development in CLT research (Sweller et al., 2011, p. 71). Mental effort has been defined "as the total amount of controlled cognitive processing in which a subject is engaged" (Paas & van Merriënboer, 1993, p. 738).

There has been a variety of different ways to measure cognitive load. Research has utilised objective techniques such as dual-task measures (Brünken et al., 2004) or measures of physiological parameters, which include heart rate (Paas & van Merriënboer, 1994), pupil dilation (van Gerven et al., 2004) and electroencephalography measures (Antonenko, 2010). More recently, Ayres (2018, p. 22) states that "evidence has emerged that objective measures have been more sensitive to differences in cognitive load than subjective measures". Advantages of objective measures include that they are administered online and are "able to measure simultaneous and continuous cognitive load" (Ayres, 2018, p. 22).

While objective measures discussed above have been found to be accurate, their implementation can be challenging, particularly in real world settings like classrooms. Hence, subjective techniques have been used more widely. A recent approach to subjectively measuring cognitive load with accuracy was the development of a psychometric instrument by Leppink et al. (2013), a test aimed to differentiate the different types of cognitive load. The approach included a questionnaire with ten items. The questionnaire included three items written to measure ICL, three items to measure ECL and four items to measure GCL. The questionnaire was initially tested in the domain of statistics and produced promising results (Klepsch et al., 2017). Leppink et al. (2014) conducted another set of experiments in 2014 involving applications of Bayes' theorem. The results supported the assumption that ICL and ECL "can be differentiated using their 10-item psychometric instrument" (Sweller et al., 2019, p. 282). Further, findings supported the "reconceptualization of germane cognitive load as referring to the actual WM resources devoted to dealing with intrinsic cognitive load" (Leppink et al., 2014, p. 40).

A second subjective technique, used in this current research, measures cognitive load on WM by the self-report rating scale developed by Paas (1992). Paas (1992) developed a subjective self-report rating scale consisting of a nine-point Likert Scale, which measures participants' perceived exerted mental effort. Paas' rating scale is a modified version of the rating scale used to measure task difficulty developed from the work of Bratfisch et al. (1971). This instrument has been shown to be valid and reliable in the measurement of cognitive load (Paas, 1992). A major advantage is its simplicity in implementation (Sweller et al., 2019). However, the subjective rating scale does not provide "real-time, concurrent data" (Sweller et al., 2011, p. 85), providing only "an indicator of cognitive load after the event so cannot be used to determine changes in cognitive load during learning or problem solving" (Sweller et al., 2011, p.85). Further, the rating provides an overall measure of ICL and ECL and does not differentiate between the different types of cognitive load (Sweller et al. 2019, p. 281). The self-report rating scale continues to be a popular measure of cognitive load, implemented in diverse settings. Recently it was used by Aldekhyl et al. (2018) in the field of ultrasonography to validate different measures of cognitive load (Sweller, 2018). Figure 2.8 below is the perceived mental effort rating scale developed by Paas (1992):

In solving or studying the preceding problem I invested

1. very, very low mental effort
2. very low mental effort
3. low mental effort
4. rather low mental effort
5. neither low nor high mental effort
6. rather high mental effort
7. high mental effort
8. very high mental effort
9. very, very high mental effort

Figure 2.8: The Mental Effort Subjective Rating Scale developed by Paas (1992).

This current research used multiple measurements of perceived mental effort after each task during the learning and test phase. Research is showing that measuring perceived mental effort at the conclusion of the learning phase or test phase will provide higher ratings than multiple measurements after each task during either the learning or test phase (Sweller et al., 2019). These ratings may be due to the depletion of working memory resources (Chen et al., 2018). Van Gog et al. (2008) stated that the cognitive load measured in the learning phase reflects the quality of instruction and the load measure in the test phase reflects the quality of the schema (Van Gog et al., 2008).

For this current research, the self-report rating scale developed by Paas (1992) was used as opposed to the Leppink Scale (Leppink et al., 2013) due to the researcher not specifically investigating GCL. The hypothesis for this current research focused on intrinsic and extraneous load, with an understanding that there was a contention around GCL, (see Section 2.3.1.3). Further, due to the time available and implementation of the study in a lecture, the self-report rating scale developed by Paas (1992) was adopted for the simplicity in administering the rating scale in a real world setting.

2.6.2 Measurements of Task Difficulty

The Task Difficulty Subjective Rating Scale is a nine-point subjective rating scale that measures the participant's perceived task difficulty in completing a task (Marcus et al., 1996). The perceived task difficulty rating relates predominantly to the task completed (Van Gog & Paas, 2008), and can be described as "how difficult the task is" (Hsu et al., 2019, p. 1). Sweller et al. (2011, p. 74) stated that "difficulty does not always match effort". Marcus et al. (1996) demonstrated how measures of difficulty related to the level of a task's element interactivity (Sweller et al., 2011). For example, a participant may perceive a task to be difficult which may lead to a lack of motivation to invest mental effort into completing the task, hence, leading to different interpretations (Van Gog & Paas 2008; Paas et al., 2005). The same subjective rating scale for perceived task difficulty can be used as was used for perceived mental effort (see Figure 2.8), except mental effort is replaced with task difficulty.

DeLeeuw and Mayer (2008) conducted research with low prior knowledge participants learning from a multimedia lesson on electric motors. The participants rated their mental effort and response time to a visual mooting task and rated the task difficulty at the conclusion of the lesson. The results showed that the mental effort ratings were "most sensitive to manipulations of intrinsic processing" and the difficulty ratings were "most sensitive to differences related to germane processing" (DeLeeuw & Mayer 2008, p. 233). This current research measured the perceived task difficulty rated by participants after each task during the learning phase and test phase.

In considering process oriented and product oriented worked examples (see Section 2.3.5.2), higher perceived cognitive load and higher perceived task difficulty experienced by novice participants engaging with process oriented worked examples may be caused by the intrinsic load imposed by the additional material provided with process worked examples. The additional information contained in the principled knowledge as well as the participants' low prior knowledge may inhibit their schema development (Kalyuga, Ayres, Chandler & Sweller, 2003).

2.6.3 Instructional Efficiency

Paas and van Merriënboer (1993) developed the Instructional Efficiency measure, which calculates the relative efficiency of instructional conditions in terms of learning outcomes which combine standardised mental effort and performance scores. This is significant as it provides information into the advantages of particular instructional designs, tasks and subject parameters (Paas & van Merriënboer, 1993). Paas and van Merriënboer (1993) argue that well-designed training materials may increase instructional efficiency, resulting in fewer cognitive resources being required for similar tasks after the training.

The Instructional Efficiency scores are displayed on a number plane and the efficiency is calculated by finding the perpendicular distance to the line that is assumed to represent an efficiency of zero, when the standardised mental effort and performance scores are equal. The Instructional Efficiency is then calculated using the formula:

Instructional Efficiency = $\frac{zP - zM}{\sqrt{2}}$

Where zP = Mean of standardised performance scores and zM = Mean of standardised mental effort scores.

Figure 2.9 provides a representation of the Instructional Efficiency comparing conventional (CONV), worked out (WORK) and completion (COMP) training conditions in research conducted by Paas and van Merriënboer (1993);

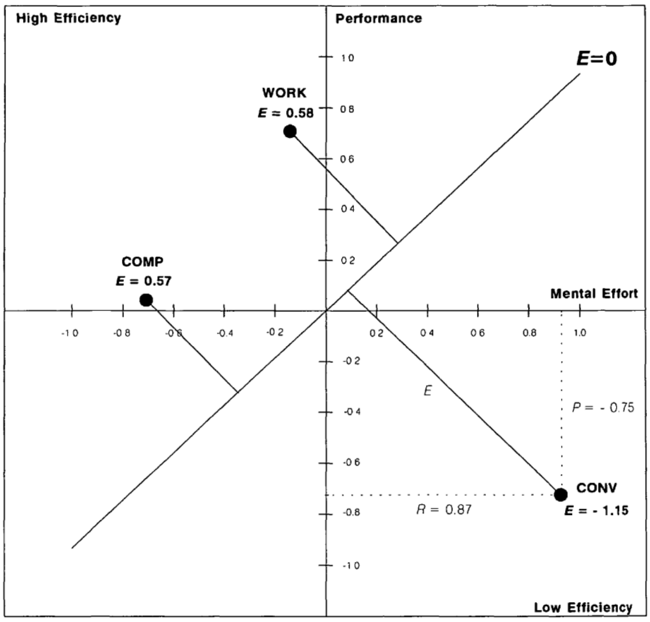

Figure 2.9: Representation of Instructional Efficiency of instructional conditions (Paas & van Merriënboer, 1993).

Instructional Efficiency can be used to compare the effects of different instructional conditions on learning (Paas & van Merriënboer, 1993). The combination of a high test performance score and a low mental effort rated by participants would indicate high instructional efficiency. Conversely, a combination of a low test performance and a high mental effort rated by participants would indicate low instruction efficiency. In the current research, the calculation of the Instructional Efficiency during Experiment 1 enabled further investigation into the impact of the instructional conditions: process oriented worked examples, product oriented worked examples and conventional problem solving, on learning (Paas & van Merriënboer, 1993).

2.7 WORKED EXAMPLES IN ILL-STRUCTURED LEARNING DOMAINS VERSUS WELL-STRUCTURED LEARNING DOMAINS

Much of CLT research that has been undertaken to examine worked examples has been in well-structured learning domains (Sweller et al., 2011). This section will define well-structured and ill-structured learning domains and is followed by an overview of research on the use of worked examples in an ill-structured learning domain, which is pertinent to the current research.

A well-structured learning domain is defined as a content specific domain that includes problems that "are considered well-defined because the given state, goal-state, and problem-solving operators are clearly specified" (Kyun et al., 2013, p. 386). An example of a well-defined problem is solving an algebraic equation. In this example, the problem states and required problem solving operators can be clearly identified. Kyun et al. (2013) state that "mathematics, science, and related technical domains are classified as well-defined" (Kyun et al., 2013, p.386). In contrast, problems in ill-structured learning domains do not have clearly specified problem states or problem-solving operators, and can have multiple goals and paths to solution (Simon, 1973; Yeong, 2021). Kyun et al. (2013, p. 386) add that in ill-defined problems the "goal state is specified to an even lesser extent" and "problem solving operators are unspecified". Yeong (2021, p. 139) adds that the use of "contextualised, open-ended problems" were more evident with ill-structured problems compared to well-structured problems. Kyun et al. (2013, p. 386) state that "literature, history, social studies, and related nontechnical domains are classified as ill-defined". Sweller et al. (2011, p. 102) provided the following as an example of an ill-defined problem, " 'Discuss the meaning of this passage' this provides an example of an ill-structured problem". Following is a discussion of key findings from recent research on worked examples in ill-structured learning domains.

Rourke and Sweller (2009) conducted research in an ill-structured learning domain that required students to "learn the characteristics needed to identify a designer's work" (Rourke & Sweller, 2009, p. 185) by either studying worked examples or completing problem-solving tasks. The results demonstrated that the use of worked examples was more effective than completing problem solving tasks. Another example of a research conducted in an ill-structured learning domain involved secondary students being presented with extracts from Shakespearean text, with one group being given explanatory notes, a form of worked example (Oksa et al., 2010). The results showed that the group of students with the explanatory notes performed better on the tasks and experienced lower cognitive load than the group of students without the notes.

Nievelstein, van Gog et al. (2013) conducted research with novice and more advanced students in the context of learning to reason about legal cases, an ill-structured learning domain. The results showed that both novice and more advanced students benefitted more from the use of worked examples than from problem solving. In this case, no expertise reversal effect was evident. The absence of the expertise reversal effect may indicate that expert learners benefit from the use of worked examples in an ill-structured learning domain (Sentz & Stefaniak, 2018).

Kyun et al. (2013) conducted research in the ill-structured learning domain of English literature. Korean university students were streamed into three groups of students, with the students in Group 1 most knowledgeable and students in Group 3 least knowledgeable. During the learning phase, half the students were presented with conventional essay questions and the other half were presented with the same questions accompanied by model answers, that is, worked examples. Tests were then administered to all students. Findings showed that the effectiveness of worked examples was greater for the students with less knowledge, hence, indicating the presence of the expertise reversal effect for the more knowledgeable students.

The above summarises the overall limited research investigating different types of worked examples in ill-structured learning domains. The research discussed in previous sections, including mathematics, physics and microeconomics, were conducted in well-structured learning domains. Clearly, further research is needed to understand the efficacy of different types of worked examples in an ill-structured learning domain with different learners. The current research investigated what type of worked examples, process oriented or product oriented, best supported participants learning and applying the characteristics of substantive communication, an ill-structured learning domain. Experiment 1 investigated the test performance scores, perceived mental effort and perceived task difficulty ratings of novice participants. Additionally, Study 2 investigated the thought processes of novice and expert participants engaging within the instructional conditions.

2.8 THE NEW SOUTH WALES QUALITY TEACHING MODEL

The following section provides an overview of the New South Wales Quality Teaching Model (NSW QTM). Participants in this research, novice pre-service teachers and expert practicing teachers, learned about the Dimensions and elements of the NSW QTM, with a particular focus on the element of substantive communication. Learning about substantive communication is considered as ill-structured as learning about the characteristics of substantive communication does not have clearly specified problem states or problem-solving operators. This current research investigates the efficacy of process oriented and product oriented worked examples within an ill-structured learning domain.

2.8.1 Introduction to the New South Wales Quality Teaching Model

The NSW QTM describes the major elements of what constitutes quality classroom practice. The NSW QTM, a framework that was developed based on research conducted in classrooms, provides a common language enabling school leaders and teachers to reflect on and evaluate teaching practices with the aim of improving student learning outcomes (NSW DET, 2008).

The NSW QTM is divided into three Dimensions and eighteen elements. The Dimensions are Intellectual Quality, Quality Learning Environment and Significance. The three Dimensions are observable in classrooms and "evidence for them can be found in written tasks (text) given to students for assessment or learning purposes" (Ladwig 2005, p. 75). Each Dimension can be observed in classrooms through six elements. Table 2.1 includes the three Dimensions and eighteen related elements:

Table 2.1

The Dimensions and elements of the New South Wales Quality Teaching Model

Intellectual Quality	**Quality Learning Environment**	**Significance**
Deep Knowledge	Explicit Quality Criteria	Background Knowledge
Deep Understanding	Engagement	Cultural Knowledge
Problematic Knowledge	High Expectations	Knowledge Integration
Higher Order Thinking	Social Support	Inclusivity
Metalanguages	Students' Self-regulation	Connectedness
Substantive Communication	Student Direction	Narrative

Table 2.2 includes the definitions for the Dimensions of Intellectual Quality, Quality Learning Environment and Significance as included in *Quality teaching in NSW public schools : a classroom practice guide* (NSW DET 2006, p. 10).

Table 2.2

*Definitions of the NSW QTM Dimensions (*NSW DET 2006, p. 10)

Definitions of the NSW QTM Dimensions (NSW DET 2006, p. 10)	
Intellectual Quality	"Refers to the pedagogy focused on producing deep understanding of important, substantive concepts, skills and ideas. Such pedagogy treats knowledge as something that requires construction and requires students to engage in higher-order thinking and to communicate substantively about what they are learning."
Quality Learning Environment	"Refers to pedagogy that creates classrooms where students and teachers work productively in an environment clearly focused on learning. Such pedagogy sets high sand explicit expectations and develops positive relationships between teachers and students and among students."
Significance	"Refers to pedagogy that helps make learning more meaningful and important to students. Such pedagogy draws clear connections with students' prior knowledge and identities, with contexts outside of the classroom, and with multiple ways of knowing or cultural perspectives."

The current research focused on the element of substantive communication within the Intellectual Quality Dimension.

2.8.2 Coding Elements

Dr James Ladwig and Professor Jennifer Gore from the University of Newcastle, in collaboration with the New South Wales Department of Education and Training developed *Quality teaching in NSW public schools: a classroom practice guide* (NSW DET, 2006*).* The guide was developed to support schools implement the NSW QTM, a framework to improve pedagogical practices. The guide includes a definition for each Dimension and information on each of the eighteen elements included in the NSW QTM.

The guide includes the Coding Scale for each of the eighteen elements. The Coding Scale includes five descriptors, represented as a code or score, which draws "upon observable aspects of classroom practice" (NSW DET 2006, p. 6). Due to focusing on observable aspects of the classroom, the five descriptors focus on "*none, some, most,* and *all of the students*, or none of the time, through to all of the time" (NSW DET 2006, p. 6). The purpose of the Coding Scale is to promote professional learning, professional conversations and reflection to support teachers in pedagogical practices leading to improved student learning outcomes. Table 2.3 includes the Coding Scale for substantive communication which responds to the question "To what extent are students regularly engaged in sustained conversations (in oral, written or artistic forms) about the ideas and concepts they are encountering?" (NSW DET 2006, p. 22).

Table 2.3

*Coding Scale for Substantive Communication (*NSW DET 2006, p. 22)

Substantive Communication	
Coding Score	**Description**
1	Almost no substantive communication occurs during the lesson.
2	Substantive communication among students and/or between teacher and students occur briefly.
3	Substantive communication amongst students and/or between teacher and students occurs occasionally and involves at least two sustained interactions.
4	Substantive communication, with sustained interactions, occurs over approximately half the lesson with teacher and/or students scaffolding the conversation.
5	Substantive communication, with sustained interactions, occurs throughout the lesson, with teachers and/or students scaffolding the communication.

2.8.3 A Focus on Substantive Communication

The current research focused on the element of substantive communication. Learning to understand and apply the NSW QTM, specifically substantive communication does not involve specifying the various problem states and problem solving operators and does not involve providing a specific, pre-determined correct answer. Thus, learning about the NSW QTM element of substantive communication can be considered an ill-structured learning domain. Substantive communication was chosen as it is an important component of the NSW QTM as it stimulates thinking, engagement and discussions in the classroom to promote learning. Additionally, it was also chosen as understanding how substantive communication can be enacted within a classroom is complex for both novices and experts, thus ensuring the content was high in element interactivity. The complexity is due to understanding the three characteristics of substantive communication and needing to keep these in WM to make a decision on the level of substantive communication based on the five Coding Scale descriptions. Further, the complexity would be more profound for novices due to their low prior knowledge and lack of experience in teaching.

Classes with high levels of substantive communication, have the following three characteristics (NSW DET, 2006):

- There is sustained interaction.
- The communication is focused on the substance of the lesson.
- The interaction is reciprocal.

The first characteristic, sustained interaction, refers to communication that continues a flow of communication beyond a simple initiate-respond-evaluate (IRE) pattern (NSW DET, 2006). IRE refers to a student responding to a teacher's question and the teacher making an evaluative comment before moving on to another question or concept. The second characteristic, focusing on the substance of the lesson, refers to communication moving beyond the recount of facts and definitions and encourages critical reasoning (NSW DET, 2006). The third characteristic, reciprocal interaction, refers to communication that involves at least two participants and the direction of the communication is at least two-way in direction (NSW DET, 2006). Participants, novice pre-service teachers and expert practicing teachers, in this current research were presented with the Coding Scale for substantive communication to support them in understanding what substantial communication looks like in a classroom. Further, in Study 2 participants were asked how they may apply substantive communication in their pedagogical practice.

2.9 SUMMARY

In this chapter, a review of literature about Cognitive Load Theory (CLT) and the NSW QTM was presented. The chapter commenced with an overview of Human Cognitive Architecture, confirming that WM is the centre of human information processing and central for successful learning, but limited in capacity. In contrast, LTM is an unlimited store of knowledge and skills, organised into schemas. The ability to demonstrate understanding, hence expertise, involves the construction and automation of schemas. CLT has developed instructional design principles that support the reduction of load on WM with the aim to support learning; these include the worked example effect, the split attention effect and the redundancy effect. Investigations have shown that the use of worked examples in well-structured learning domains benefit novice learners and hinder expert learners, referred to as the expertise reversal effect. There has been less research involving the use of worked examples in an ill-structured learning domain. This current research investigated the use of worked examples in an ill-structured learning domain, the NSW QTM, with both novice and expert participants. The next chapter, Chapter 3, provides an overview of the research design for Experiment 1 and Study 2.

Chapter 3

OVERVIEW OF RESEARCH DESIGN

3.1 INTRODUCTION

This research investigated the efficacy of process oriented and product oriented worked examples in an ill-structured learning domain. The New South Wales Quality Teaching Model (NSW QTM) element of substantive communication represented the content to be learned in the ill-structured learning domain. This research comprised two studies – Experiment 1 and Study 2. Experiment 1 used a quantitative approach to investigate the effectiveness of process oriented and product oriented worked examples for pre-service teachers (novices) learning about the characteristics of substantive communication. Study 2 built on the findings of Experiment 1 by using a qualitative approach to investigate the thought processes of pre-service teachers (novices) and practicing teachers (experts) learning about the characteristics of substantive communication using process oriented and product oriented worked examples. This chapter provides an overview of Experiment 1 and Study 2 conducted in this research. The following four chapters present Experiment 1 (Chapter 4) and Study 2 (Chapters 5, 6 and 7).

3.2 RESEARCH AIMS

The theoretical framework that underpins this current research is Cognitive Load Theory (CLT) which argues that working memory (WM) has a limited capacity, and for optimal learning to occur WM resources need to be optimized (Clark et al., 2006; Eysenck & Clavo, 1992; Paas et al., 2003). Based on this premise, CLT has informed the design of instructions to reduce load on limited WM to ensure efficient use of WM to enhance learning, that is, schema construction and automation of schemas (Sweller et al., 2011; Sweller et al., 2019). Reducing load on limited WM by optimising instructional design is of particular importance when a learner is a novice and the information to be learnt is complex (Kalyuga, 2007). Worked examples have been shown to reduce extraneous load by focusing on problem states and steps to solutions and thus have been found to be beneficial for novice learners (Cooper & Sweller, 1987; Plass et al., 2010). In particular, the use of process oriented worked examples, which include both the solution steps (strategic information) and the rationale of the steps (principled knowledge), support novice learners in well-structured learning domains (Van Gog et al., 2004, 2008). The overall goal of the research was to address the research gap by investigating the efficacy of process oriented and product oriented worked examples within an ill-structured learning domain. Experiment 1 and Study 2, investigated which instructional condition; process oriented worked examples (Process condition), product oriented worked examples (Product condition) or conventional problem solving (Control condition), supported participants best in identifying and applying knowledge of the New South Wales Quality Teaching Model element of substantive communication.

The aim of Experiment 1 was three-fold:

1. To investigate participants' test performance scores for the three instructional conditions.
2. To investigate participants' perceived cognitive load for the three instructional conditions.
3. To investigate participants' perceived task difficulty for the three instructional conditions.

The aim of Study 2 was to investigate:

1. How experts and novices engaged with the three instructional conditions.
2. How experts and novices made meaning from the three instructional conditions.

3.3 RESEARCH QUESTIONS AND RELATED HYPOTHESES

Four research questions and associated hypotheses further guided this current research. Research Question 1, which focused on performance scores, had two accompanying hypotheses:

Research Question 1: When learning about the characteristics of substantive communication, do participants presented with process oriented worked examples achieve higher test performance scores during the *test phase* than participants presented with product oriented worked examples, and do participants presented with product oriented worked examples achieve higher test performance scores during the *test phase* than participants engaging in conventional problem solving?

Hypothesis 1

When learning about the characteristics of substantive communication, participants presented with the process oriented worked example instructional condition (hereafter referred to as 'Process condition') will achieve higher test performance scores during the *test phase* than participants presented with the product oriented worked example instructional condition (hereafter referred to as 'Product condition').

The above hypothesis is informed by research findings showing process oriented worked example provide participants with the principled knowledge (why) and strategic information (how) to support problem solving (Ohlsson & Rees, 1991, Van Gog et al., 2008). The background to this hypothesis is provided in Section 2.3.5.2.

A summary statement for Hypothesis 1 is as follows:
H1: Test performance scores: Process condition > Product condition

Hypothesis 2

When learning about the characteristics of substantive communication, participants presented with the Product condition will achieve higher test performance scores during the *test phase* than learners presented with the conventional problem solving condition (hereafter referred to as 'Control condition').

A summary statement for Hypothesis 2 is as follows:
H2: Test performance scores: Product condition > Control condition

The above hypothesis is informed by research findings showing product oriented worked example provide participants with the strategic information (how) to assist in solving the problems during the test phase (Ohlsson & Rees, 1991, Van Gog et al., 2008). The background to this hypothesis is provided in Section 2.3.5.2.

Research Question 2 which focused on perceived mental effort and perceived task difficulty ratings during the learning phase, had two accompanying hypotheses:

Research Question 2: When learning about the characteristics of substantive communication, do participants presented with the Process condition or Control condition, report higher perceived cognitive load and higher perceived task difficulty during the *learning phase* than participants presented with the Product condition during the *learning phase*?

Hypothesis 3

When learning about the characteristics of substantive communication, participants presented during the *learning phase with* the Process condition or Control condition, will report higher perceived cognitive load than participants presented with the Product condition.

A summary statement for Hypothesis 3 is as follows:
H3: Mental effort (Learning phase): Process condition or Control condition > Product condition

Hypothesis 4

When learning about the characteristics of substantive communication, participants presented during the *learning phase* with the Process condition or Control condition, will report higher perceived task difficulty than participants presented with the Product condition.

A summary statement for Hypothesis 4 is as follows:
H4: Task difficulty (Learning phase): Process condition or Control condition > Product condition

The above hypotheses are informed by research findings showing when comparing process oriented and product oriented worked examples, the higher perceived cognitive load and higher perceived task difficulty reported by the Process condition may be caused by the intrinsic load imposed by the additional material provided within process oriented worked examples. The additional information as well as the participants low prior knowledge may have inhibited their schema development (Kalyuga et al., 2003). The background to this hypothesis is provided in Section 2.3.5.2, Section 2.6.1 and Section 2.6.2.

In comparing the Control condition and Product condition, the higher perceived cognitive load and higher perceived task difficulty reported by the Control condition may be caused by the lack of information provided during the Control condition for the participant to support the development of appropriate schemas. Conventional problem solving requires the participant to adopt a means-ends problem solving strategy which has been shown to lead to a higher perceived cognitive load being experienced (see Section 2.3.5 for background information on a means-ends problem solving strategy). Whereas the worked examples provide a scaffold for the participant to search and match information to make meaning (Chandler & Sweller, 1991).

Research Question 3 which focused on perceived mental effort and perceived task difficulty ratings during the test phase, had two accompanying hypotheses:

Research Question 3: When learning about the characteristics of substantive communication, do participants presented with the Process condition report lower perceived cognitive load and lower perceived task difficulty during the *test phase* than participants presented with the Product condition?

Hypothesis 5

When learning about the characteristics of substantive communication, participants presented with the Process condition will report lower perceived cognitive load during the *test phase* than participants presented with the Product condition.

A summary statement for Hypothesis 5 is as follows:
H5: Mental effort (Test phase): Process condition < Product condition

Hypothesis 6

When learning about the characteristics of substantive communication, participants presented with the Process condition will report lower perceived task difficulty during the *test phase* than participants presented with the Product condition.

A summary statement for Hypothesis 6 is as follows:

H6: Task difficulty (Test phase): Process condition < Product condition

Hypothesis 5 is informed by research findings showing that the lower perceived mental effort rating for the Process condition in the test phase may be due to better schemata acquired or rules automated during the learning phase for participants (Paas, 1992). The background to this hypothesis is provided in Section 2.3.5.2, Section 2.6.1 and Section 2.6.2, including research by Kalyuga et al. (2001) and van Gog et al. (2008) in Section 2.3.5.2. In considering perceived task difficulty, the researcher has hypothesized similar outcomes for both Hypothesis 5 and Hypothesis 6.

Research Question 4 which also focused on perceived mental effort and perceived task difficulty ratings during the test phase, had two accompanying hypotheses:

Research Question 4: When learning about the characteristics of substantive communication, do participants presented with the Process condition or Product condition report lower perceived cognitive load and lower perceived task difficulty during the *test phase* than participants presented with the Control condition?

Hypothesis 7

When learning about the characteristics of substantive communication, participants presented with the Process condition or Product condition will report lower perceived cognitive load during the *test phase* than participants presented with the Control condition.

A summary statement for Hypothesis 7 is as follows:

H7: Mental effort (Test phase): Process condition or Product condition < Control condition

Hypothesis 8

When learning about the characteristics of substantive communication, participants presented with the Process condition or Product condition will report lower perceived task difficulty during the *test phase* than participants presented with the Control condition.

A summary statement for Hypothesis 8 is as follows:
H8: Task difficulty (Test phase): Process condition or Product condition < Control condition

Hypothesis 7 is informed by research findings showing that the lower perceived mental effort rating during the test phase may be due to the extra information that is provided with both process and product oriented worked examples that participants can then apply during the test phase compared to conventional problem solving. This may be due to better schemata acquired or rules automated during the test phase for participants presented with worked examples (Paas, 1992). The background to this hypothesis is provided in Section 2.3.5.2, Section 2.6.1 and Section 2.6.2. In considering perceived task difficulty, the researcher has hypothesized similar outcomes for both Hypothesis 7 and Hypothesis 8.

The following two exploratory questions guided Study 2:

Research Question 1: When learning about the characteristics of substantive communication, how do novice and expert participants engage with and make meaning from the three different instructional conditions; Process condition, Product condition or Control condition within an ill-structured learning domain?

Research Question 2: When learning about the characteristics of substantive communication, how do novice and expert participants who have engaged with one instructional condition perceive the other two instructional conditions?

3.4 OVERVIEW OF EXPERIMENT 1 AND STUDY 2

Experiment 1 and Study 2 investigated what worked examples best supported participants learning and applying the characteristics of substantive communication. Experiment 1 used a quantitative research approach to investigate the effectiveness of process oriented and product oriented worked examples for pre-service teachers (novices) learning about the characteristics of substantive communication. Experiment 1 was conducted in three phases:

- Introductory Phase.
- Learning Phase.
- Test Phase.

During both the learning phase and test phase, participants were asked to rate their perceived mental effort and perceived task difficulty. Following this, participants completed an evaluation of their experience, evaluating whether they enjoyed learning in their allocated instructional condition and if they found this type of instruction engaging.

Study 2 built on the findings of Experiment 1 by using a small-scale qualitative approach to investigate the thought processes of pre-service teachers (novices) and practicing teachers (experts) learning about the characteristics of substantive communication using process oriented and product oriented worked examples. The commentary provided by the participants in Study 2 was used to further investigate the pattern of quantitative results collected in Experiment 1. Study 2 was conducted in three phases:

- Phase 1: Participants engaged with one instructional condition similar as in Experiment 1.
- Phase 2: Participants were introduced to the other two instructional conditions.
- Phase 3: Participants were asked to share their perceptions of how they could use worked examples in their own teaching.

3.4.1 Data Collection

Experiment 1 used a between-subjects design to examine test performance scores, perceived cognitive load and perceived task difficulty ratings of participants when learning about and completing NSW QTM substantive communication tasks. A one-way ANOVA (Analysis of Variance) between instructional conditions was conducted for each of the dependent variables.

The independent variable was:

1. Instructional Design Condition: The use of process oriented worked examples, product oriented worked examples or conventional problem solving.

The dependent variables were as follows:

1. Performance on test items.
2. Reported perceived cognitive load.
3. Reported perceived task difficulty.

Table 3.1 provides a summary of the data collected and instruments used in Experiment 1 and Study 2.

Table 3.1

Data collected and instrument used

Variable	Instrument
Test Performance Scores	Scores on three test items administered during the Test Phase.
Perceived Mental Effort	Cognitive Load Subjective Rating Scale (Paas, 1992).
Perceived Task Difficulty	Task Difficulty Subjective Rating Scale (Schmeck et al., 2014).
Instructional Efficiency	Performance scores and perceived mental effort ratings used to calculate the Instructional Efficiency using the formula: Instructional Efficiency = $\frac{zP - zM}{\sqrt{2}}$ (Paas & Van Merriënboer, 1993).

In Study 2, the researcher collected quantitative data as per Experiment 1, and conducted interviews with the participants to collect qualitative data, which was audio recorded and transcribed. The qualitative data was collected to understand participants' perceptions and engagement with the three instructional conditions in the way they made meaning from each instructional condition. The qualitative data was the main data source for Study 2 and the descriptive statistics were calculated to provide possible insight into the qualitative data. The descriptive data included the mean of test performance scores, perceived mental effort ratings and perceived task difficulty ratings. Due to the small sample size, the collected descriptive data represented non-statistically significant results and was presented to solely show trends in the data and accompany the qualitative data collected for Study 2.

3.4.2 Data Analysis

Experiment 1 used a between-subjects design to examine test performance scores, perceived mental effort ratings and perceived task difficulty ratings of participants when learning about and completing NSW QTM substantive communication tasks. A one-way ANOVA, between instructional conditions was conducted for each of the dependent variables in Experiment 1 (see Section 3.4.1 for dependent variables). Further analysis of data by means of Cohen's *d* test was performed and the Instructional Efficiency was calculated to compare the effects of the three instructional conditions on learning (van Gog & Paas, 2008).

In Study 2, the researcher conducted qualitative coding to enable the identification of different themes and the relationships between themes (Medelyan, 2020) to understand how the participants engaged with and made meaning from the three different instructional conditions. The researcher initially read through the transcripts several times to familiarise himself with the data (Nowell et al., 2017). Following this, the researcher coded the transcripts line by line and developed a series of codes (Nowell et al., 2017; Yi, 2018). Similar codes were then categorised allowing the researcher to identify overarching and consistent themes (Nowell et al., 2017; Yi, 2018). The themes, extrapolated from participant transcribed responses, provided an understanding of how novice and expert participants engaged with and made meaning from the three different instructional conditions. In addition, what participants reported verbally was coded by the researcher to identify key words to encapsulate each participant's thinking process and learning approaches they adopted to make meaning. These were then listed from highest to lowest cognitive order using Bloom's Taxonomy (Stanny, 2016) to enable the researcher to determine how the participants' prior knowledge and instructional condition influenced how they engaged and made meaning. The following chapters provide further details of the methodology and instructional materials used, data analysis and the key findings for Experiment 1 and Study 2.

Chapter 4

EXPERIMENT 1

4.1 INTRODUCTION

In Experiment 1 a quantitative research experimental design was used to investigate the effectiveness of process oriented and product oriented worked examples for pre-service teachers (novices) learning about the characteristics of substantive communication within an ill-structured learning domain. Worked examples provide step-by-step solutions to problems (Sweller et al., 2011, p. 99) by modelling to learners how to perform a particular skill or task (Clark et al., 2006). Studying worked examples has shown to reduce ineffective cognitive load and support learning compared to solving the equivalent problems by conventional methods (Paas et al., 2003a). Chapter 2 literature review presented two types of worked examples that can support learning:

- process oriented worked examples, which provide statements explaining each of the steps towards solution
- product oriented worked examples, that provide step-by-step solutions without the supporting explanations of each of the steps (Sweller et al., 1998, 2019).

For further information on the worked examples and their effectiveness please see section 2.3.5.

Experiment 1 focused on the use of process oriented and product oriented worked examples, with the aim to understand which type of worked example supported novice learners' understanding within an ill-structured learning domain. Process oriented and product oriented worked examples have been predominantly researched in well-structured learning domains such as Mathematics, Science and Economics (Sweller et al., 2011). While there has been extensive research demonstrating the effectiveness of worked examples in well-structured content domains (Atkinson et al., 2000; Renkl, 2005), less research has been conducted on worked examples' effectiveness in ill-structured content domain. Experiment 1 aimed to address this research gap by investigating the effectiveness of process oriented and product oriented worked examples within an ill-structured learning domain (Section 2.3.5.2

of the literature review chapter provides examples of research studies involving the use of process oriented and product oriented worked examples).

Worked examples have shown to be more effective with novice learners than conventional problem solving. Conventional problem solving using means-ends analysis (see Section 2.3.5), is a cognitive consuming problem-solving strategy which involves reducing the "differences between the current state and the goal state by applying legal operators (e.g., equations) until the goal state is achieved" (Trumpower et al., 2004, p. 1380). This approach "requires problem solvers to process a large number of interacting elements" (Sweller et al., 2011, p. 100), which can increase the level of extraneous load, limit schema acquisition, automation and impact learning. The instructional content used in Experiment 1 was based on the New South Wales Quality Teaching Model (NSW QTM), a framework through which quality teaching practices can be evaluated. Specifically, the element of substantive communication was chosen as it is an important component of the NSW QTM, it aims to stimulate thinking, engagement and discussions in classrooms to promote learning. Additionally, substantive communication was chosen as understanding how it can be enacted within a classroom is complex for novice teachers, thus ensuring the content was high in element interactivity. Learning to understand and apply the NSW QTM, specifically substantive communication does not involve specifying the various problem states and problem solving operators and does not involve providing a specific, pre-determined correct answer, thus is considered an ill-structured learning domain (see Section 2.8.3).

The aim of Experiment 1 was three-fold:

1. To investigate participants' test performance scores for the three instructional conditions.
2. To investigate participants' perceived cognitive load for the three instructional conditions.
3. To investigate participants' perceived task difficulty for the three instructional conditions.

The four research questions and associated hypotheses for Experiment 1 were:

Research Question 1: When learning about the characteristics of substantive communication, do participants presented with the Process condition achieve higher test performance scores during the *test phase* than participants presented with the Product condition, and do participants presented with the Product condition achieve higher test performance scores during the *test phase* than participants presented with the Control condition?

Hypothesis 1

When learning about the characteristics of substantive communication, participants presented with the Process condition will achieve higher test performance scores during the *test phase* than participants presented with the Product condition.

Hypothesis 2

When learning about the characteristics of substantive communication, participants presented with the Product condition will achieve higher test performance scores during the *test phase* than learners presented with the Control condition.

Research Question 2: When learning about the characteristics of substantive communication, do participants presented with the Process condition or Control condition, report higher perceived cognitive load and higher perceived task difficulty during the *learning phase* than participants presented with the Product condition during the learning phase?

Hypothesis 3

When learning about the characteristics of substantive communication, participants presented during the *learning phase* with the Process condition or Control condition, will report higher perceived cognitive load than participants presented with the Product condition.

Hypothesis 4

When learning about the characteristics of substantive communication, participants presented during the *learning phase* with the Process condition or Control condition, will report higher perceived task difficulty than participants presented with the Product condition.

Research Question 3: When learning about the characteristics of substantive communication, do participants presented with the Process condition report lower perceived cognitive load and lower perceived task difficulty during the *test phase* than participants presented with the Product condition?

Hypothesis 5

When learning about the characteristics of substantive communication, participants presented with the Process condition will report lower perceived cognitive load during the *test phase* than participants presented with the Product condition.

Hypothesis 6

When learning about the characteristics of substantive communication, participants presented with the Process condition will report lower perceived task difficulty during the *test phase* than participants presented with the Product condition.

Research Question 4: When learning about the characteristics of substantive communication, do participants presented with the Process condition or Product condition report lower perceived cognitive load and lower perceived task difficulty during the *test phase* than participants presented with the Control condition?

Hypothesis 7

When learning about the characteristics of substantive communication, participants presented with the Process condition or Product condition will report lower perceived cognitive load during the *test phase* than participants presented with the Control condition.

Hypothesis 8

When learning about the characteristics of substantive communication, participants presented with the Process condition or Product condition will report lower perceived task difficulty during the *test phase* than participants presented with the Control condition.

4.2 METHODOLOGY

4.2.1 Research Design

This experiment used a between-subjects design to examine test performance scores, perceived cognitive load and perceived task difficulty ratings of participants when learning about and completing NSW QTM substantive communication tasks. A one-way ANOVA (Analysis of Variance), between instructional conditions was conducted for each of the dependent variables.

The independent variable was the instructional design condition, that is, the Process condition, Product condition or Control condition.

The dependent variables were as follows:

1. Performance on test items.
2. Reported perceived cognitive load measured by the Cognitive Load Subjective Rating Scale (Paas, 1992).
3. Reported perceived task difficulty measured by the Task Difficulty Subjective Rating Scale (Schmeck et al., 2014).

The Cognitive Load Subjective Rating Scale, is a nine-point subjective rating scale (Paas, 1992). The scale measures participants' perceived exerted mental effort (See Section 2.6.1). This instrument has been shown to be valid and reliable in the measurement of cognitive load (Paas, 1992). The Task Difficulty Subjective Rating Scale is also a nine-point subjective rating scale (See Section 2.6.2). This scale measures the participant's perceived task difficulty in completing a task (Marcus et al., 1996). While the perceived task difficulty and perceived mental effort may correlate, they are different constructs (Schmeck et al., 2015). Mental effort is defined "as the total amount of controlled cognitive processing in which a subject is engaged" (Paas & Van Merriënboer, 1993, p. 738) and is described as "how hard I tried" (Hsu et al., 2019, p. 1). Perceived task difficulty relates predominantly to the task completed (Van Gog & Paas, 2008) and is described as "how difficult the task is" (Hsu et al., 2019, p. 1). During the experiment, participants were asked to rate their perceived mental effort and perceived task difficulty after each task during the learning phase and during the test phase.

Approval to conduct Experiment 1 was received from the Human Research Ethics Committee at the University of Wollongong (Appendix A) to conduct the experiment in 2016. A letter of information (Appendix B) was provided to participants with information on the purpose, description and procedures of the experiment. Each participant signed a consent form (Appendix C).

4.2.2 Participants

Participants were pre-service teachers enrolled in either their first year of a two-year post-graduate Masters of Teaching programme (this program offers both primary or secondary school focus) or their final year of a four-year Bachelor of Primary Education programme at an Australian regional university. As pre-service teachers are training to become teachers, their understanding and application of the NSW QTM and substantive communication was limited. Due to the limited knowledge of the NSW QTM and substantive communication and limited experience of classroom teaching, the Master of Teaching participants and fourth-year Bachelor of Primary Education participants were both considered to be novices.

4.2.2.1 Master of Teaching Participants

For the first year Master of Teaching participants, the experiment was conducted during the tutorial time for the introductory subject titled "What is Teaching?", over a three-week period during Semester One, 2016. The tutorial groups were a mix of male and female and primary and secondary Master of Teaching students. The experiment was conducted in the students' usual tutorial room, which provided a quiet and appropriate place to conduct the experiment. Due to the nature of the experimental design where each condition had a modified video aligned with the nature of the instructional condition (explained in section 4.2.3), the researcher, with advice from supervisors, randomly assigned an instructional condition to a tutorial group, as each tutorial had a mix of male and female and primary and secondary Master of Teaching students. The first tutorial group was presented with the Process condition, the second tutorial group was presented with the Product condition and the third tutorial group was presented with the Control condition. There were 55 Master of Teaching participants (18 male and 37 female) aged 21 years to 51 years. Twenty-seven of these participants were presented with the Process condition, 18 were presented with the Product condition and 10 were presented with the Control condition. There was a large difference in the number of participants between the two worked example instructional conditions and the conventional problem-solving condition due to the lack of number of students available for the latter instructional condition due to the later tutorial time and lower class tutorial numbers.

4.2.2.2 Bachelor of Primary Education Participants

For the 4th year Bachelor of Primary Education undergraduate pre-service teachers, the experiment was conducted in the final semester of their university course in 2016, during a full-day workshop organised by the head lecturer. The instructional materials and procedure for this experiment were exactly the same as the experiment conducted earlier in the year with the Master of Teaching participants. The participants were involved in a full day seminar for their Bachelor of Primary Education programme and the head lecturer assisted this research by randomly forming three groups of students, including both males and females, to participate in Experiment 1. The randomly formed groups coincided with the activities that were organised by the head lecturer for the full-day workshop. The full-day workshop required participants to attend two sessions organised by the head lecturer and one session to participate in Experiment 1. The first group of participants were presented with the Process condition, the second group of participants were presented with the Product condition and the third group of participants were presented with the Control condition. As with the Master of Teaching participants, this was organised so that each experimental group had a mix of male and female participants, and each group was randomly allocated to an instructional condition. There were thirty 4th Year Bachelor of Primary Education undergraduate participants (13 male and 17 female) aged 22 years to 38 years. Thirteen of these participants were presented with the Process condition, fourteen were presented with the Product condition and three were presented with the Control condition. The lower number of participants for the Control condition was due to that instructional condition being the final session conducted during the afternoon. Table 4.1 shows the range of ages and the total number of male and female participants for each of the instructional conditions.

Table 4.1

Range of ages and number of male and female participants for the three instructional conditions

Range of Ages and Number of Male and Female Participants					
Instructional Condition	Range of Ages (years)	Males	Females	Total	Total of Master of Teaching / Bachelor of Primary Education participants
Process Condition	21 - 26	11	29	40	27 / 13
Product Condition	22 - 47	15	17	32	18 / 14
Control Condition	21 - 51	5	8	13	10 / 3

4.2.3 Instructional Materials

The experimental materials were developed by the researcher in consultation with PhD supervisors, international expert CLT researchers and three Education Officers from a regional Catholic Education Diocese. Further advice from CLT experts was obtained during presentations of the details of the experiment at the International Cognitive

Load Theory Conferences in the United States of America in 2015 (Sozio et al., 2015), Germany in 2016 (Sozio et al., 2016) and Australia in 2017 (Sozio et al., 2017).

Participants were presented with one of three instructional conditions:

1. Process condition.
2. Product condition.
3. Control condition.

The process oriented and product oriented worked examples used in Experiment 1 included online video recordings of lessons being taught, annotations on the video recordings and hard copy documents. The participants in the Control condition were provided with practice problems to solve without any support or guidance during the practice activity. Experiment 1 consisted of three phases:

- Introductory Phase (Phase 1),
- Learning Phase (Phase 2) and
- Test Phase (Phase 3).

Figure 4.1 below provides an overview of the Experiment 1 procedure. The section following Figure 4.1 describes the instructional materials used during the three phases. This is followed by specific details explaining the three phases in Section 4.2.4.

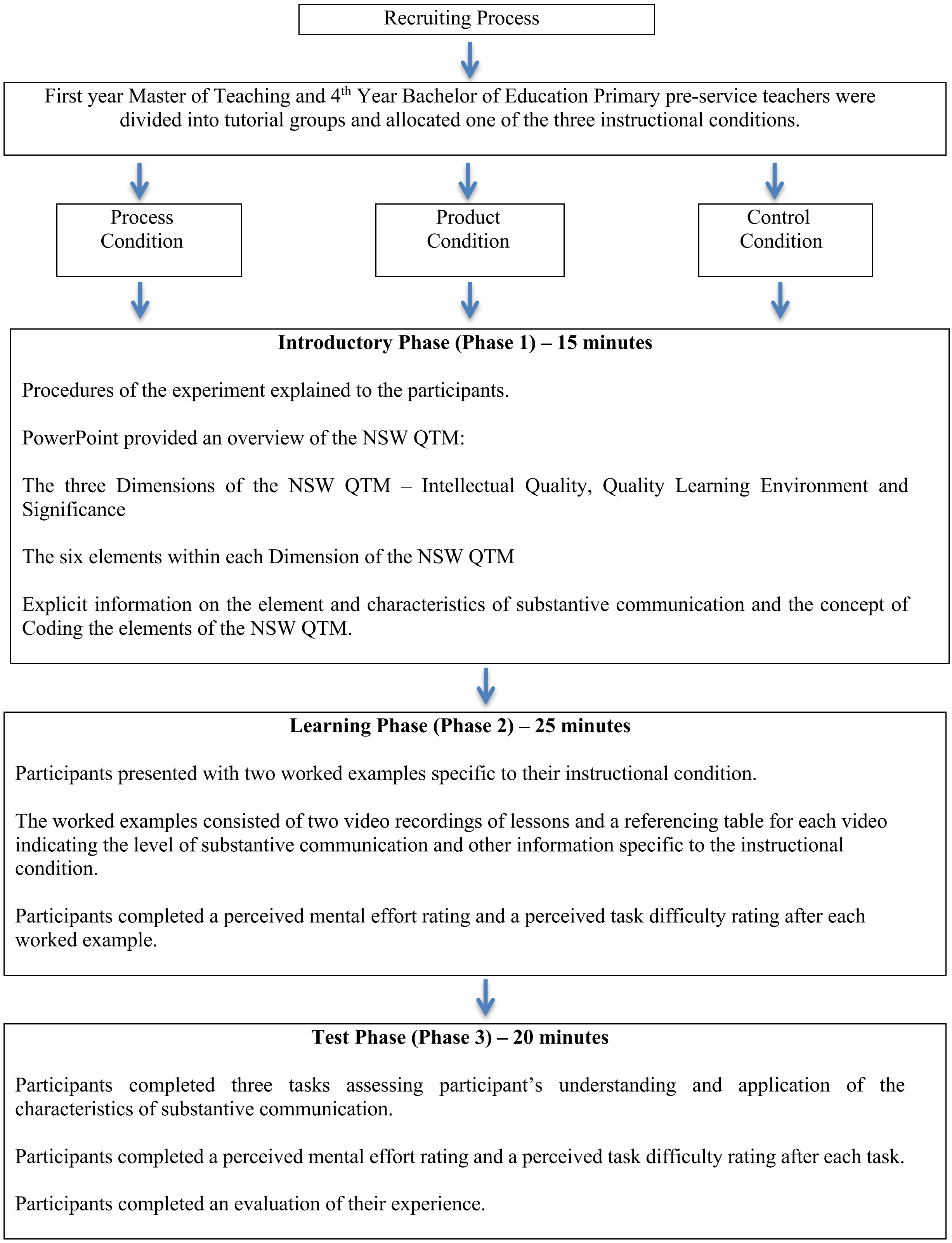

Figure 4.1. Experiment 1 procedure.

4.2.3.1 Phase 1 - PowerPoint Presentation During: Introductory Phase

During the introductory phase (Phase 1), participants in each instructional condition were presented with a sixteen slide PowerPoint presentation that provided a general introduction to the NSW QTM and more detailed information about the characteristics of substantive communication (Appendix D). The first slide was a title slide with the heading "The NSW Quality Teaching Model" and the next two slides provided an overview of the NSW QTM and identified the three Dimensions and the six elements included within each Dimension. Slide four provided a definition of substantive communication and slides five to eight described the three characteristics of high levels of substantive communication. Slide nine referred to the characteristics of low levels of substantive communication. Slides ten to thirteen described the five-point Coding Scale used to rate the effectiveness of substantive communication when viewing a lesson. The description of a level 5 rated lesson indicated the features of a lesson with high levels of effective substantive communication present, and a description of a level 1 rated lesson indicated that there was minimal to no effective substantive communication present. Depending on the instructional condition for the participants, the remaining slides provided screen shots of the annotations included in the video recordings of lessons that they were about to watch during the learning phase of the experiment.

4.2.3.2 Phase 2 – Worked Examples: Learning Phase

The following section provides a description of the worked examples used in Experiment 1. The worked examples consisted of video recordings of the lessons along with the referencing tables included in the accompanying hard copy participant booklet. Video recordings of the lessons were developed to reflect the three instructional conditions of Experiment 1: Process condition, Product condition and Control condition.

4.2.3.2.1 Video Recordings of the Lessons

A set of video recordings were produced by the New South Wales (NSW) Department of Education and Training and were used to support teachers in their understanding of the eighteen elements of the NSW QTM. This current research used a section of two videos of this video set of recordings, with a focus on substantive communication. The first video recording was a Personal Development, Health and Physical Education (PDHPE) lesson taught by a female teacher to a group of middle school female secondary students, which focused on the issue of safety. The timing of this video recording was seven minutes and forty-six seconds. The second video recording was a Japanese language lesson taught by a female teacher to a group of middle school secondary students, both male and female, which focused on counting in Japanese. The timing for this video recording was four minutes and fifteen seconds. The following was the process undertaken by the researcher to develop the two video recordings of the lessons (PDHPE and Japanese lesson) for the three instructional conditions (Process, Product and Control):

1. Analysed the two video recordings for levels of substantive communication and edited the video recordings of the lessons to include annotations relevant to the particular instructional condition.
2. Wrote scripts to be delivered to participants for each instructional condition (See Appendix G for an example of the script for the Process condition).
3. Embedded ten second pauses at key points during the video recording of the lessons for each instructional condition (this was so the video recordings for each instructional condition were the same length).

The researcher used information provided in accompanying resources created by NSW DET (2006) and consulted with three Education Officers who worked in a Catholic Education Office which supported a system of schools, to validate the identified levels of substantive communication included in the annotations during the video recordings of the lesson.

During the ten second pauses at key points during the video recordings, annotations were presented on the screen for the two worked example instructional conditions which indicated the level of substantive communication that was present during the section of the lesson observed just prior to the pause. In addition, the annotations for the Process condition included the reason explaining the level of substantive communication. There were no annotations for the Control condition.

There were sixteen ten second pauses during the video recording of the PDHPE lesson and seven pauses during the video recording of the Japanese language lesson. Appendix R includes a table providing the timing of the pauses and the annotations that were included on the screen at these times for the Process and Product conditions. In addition, Appendix R includes a web link enabling access to the video recordings used for each instructional condition during the Learning Phase. The following provides images and further information on the video recordings of lessons for each of the three instructional conditions.

The Process condition video recordings included annotations on the screen at key points indicating whether substantive communication was evident or not during the section of the lesson that the participants had just watched, and also a brief description using the language that describe the three characteristics of substantive communication to explain why its presence was either high or low. The annotations for the process oriented worked example comprise of up to three lines. As depicted in Figure 4.2 below, the T and S represent the commentary and responses of teachers (T) and students (S), which inform the level of substantive communication. There is also a concluding statement indicating whether substantive communication is evident or not evident in the section of the video lesson viewed prior to the annotation during the pause. The pauses and annotations appeared for ten seconds to allow participants the time to read the annotations and think about the level of substantive communication. Figure 4.2 below contains an image of an annotation for the process oriented worked example.

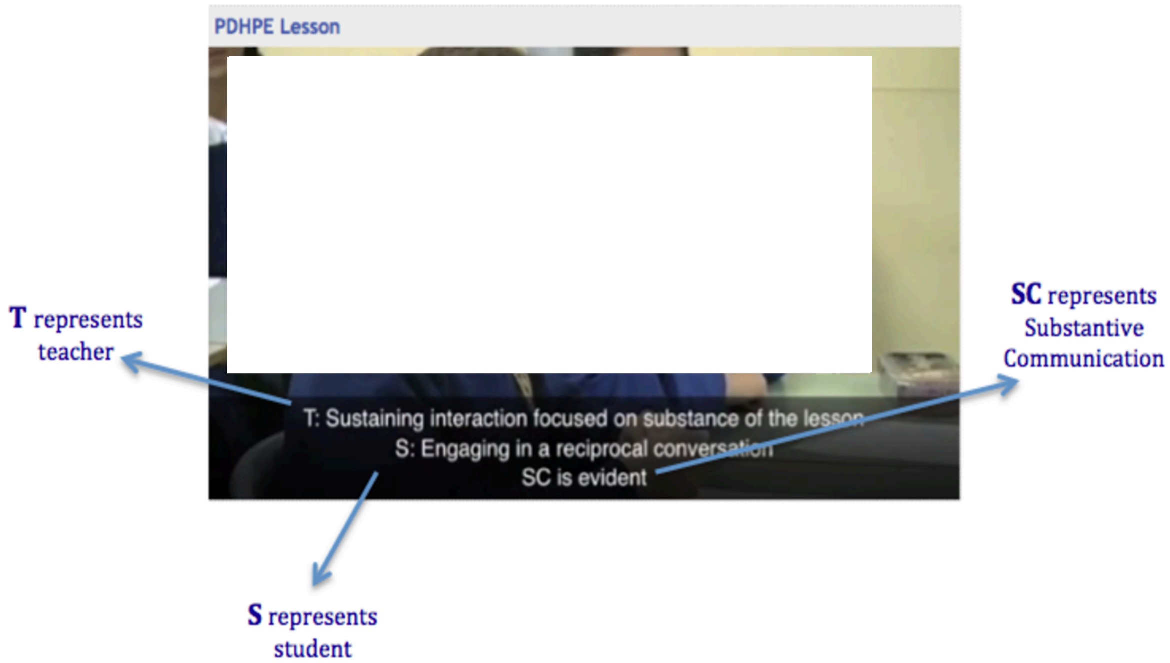

Figure 4.2. Example of an annotation provided during the video recording of a lesson for the Process condition.

Following is the audio text during this section of the video lesson recording which demonstrated the teacher sustaining interaction focused on the substance of the lesson and the students engaging in reciprocal conversation, indicating that substantive communication is evident. Line 1 below commences twelve seconds into the video recording of the lesson.

Line 1: Teacher: Going on from what we've done from our previous lesson, can anyone think back to any issues of concern regarding personal safety that you may have?

Line 2: Student 1: Walking at night alone on your way home.

Line 3: Student 2: Catching a train by yourself.

Line 4: Teacher: Anything else, Rhianne?

Line 5: Student 3: Going to parties and stuff and night time.

Line 6: Teacher: OK, what things about parties might concern you?

Line 7: Student 3: Like if there's alcohol being served.

Line 8: Teacher: OK, generally you would hope that parties are fun. So are you saying that alcohol may be the thing that is concerning?

Line 9: Student 3: Yes.

Line 10: Teacher: Farah?

Line 11: Student 4: Being followed by strangers at night.

There is a pause in the video after Line 3 of the audio text with the following annotation on the screen;

T: Asks a routine question

S: Provide short answers

Interaction is not reciprocal – SC not evident.

The following annotation occurs after Line 5;

T: Asks 'anything else' and student responds.

Sustaining interaction through continuation of an idea – SC evident.

The following annotation occurs after Line 9;

T: Asks 'what things at parties might concern you' and sustains interaction with the students on the substance of the lesson – SC evident.

The Product condition video recordings only included annotations on the screen at key points indicating whether substantive communication was evident or not during the section of the lesson that the participants had just watched. The timing for the pause was also ten seconds. Figure 4.3 is an image of an annotation for the product oriented worked example.

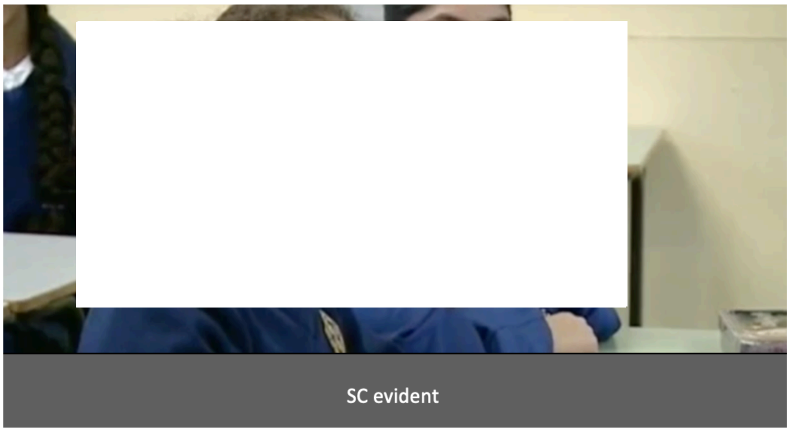

Figure 4.3. Example of an annotation provided during the video recording of a lesson for the Product condition.

The Control condition video recordings did not include any annotations on the screen at key points indicating whether substantive communication was evident or not during the section of the lesson that the participants had just watched. The participants were notified that there would be pauses at key points during the video recordings and that during these pauses they were to reflect on the level of substantive communication within the lesson prior to the pause. The timing for the pause was also ten seconds. Figure 4.4 is an image for the Control condition:

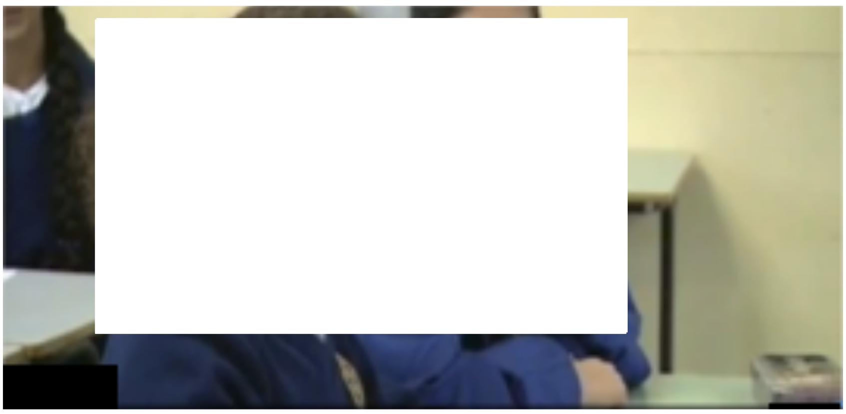

Figure 4.4. Example of the video recording of a lesson for the Control condition.

4.2.3.2.2 Participant Booklet

A twelve-page booklet was designed and included text material to accompany the video recordings of the lessons that provided steps to solution through the referencing tables presented with the video recordings during the Learning Phase. The twelve-page booklet also included test items, cognitive load measures, task difficulty measures and an evaluation/reflection for the participants to complete (See Appendix E). The participant booklet provided scaffolds for the video recordings of the lessons and supported the experimental process during Phases 2 and 3. The two worked examples in the participant booklet (Tasks 2 and 3) provided the solution to the problem (including the level of substantive communication evident in the video presented as a Coding Score) for both the Process and Product conditions. The participant booklet for the Control condition also provided the Coding Score for both video recordings. These were presented in the referencing table (see pages 2 and 4 of Appendix E and Appendix F). Additional information included in the referencing table was dependent on the instructional condition.

The twelve-page booklet, presented in black and white, printed on single-sided A4 paper comprised of a cover page titled "The NSW Quality Teaching Model" and had a rectangular box that required participants to identify their participation number, gender and age. The participant numbers were written on the booklets prior to the experiment commencing and were distributed to participants in the room, commencing with the students sitting at the front. The numbering system identified the instructional condition of the experiment. For the Process condition, the participant numbers commenced with PP (e.g., PP12). For the Product condition, the participant numbers commenced with PT and for the Control condition, the participant numbers began with CT.

On the front page of the booklet (page 1), participants were asked to write a response to two statements with the purpose of identifying prior knowledge of the NSW QTM and substantive communication. This information enabled the researcher to confirm the participants were novices. The two statements were:

- Write down everything you know about the NSW Quality Teaching Model, and
- Write down everything you know about substantive communication.

The researcher marked the responses to these two questions. The mean score for the participants' responses to the two questions was 0.4 / 4 with a standard deviation of 0.8. This result confirmed the participants as novices in relation to the NSW QTM and substantive communication (See Appendix H for the marking criteria).

Following from this first introductory page there were six tasks for participants to work through, the final task being an evaluation (See Appendix E). Tasks 1 and 2 required participants to engage with the worked examples (Learning Phase). Tasks 3, 4 and 5 were test items (Test Phase). Each test item was presented on a new page and was followed by the Mental Effort Rating and Task Difficulty Rating tables. Task 6 required participants to complete an evaluation of their experience during the experiment. The following sections provide details on each of the worked examples, test items and rating scales included within the participant booklet.

4.2.3.2.2.1 Participant Booklet Phase 2: Learning Phase (pages 2 – 5)

The learning phase (Phase 2) followed immediately after the introductory phase (Phase 1). The following section provides an overview of the information contained in the participant booklet specific to the learning phase for Experiment 1. Table 4.2 below provides a summary of the purpose of each page of the participant booklet during the learning phase.

Table 4.2

Summary of the purpose of each page in the participant booklet during the learning phase

Page Number	Purpose	Description
1: Title Page	Demographic Information. Questions to ascertain participants' understanding of the NSW QTM and substantive communication.	Table provided for participants to enter demographic information and two questions to ascertain participants' understanding of the NSW QTM and substantive communication.
2: Worked Example 1 (WE1)	Understanding substantive communication in PDHPE lesson.	Referencing table provided coding of substantive communication for the lesson. Information provided was dependent on instructional condition.
3: Mental effort/task difficulty ratings (WE1)	Perceived mental effort and perceived task difficulty ratings.	Two tables containing nine-point Likert scales for participants to rate their perceived mental effort and perceived task difficulty.
4: Worked Example 2 (WE2)	Understanding substantive communication in Languages lesson.	Referencing table provided coding of substantive communication for the lesson. Information provided was dependent on instructional condition.
5: Mental effort/task difficulty ratings (WE2)	Perceived mental effort and perceived task difficulty rating.	Two tables containing nine-point Likert scales for participants to rate their perceived mental effort and perceived task difficulty.

Appendix F contains the referencing table that was included in the participant booklet for each of the three instructional conditions for the first video lesson recording, the PDHPE lesson. The referencing tables, along with the video recordings of the lessons, formed the worked example for the Process and Product conditions, described in Table 4.2 above in the Description column.

4.2.3.3 Phase 3 – Test Items: Test Phase

The test phase followed immediately after the learning phase. The test phase required participants to complete three test items and an evaluation. The three test items can be accessed in the participant booklet included in Appendix E. The following section provides an overview of the instructional material presented in the participant booklet during the test phase.

4.2.3.3.1 Participant Booklet Phase 3: Test Phase (pages 6 to 11)

The researcher designed the test items, which included a recall task, near transfer tasks and far transfer tasks. Recall tasks require participants to recall information, near transfer tasks require participants to apply learnings to similar tasks presented previously and far transfer tasks require participants to apply learnings to a new situation. Table 4.3 below provides an overview of the test phase test items participants completed, the purpose of each task, marks allocated (see Appendix H) and design of the task. After each task, participants completed a mental effort rating and a task difficulty rating.

Table 4.3

Overview of Test Items 1, 2 and 3 administered during the Test Phase (Phase 3) of the experiment

Task Number	Purpose of the Task	Task Description	Marks	Task Design
Performance Task 1	Participants recalling and identifying the characteristics of substantive communication in a vignette of a conversation between a teacher and students.	Task 1a: Participants were required to identify characteristics of substantive communication present throughout the dialogue.	3 Marks	Recall
		Task 1b: Participants were required to identify and verify	3 Marks	Near Transfer

		characteristics of substantive communication present throughout the dialogue through providing specific quotes to support their choices.		
Performance Task 2	Participants identifying and justifying characteristics of reciprocal communication, a characteristic of substantive communication, after watching a video of an interaction between a teacher and students.	Task 2a: Participants to indicate whether the characteristic of reciprocal communication was evident.	1 Mark	Near Transfer
		Task 2b: Participants were required to provide evidence to justify their response for Task 2a.	1 Mark	Near Transfer
	Participants providing strategies to enhance the effectiveness of the characteristics of sustained interaction in the interaction between a teacher and students.	Task 2c: Participants required to provide strategies on how to enhance the rating of the element of sustained interaction during the video recording.	1 Mark	Far Transfer
Performance Task 3	Participants providing strategies on how they would enhance two identified characteristics of substantive communication.	Task 3a: Participants viewed a recording of a section of a science lesson and were required to suggest one strategy of how they would enhance the two identified characteristics of	2 Marks	Far Transfer

	substantive communication.		
	Task 3b: Participants required to suggest a second strategy of how they would enhance the two identified characteristics of substantive communication.	2 Marks	Far Transfer

Following the completion of all three test items, participants were required to complete an evaluation of their experience during the experiment (page 12 of the booklet). The evaluation required participants to respond using a five-point Likert scale to the two exploratory statements:

- I enjoyed learning in this way, and
- I found this type of instruction engaging.

The Likert scale ranged from Strongly Disagree to Strongly Agree. The exploratory statements were developed by the researcher to ascertain how the different instructional conditions influenced engagement and participation. See Task 6 in Appendix E for the evaluation page of the participant booklet.

4.2.3.3.2 Mental Effort and Task Difficulty Ratings

After each task in the learning phase and subsequent test phase, a nine-point Mental Effort Rating (Paas, 1992; Paas et al., 2003) and Task Difficulty Rating (DeLeeuw & Mayer, 2008) was presented for participants to complete. Figure 4.5 below is a representation of the Mental Effort Rating Scale.

Rate the amount of mental effort you invested to complete Task 2. Circle your rating.

1	2	3	4	5	6	7	8	9
Extremely low mental effort				Neither low nor high mental effort				Extremely high mental effort

Figure 4.5. Representation of the Mental Effort Rating Scale.

Figure 4.6 below is a representation of the Task Difficulty Rating Scale.

Rate how difficult the task was for you.

1	2	3	4	5	6	7	8	9
Extremely easy				Neither easy nor difficult				Extremely difficult

Figure 4.6. Representation of the Task Difficulty Rating Scale.

4.2.4 Procedure

During Experiment 1, participants were presented with two worked examples specific to their instructional condition. The worked examples consisted of two video recordings of lessons (PDHPE and Japanese language) and a referencing table for each video indicating the level of substantive communication and other information specific to the instructional condition i.e., Process condition, Product condition or Control condition. The worked examples provided participants training in learning how to identify and rate levels of substantive communication present during a lesson. In total, Experiment 1 took 60 minutes to complete. Each phase of the experiment as presented in Figure 4.1.

4.2.4.1 Introductory Phase (15 minutes)

The researcher introduced the experiment to ensure the participants understood the structure and purpose of the experiment and tasks they would be completing. Participants were informed they would be working through a booklet, which included the worked examples and test items. During the introduction, participants were asked to complete the front cover of the booklet and finalise the completion of the participation and consent forms. Participants were then presented a PowerPoint introducing the NSW QTM and, in particular, the element and characteristics of substantive communication. The characteristics of substantive communication include (see Section 2.8):

- Sustained interaction
- Communication focused on the substance of the lesson
- The interaction is reciprocal.

Procedures for the experiment were explained to the participants and the researcher read from a script to ensure that all participants received the same information in accordance with each participant's instructional condition (see Appendix G). This included when participants could open the booklet, when to turn pages of the booklet throughout the experiment, not to turn back pages throughout the experiment and not being able to make notes while watching the video recordings of the lessons. One of the researcher's two supervisors was present during each of the instructional conditions to ensure the script and procedures were the same across the three instructional conditions.

Participants were told they would be required to complete a number of test items throughout the experiment followed by rating their perceived mental effort exerted and perceived task difficulty after each test item. The researcher provided an example of a mental effort and task difficulty rating (see Appendix G). A digital timer was used to ensure each timed component of the experiment was consistent with the indicated timing in the participant booklet and between instructional conditions.

Following this, the researcher described the characteristics of low levels of substantive communication within a classroom environment. The concept of Coding was then introduced to the participants. The descriptions of the Coding levels were presented to the students on a PowerPoint slide (see Appendix D). Coding is a way in which the participants can rate the effective use of substantive communication when viewing a lesson, by using a five-point scale. A rating of one represents a lesson low in substantive communication and a rating of five represents a lesson high in substantive communication.

4.2.4.2 Learning Phase (25 minutes)

Immediately after the Introductory PowerPoint presentation, participants were asked to turn to page one of their booklet. At this point, the participants were told that they would be watching two video recordings of lessons. As stated previously, the video recordings of the lessons and the corresponding referencing table in the participant booklet served as worked examples for the participants to further develop an understanding of the characteristics and levels of substantive communication and to then apply this understanding to classroom teaching practices. The online video recordings of the lessons were shown on a large screen to the participants. For each of the three instructional conditions, there were ten second pauses at key points during the lesson. For the Process and Product conditions, annotations on the screen were shown during these pauses to indicate the level of substantive communication that was present during the section of the lesson observed just prior to the pause. The video recordings during the Control condition, also included pauses at the same key points as the other two instructional conditions but did not include any annotations. The pauses at these key points ensured that the video recordings were of the same length for each instructional condition and that participants in each condition were provided the same time to think about the level of substantive communication that was present.

The participant booklet included referencing tables which provided model answers for each instructional condition that indicated the level of substantive communication that was demonstrated during the video recording of the lesson which had just been watched (see Appendix F). Prior to watching the video recordings of the two lessons, participants were given forty-five seconds to read the referencing table. Participants then watched the video recording of the lesson. Following this, participants were given another forty-five seconds to re-read the referencing table in the booklet. Immediately after re-reading the information provided in the referencing table, participants were given twenty seconds to complete their perceived mental effort and perceived task difficulty ratings. This process was then repeated for a second video recording of the Japanese language lesson.

4.2.4.3 Test Phase (20 minutes)

Following the learning phase, participants commenced the test phase. The participant booklet included three test items and an evaluation for the participants to complete during the test phase. Table 4.3 above provides a brief description of each test item and includes the marks for each section of each test item. Immediately upon completing each test item, participants were given twenty seconds to rate their perceived mental effort and perceived task difficulty.

Upon completing the three test items, as stated above participants completed an evaluation of their experience during the experiment. This involved rating their experience on a five-point Likert scale on the statements "I enjoyed learning in this way" and "I found this type of instruction engaging".

4.2.4.4 Modifications as a Result of the Pilot Study

Prior to conducting the experiment, a pilot was conducted with 25 students. The pilot was conducted in September 2015 with fourth year Bachelor of Mathematics / Science Education students. Students were allocated one of the three instructional conditions and engaged with the material under the facilitation of the researcher. The purpose of the pilot was to ascertain the time needed for each experimental phase and ensure the clarity of the instructional materials for each condition. As a result of the pilot experiment, a number of changes were made to the design and timing of the experiment. Table 4.4 below outlines the modifications and reasons for them.

Table 4.4

Modifications made to the experiment design as a result of pilot experiments

Modifications	Reasons
The time to read the Coding Score information in the Participation Booklet changed from one minute to forty-five seconds.	During the pilot study the participants completed the reading of the Coding Score within forty-five seconds. Reducing the time kept would keep the participants on task.
The working time to complete Task 2 decreased from three minutes to two minutes and the working time to complete Task 3 decreased from four minutes to two minutes.	During the pilot study the participants completed the Tasks within two minutes. Reducing the time would keep the participants on task.
The time to rate perceived mental effort and perceived task difficulty decreased from one minute to twenty seconds.	As these ratings need to occur immediately after each task, the timing to complete these ratings was reduced (Ayres, Paul, and Fred Paas, 2012)

4.3 ANALYSIS

The dependent variables under analysis were individual test item scores, total test performance scores, individual task mental effort ratings, learning phase mental effort ratings, test phase mental effort ratings, individual task difficulty ratings, learning phase task difficulty ratings, test phase task difficulty ratings and evaluation ratings.

In order to minimise data collector bias, a predetermined marking criteria was applied. This guided the marker on how to allocate marks to responses to the test items. The researcher's three supervisors reviewed the marking criteria (Appendix H). To ensure consistency in the allocation of marks, the researcher randomly marked ten participant booklets, without identifying the instructional condition of the scripts. The researcher's supervisors then marked the same ten scripts by applying the marking criteria and compared their scripts to the scripts marked by the researcher. A discussion on the application of the marking criteria was undertaken between the researcher and supervisors to ensure consistency in the application of the marking. The researcher then double marked the remaining scripts. Scores were recorded in an excel spreadsheet. After the data was entered into SPSS (Version 24), the data was then double checked by the researcher for accuracy.

A one-way ANOVA, between instructional conditions was conducted for each of the dependent variables identified by the Test of Homogeneity of Variances. An alpha level of 0.05 was used as the criterion for determining statistical significance. *Post-hoc* comparisons using Tukey were calculated for results where the homogeneity of variance was significant ($p < 0.05$). The Tukey HSD test is a post hoc test used to determine whether a set of conditions significantly differs from one or more others (Allen 2017). The Dunnett Statistical Analysis, which compares groups with other groups (Ruxton & Beauchamp, 2008), was used where the result of the homogeneity of variance was significant, $p < 0.005$. To further investigate hypotheses in relation to test performance scores and mental effort ratings, Instructional Efficiency measures were calculated. Instructional Efficiency enables the comparison of different instructional conditions on learning through considering test performance scores and perceived mental effort on a test (Paas & Van Merriënboer, 1993).

4.4 RESULTS

The following sections present the analysis of the dependent variables. The test performance scores, perceived mental effort ratings, perceived task difficulty ratings and instructional efficiency are presented. In addition, the participant perceptions of the instructional materials are presented. The data collected from the Master of Teaching students and Bachelor of Primary Education students have been combined in the following analysis. This is due to the sample size and the procedure, learning materials and test items being exactly the same for both cohorts.

4.4.1 Test Performance Scores

A one-way ANOVA was conducted on test performance scores to determine any differences between the three instructional conditions. The result from the homogeneity of variances test was not significant ($p > 0.05$) for the test performance scores, therefore, the variances within conditions were considered to be homogeneous. Test performance scores including the mean and standard deviation for each instructional condition are presented in Table 4.5, with an asterisk indicating a significant main effect. Cohen's *d* was calculated to measure effect size. Values of 0.20, 0.50 and 0.80 indicated effect sizes that were small, medium and large respectively (Cohen, 1998).

Table 4.5

Means and standard deviations for the test performance scores during the test phase

	Test Performance Scores			
Instructional Condition	Task 1 (Recall Task) (6 Marks)	Task 2 (Near / Far Transfer Task) (3 Marks)	Task 3 (Far Transfer Task) (4 Marks)	Total (13 Marks)
Process Condition (N=40)	3.14 (1.28)*	2.28 (1.01)	1.83 (0.87)	7.24 (2.41)*
Product Condition (N=32)	2.16 (1.55)	2.11 (1.05)	1.45 (1.04)	5.72 (2.34)
Control Condition (N=13)	2.50 (1.49)	1.69 (1.18)	1.46 (0.97)	5.65 (2.02)

Results from the one-way ANOVA for test performance indicated a significant main effect for the test performance scores, $F(2, 82) = 4.60$, $p = 0.013$. Post-hoc comparisons using the Tukey HSD test showed that the test performance scores for the Process condition was significantly higher than the test performance scores for the Product condition, $p = 0.02$, with a medium effect size obtained, $d = 0.64$.

Results from the one-way ANOVA for test performance scores indicated a significant main effect for Task 1, $F(2, 82) = 4.347$, $p = 0.016$. Post-hoc comparisons using the Tukey HSD test showed that the Task 1 test performance scores for the Process condition was significantly higher than the Task 1 test performance scores for the Product condition, $p = 0.013$. Results from the one-way ANOVA for test performance scores showed no significant main effect for Task 2, $F(2, 82) = 1.512$, $p = 0.227$ and Task 3, $F(2, 82) = 1.587$, $p = 0.211$.

The results of Task 1 and the total test performance scores confirm Hypothesis 1, which states that when learning about the characteristics of substantive communication, participants presented with the Process condition will achieve higher test performance scores during the test phase than participants presented with the Product condition.

Hypothesis 2 states that when learning about the characteristics of substantive communication, participants presented with the Product condition will achieve higher test performance scores during the test phase than learners presented with the Control condition. While the participants presented with Product condition scored a higher mean than participants presented with the Control condition, the results were not statistically significant.

4.4.2 Mental Effort Ratings

A one-way ANOVA was conducted on mental effort ratings to determine differences between the three instructional conditions. Participants rated their perceived mental effort after the presentation of both worked examples during the learning phase and after each of the three test items during the test phase (see Appendix I). The result from the homogeneity of variances test was not significant ($p > 0.05$) for the mental effort ratings during the learning phase, therefore the variances within instructional conditions were considered to be homogeneous. Mental effort ratings, including the mean and standard deviation for each instructional condition during the learning phase are presented in Table 4.6, with an asterisk indicating a significant main effect. The perceived mean mental effort ratings (Total) and ratings for each worked example are included.

Table 4.6

Means and standard deviations for the mental effort ratings during the learning phase

Mental Effort Ratings – Learning Phase			
Instructional Condition	Worked Example 1 (9)	Worked Example 2 (9)	Total (9)
Process Condition (N=40)	3.08 (1.61)	2.62 (1.31)	2.89 (1.36)
Product Condition (N=32)	2.91 (1.87)	2.13 (1.76)	2.52 (1.51)
Control Condition (N=13)	3.23 (1.64)	3.85 (1.95)*	3.54 (1.53)

Results from the one-way ANOVA for mental effort ratings during the learning phase showed no significant main effect for the total learning phase, $F(2, 82) = 2.346$, $p = 0.102$. While there were non-significant results, the learning phase mean mental effort rating for the Control condition was higher than the Product condition, with a medium effect size obtained, $d = 0.67$. The learning phase mean mental effort rating for the Process condition was higher than the Product condition, with a medium effect size obtained, $d = 0.26$.

Results from the one-way ANOVA for mental effort ratings during the learning phase showed no significant main effect for Worked Example 1, $F(2, 82) = 0.185$, $p = 0.831$. However, results from the one-way ANOVA for mental effort ratings during the learning phase indicated a significant main effect for Worked Example 2, $F(2, 82) = 5.373$, $p = 0.01$. Post-hoc comparisons using the Tukey HSD test showed that the mental effort rating for Worked Example 2 for both the Process and Product conditions were significantly lower than the mental effort rating for the participants presented with the Control condition, $p = 0.004$ in comparison to the Product condition and $p = 0.048$ in comparison to the Process condition. In comparing the Product and Control conditions (as per part of Hypothesis 3), these results for Worked Example 2 aligned with Hypothesis 3, which states that when learning about the characteristics of substantive communication, participants presented during the learning phase with the Control condition, will report higher perceived cognitive load than participants presented with the Product condition.

The result from the homogeneity of variances test was not significant ($p > 0.05$) for the mental effort ratings during the test phase, therefore the variances within conditions were considered to be homogeneous. Mental effort ratings, including the mean and standard deviation for each instructional condition and test items during the test phase are presented in Table 4.7.

Table 4.7

Means and standard deviations for the mental effort ratings during the test phase

	Mental Effort Ratings –Test Phase			
Instructional Condition	Task 1 (9)	Task 2 (9)	Task 3 (9)	Mean Rating (9)
Process Condition (N=40)	5.23 (1.44)	4.90 (1.34)	5.95 (1.20)	5.36 (1.08)
Product Condition (N=32)	4.91 (1.67)	4.66 (1.72)	5.34 (1.70)	4.97 (1.29)
Control Condition (N=13)	5.46 (1.81)	5.38 (1.45)	6.38 (1.26)	5.74 (1.15)

Results from the one-way ANOVA for mental effort ratings during the test phase showed no significant main effect for the total test phase, $F(2, 82) = 2.214$, $p = 0.116$. While there were non-significant results, the test phase mean mental effort rating for the Control condition was higher than the Process condition, with a medium effect size obtained, $d = 0.34$. The test phase mean mental effort for the Control condition was also higher than the Product condition, with a medium effect size obtained, $d = 0.63$.

Results from the one-way ANOVA for mental effort ratings during the test phase showed no significant main effect for Task 1, $F(2, 82) = 0.670$, $p = 0.514$, for Task 2, $F(2, 82) = 1.087$, $p = 0.342$ and for Task 3, $F(2, 82) = 2.995$, $p = 0.056$. To be noted, Task 3, a far transfer task, was the most complex of the three tasks as it required participants to evaluate the level of two characteristics of substantive communication and apply their understanding to their own teaching practice. Participants' perceived the mental effort rating for Task 3 to be the highest suggesting that participants are able to accurately assess their cognitive load.

Hypothesis 5 states that when learning about the characteristics of substantive communication, participants presented with the Process condition will report lower perceived cognitive load during the test phase than participants presented with the Product condition. The results from the experiment did not demonstrate statistical significance, hence, Hypothesis 5 was not supported.

Hypothesis 7 states that when learning about the characteristics of substantive communication, participants presented with the Process condition or Product condition will report lower perceived cognitive load during the test phase than participants presented with the Control condition. The total test phase means for the mental effort ratings from the Process and Product conditions were both lower than the mean mental effort ratings for the Control condition. However, there was no statistical significance, hence Hypothesis 7 was not supported. A discussion of the mental effort rating results can be found at the end of this chapter.

4.4.3 Task Difficulty Ratings

A one-way ANOVA was conducted on task difficulty ratings to determine differences between the three instructional conditions. Participants rated their perceived task difficulty rating after the presentation of both worked examples during the learning phase and after each of the three tasks during the test phase (see Appendix I). The result from the homogeneity of variances test was significant ($p > 0.05$) for the task difficulty ratings during the learning phase and for Task 2 during the test phase, therefore the variances within conditions were considered to be not homogeneous. The result from the homogeneity of variances test was not significant ($p > 0.05$) for the task difficulty ratings for Task 1, Task 3 and the total test phase, therefore the variances within conditions were considered to be homogeneous. Task difficulty ratings, including the mean and standard deviation for each instructional condition during the learning phase are presented in Table 4.8, with an asterisk indicating a significant main effect.

Table 4.8

Means and standard deviations for the task difficulty ratings during the learning phase

Instructional Condition	Task Difficulty Ratings – Learning Phase Worked Example 1 (9)	Worked Example 2 (9)	Total (9)
Process Condition (N=40)	1.98 (1.10)	1.87 (1.08)	1.91 (1.02)
Product Condition (N=32)	2.99 (1.48)	1.63 (1.04)	1.81 (0.97)
Control Condition (N=13)	2.92 (1.85)	3.46 (1.98)*	3.19 (1.73)*

Results from the one-way ANOVA for task difficulty ratings during the learning phase indicated a significant main effect for the total learning phase, $F(2, 82) = 7.567$, $p = 0.001$. Post-hoc comparisons using the Dunnett test showed that the task difficulty rating for the total learning phase for the Control condition was significantly higher than the rating for the Product condition, $p = 0.045$, with a large effect size obtained, $d = 0.98$. The Control condition did not statistically differ from the Process condition, $p = 0.066$.

Results from the one-way ANOVA for task difficulty ratings during the learning phase showed no significant main effect for Worked Example 1, $F(2, 82) = 2.545$, $p = 0.085$. However, results from the one-way ANOVA for task difficulty ratings during the learning phase indicated a significant main effect for Worked Example 2, $F(2, 82) = 10.640$, $p = 0.000$. Post-hoc comparisons using the Dunnett test showed that the task difficulty rating for Worked Example 2 was significantly higher for the Control condition than for both the Product condition and Process condition, $p = 0.019$ and $p = 0.04$ respectively.

Hypothesis 4 states that when learning about the characteristics of substantive communication, participants presented during the learning phase with the Process condition or Control condition, will report higher perceived task difficulty than participants presented with the Product condition. The results from the experiment revealed a significant difference between the Control condition and Product condition, and no difference between the Control condition and Process condition. However, for Worked Example 2, for the Control condition there was a statistical significance with higher task difficulty ratings compared to both the Process condition and Product condition.

The result from the homogeneity of variances test was not significant ($p > 0.05$) for the task difficulty ratings during the test phase for all ratings except for Task 2, therefore the variances within instructional conditions were considered to be homogeneous. Task difficulty ratings, including the mean and standard deviation for each instructional condition during the test phase are presented in Table 4.9.

Table 4.9

Means and standard deviations for the task difficulty ratings during the test phase.

	Task Difficulty Ratings – Test Phase			
Instructional Condition	Task 1 (9)	Task 2 (9)	Task 3 (9)	Mean Rating (9)
Process Condition (N=40)	4.20 (1.74)	3.78 (1.54)	5.40 (1.58)	4.46 (1.32)
Product Condition (N=32)	3.97 (1.60)	3.59 (1.50)	5.06 (1.95)	4.21 (1.33)
Control Condition (N=13)	5.23 (2.09)	4.92 (2.18)*	6.31 (1.55)	5.49 (1.51)*

Results from the one-way ANOVA for task difficulty ratings during the test phase indicated a significant main effect for the total phase, $F(2, 82) = 4.265$, $p = 0.017$. Post-hoc comparisons using the Tukey HSD test showed that the perceived task difficulty rating during the test phase was significantly higher for the Control condition than for both the Product condition, $p = 0.013$ with large effect size, d = 0.90, and the Process condition, $p = 0.049$, medium effect size, d = 0.73.

Results from the one-way ANOVA for task difficulty ratings during the test phase showed no significant main effect for Task 1, $F(2, 82) = 2.480$, $p = 0.090$. One-way ANOVA results for task difficulty ratings during the test phase indicated a significant main effect for Task 2, $F(2, 82) = 3.212$, $p = 0.045$. Post-hoc comparisons using the

Tukey HSD test showed that the task difficulty rating for Task 2 for the Control condition was significantly higher than the task difficulty ratings for the Product condition, $p = 0.041$. Results from the one-way ANOVA for task difficulty ratings during the test phase showed no significant main effect for Task 3, $F(2, 82) = 2.408$, $p = 0.096$.

Hypothesis 6 states that when learning about the characteristics of substantive communication, participants presented with the Process condition will report lower perceived task difficulty during the test phase than participants presented with the Product condition. The results from the experiment did not demonstrate statistical significance. Hence, Hypothesis 6 was not supported.

Hypothesis 8 states that when learning about the characteristics of substantive communication, participants presented with the Process condition or Product condition will report lower perceived task difficulty during the test phase than participants presented with the Control condition. Results from the one-way ANOVA for task difficulty ratings indicated a significant main effect for the total task difficulty rating for the test phase. Further, the post-hoc comparisons using the Tukey HSD test showed that the task difficulty rating during the test phase for the Control condition was significantly higher than the task difficulty ratings during the test phase for both the Process condition and Product condition. Thus, the results confirm Hypothesis 8. A discussion of the task difficulty rating results can be found at the end of this chapter.

4.4.4 Instructional Efficiency

Measures of mental effort and test performance can be used for a calculation to obtain Instructional Efficiency. Instructional Efficiency can be used to compare the effects of different instructional conditions on learning (Paas & Van Merriënboer, 1993). The combination of a high test performance and a low mental effort rated by participants would indicate high instructional efficiency. Similarly, a combination of a low test performance and a high mental effort rated by participants would indicate low instructional efficiency. This provides information into the advantages of particular instructional designs, tasks and subject parameters (Paas & Van Merriënboer, 1993). Paas and Van Merriënboer (1993) argue that well-designed training materials may increase instructional efficiency, resulting in fewer cognitive resources being required for similar tasks after the training.

To calculate Instructional Efficiency scores, initially, student test performance scores and mental effort scores are standardised by converting each score into a z-score. These are calculated by subtracting the total mean from each score within each instructional condition and dividing by the standard deviation of the total scores. Following this, the mean of the standardised mental effort scores is subtracted from the mean of the standardised performance scores. The result is then divided by the square root of two. The Instructional Efficiency is then calculated using the below formula.

Instructional Efficiency = $\frac{zP - zM}{\sqrt{2}}$

Where zP = Mean of standardised performance scores and zM = Mean of standardised mental effort scores.

When the standardised performance mean score is greater than the standardised mental effort mean score, zP > zM, the Instructional Efficiency is beneficial, indicating the instructional material is efficient. When the standardised mental effort is greater than the standardised performance score, zM > zP, the instructional material is less efficient. A one-way ANOVA was conducted on the Instructional Efficiency scores to determine any differences between the three experimental conditions. The Instructional Efficiency means and standard deviations are included in Table 4.10.

Table 4.10

Means and standards deviations for Instructional Efficiency

Means and Standard Deviations for Instructional Efficiency	
Instructional Condition	Efficiency
Process Condition (N=40)	0.18 (0.82)
Product Condition (N=32)	-0.03 (1.09)
Control Condition (N=13)	-0.51 (1.01)

The result of the homogeneity of variance was not significant ($p > 0.05$) indicating the variances within conditions were considered to be homogenous for all measurements. Results from the one-way ANOVA for test performances indicated there was no significant main effect for the total performance score, $F(2, 82) = 2.50$, $p = 0.09$. Even though not significant at the 5% level, the *p*-value indicated that the results were significant at the 10% level.

Figure 4.7 represents the standardised performance mean scores and the standardised mental effort mean scores plotted against each other on a graph for each instructional condition. The three instructional conditions are identified by a labelled dot. In Figure 4.7, Control represents the Control condition.

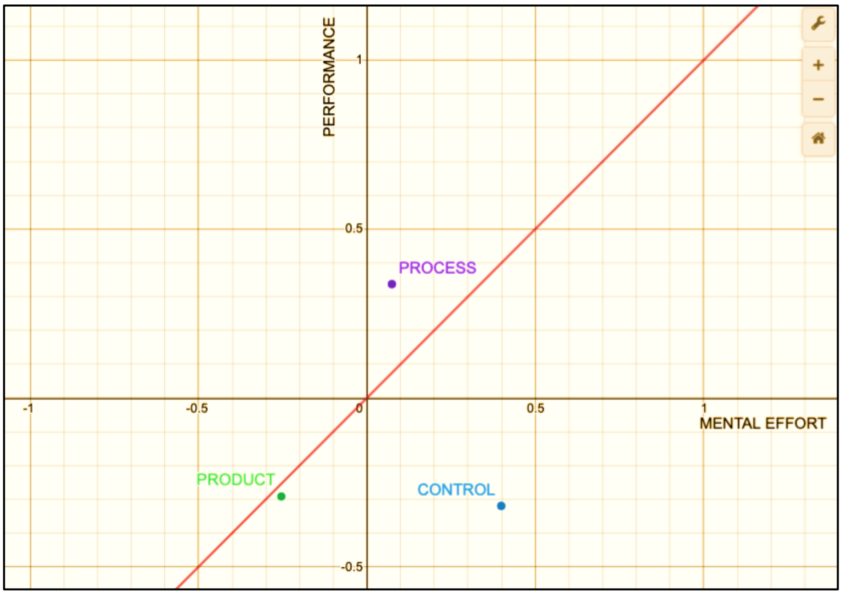

Figure 4.7. Standardised performance mean scores and the standardised mental effort mean scores plotted against each other on a graph for each instructional condition.

The Instructional Efficiency is represented by the perpendicular distance between each point and the red line. The red line shows when performance equals mental effort. High Instructional Efficiency occurs when performance is high and mental effort is low. This region would be represented by the top left quadrant of the graph. Low Instructional Efficiency occurs when performance is low and mental effort is high, this region would be represented by the bottom right quadrant of the graph.

It can be seen on the graph above that the Process condition is above the red line. The Product condition and Control condition are below the red line, with the Control condition being further to the right of the red line compared to the Product condition. Even though the ANOVA indicated that results were not significant, visual inspection of the graph suggests that the Process condition has a higher Instructional Efficiency than the Product and Control conditions, with the Control condition the lowest.

Hypothesis 1 states that when learning about the characteristics of substantive communication, participants presented with the Process condition will achieve higher test performance scores during the test phase than participants presented with the Product condition. Figure 4.7 shows the standardised performance mean score for the Process condition is greater than the standardised mental effort mean score for Product and Control conditions. This result suggests that the process oriented instructional material was an efficient way of learning for novice participants and supports the hypothesis.

4.4.5 Participant Perception of Instructional Materials

At the conclusion of the experiment, participants were asked to complete a survey reflecting on their learning experience. Participants were asked to rate their responses to the following two statements on a five-point scale:

1. I enjoyed learning in this way.
2. I found this type of instruction engaging.

A rating of 1 represented a ‘Strongly Disagree’ response and a rating of 5 represented a ‘Strongly Agree’ response. The mean ratings for the three instructional conditions and each statement are presented in Table 4.11.

Table 4.11

Means and standard deviations (in brackets) of evaluation scores

Means and Standard Deviations of Evaluation Scores		
Instructional Condition	Statement One Ratings	Statement Two Ratings
Process Condition (N=40)	3.10 (1.01)	2.70 (1.04)
Product Condition (N=32)	2.28 (0.85)	1.19 (0.93)
Control Condition (N = 13)	3.38 (1.04)*	3.23 (1.42)*

Results from the one-way ANOVA indicated a significant main effect for Statement One ratings, $F(2, 82) = 9.029$, $p = 0.001$. Post-hoc comparisons using the Tukey HSD test showed that the rating for the Product condition was significantly lower than the rating for the Control condition, $p = 0.002$. The results suggest that the participants of the Control condition enjoyed learning the most, compared to participants in the remaining two instructional conditions.

Results from the one-way ANOVA indicated a significant main effect for Statement Two ratings, $F(2, 82) = 4.822$, $p = 0.010$. Post-hoc comparisons using the Tukey HSD test showed that the rating for the Product condition was significantly lower than the rating for the Control condition, $p = 0.011$. The results suggest that the Control condition engaged participants significantly more than the Process condition and the Product condition.

The results from the evaluation ratings indicated that the participants of the Control condition enjoyed learning from their instructional condition and found their instructional condition most engaging compared to the Process and Product conditions. However, the perceived mental effort ratings and perceived task difficulty ratings were highest for the Control condition during the learning and test phases, suggesting they found learning from the

Control condition less useful than the remaining two instructional conditions. In contrast, the evaluation ratings from participants presented with the Product condition indicated they enjoyed learning this way least and found their instructional condition least engaging. This is not aligned with the perceived mental effort ratings and perceived task difficulty ratings which were lowest for the Product condition during the learning and test phases, suggesting learning from product oriented worked examples was supportive. These results are counter intuitive to what would be expected with mental effort and tasks difficulty ratings being not aligned with engagement and enjoyment ratings. A possible reason for the conflicting results may be that the Control condition participants were familiar with this type of problem solving and were able to engage more readily within this instructional condition. Based on these results, there was a need to further investigate this anomaly between the participants' perceived mental effort and task difficulty ratings and their evaluation ratings of enjoyment and engagement. This provided the rationale for Study 2, which included participant verbal protocols to investigate how participants engaged with and made meaning from the three instructional conditions.

In addition to completing the five-point rating scale for enjoyment and engagement, participants were provided with an opportunity to comment on their enjoyment and engagement. Not all participants provided a comment. In total, participants from the Control condition provided eight comments, participants from the Product condition eighteen comments and participants from the Process condition twenty four comments. All comments are included in Appendix J. The commentary was thematically analysed. Table 4.12 below includes the three themes and an example of participant commentary;

Table 4.12

Common Themes From Participant Commentary and Examples of Participant Commentary

Common Themes from Participant Commentary	Example of Participant Commentary
The video recording of the lesson was helpful and supported learning	Videos were engaging. Discovery learning. Using a visual medium was engaging.
The ability to make notes while watching the video recording would have been useful	I need to write notes and re-read notes.
The length of the video recording was too long	The videos were a little long but better than slabs of writing. It was engaging for the subject matter. The topic was interesting, just late in the day.

The commentary from the evaluation across the three instructional conditions did not provide any real insights into how the participants engaged with and made meaning from the instructional conditions. In addition, based on contradictory results between the descriptive data and ratings and commentary provided by the Control condition participants during the evaluation, there was a need to understand how participants engaged with and made meaning from each instructional condition. This provided the rationale for Study 2, with the aim to understand how learners engage and make sense of information across the three instructional conditions.

4.5 DISCUSSION

The overall purpose of this experiment was to investigate whether process oriented or product oriented worked examples best support learners within an ill-structured learning domain. The aim of the experiment was three-fold:

1. To investigate whether process oriented or product oriented worked examples best support pre-service teachers in identifying and applying knowledge of the NSW QTM element of substantive communication.
2. To investigate how each type of worked example impacted on the perceived cognitive load of participants.

3. To investigate how each type of worked example impacted on the perceived difficulty of participants.

Table 4.13 contains a summary of the results for the eight hypotheses. A discussion of the results for each of the research questions then follows. The following sections answer the eight hypothesis and four research questions based on data analysis.

Table 4.13

Summary of hypotheses results

Hypotheses	Results
H1: Participants presented with the Process condition will achieve higher test performance scores during the *test phase* than participants presented with the Product condition.	Confirmed
H2: Participants presented with the Product condition will achieve higher test performance scores during the *test phase* than learners presented with the Control condition.	Not confirmed
H3: Participants presented during the *learning phase* with the Process condition will report higher perceived cognitive load than participants presented with the Product condition.	Not Confirmed
H3: Participants presented during the *learning phase* with the Control condition will report higher perceived cognitive load than participants presented with the Product condition.	Not Confirmed (Confirmed for Worked Example 2)
H4: Participants presented during the *learning phase* with the Process condition will report higher perceived task difficulty than participants presented with the Product condition.	Not confirmed
Participants presented during the *learning phase* with the Control condition, will report higher perceived task difficulty than participants presented with the Product condition.	Confirmed (Including for Worked Example 2)
H5: Participants presented with the Process condition will report lower perceived cognitive load during the *test phase* than participants presented with the Product condition.	Not confirmed
H6: Participants presented with the Process condition will report lower perceived task difficulty during the *test phase* than participants presented with the Product condition.	Not confirmed

H7: Participants presented with the Process condition will report lower perceived cognitive load during the *test phase* than participants presented with the Control condition.	Not confirmed
Participants presented with the Product condition will report lower perceived cognitive load during the *test phase* than participants presented with the Control condition.	Not confirmed
H8: Participants presented with the Process condition will report lower perceived task difficulty during the *test phase* than participants presented with the Control condition.	Confirmed
Participants presented with the Product condition will report lower perceived task difficulty during the *test phase* than participants presented with the Control condition. .	Confirmed

4.5.1 Summary of Results for Test Performance Scores across Instructional Conditions

Research question one was when learning about the characteristics of substantive communication, do participants presented with the Process condition achieve higher test performance scores during the test phase than participants presented with the Product condition, and do participants presented with the Product condition achieve higher test performance scores during the test phase than participants presented with the Control condition? Results for total test performance showed a statistically significant difference in the total test performance scores of the participants presented with the Process condition compared to participants presented with the Product condition during the test phase, with the Process condition scores having the higher mean. Hence, Hypothesis 1 was confirmed.

In addition, the Instructional Efficiency analysis showed that the standardised performance mean score for the Process condition was greater than the standardised mental effort mean score for Product and Control conditions (see Section 4.4.4). This result, even though not statistically significant, suggests that the Process condition material was an efficient way of learning for novice participants and supports Hypothesis 1.

Results for total test performance showed that there was no statistically significant difference in the total test performance scores of the participants presented with the Product condition compared to participants presented with the Control condition. Hence, Hypothesis 2 was not confirmed. While there was no significant difference, total test performance scores for the Product condition had a higher mean than for the Control condition. The findings showed that providing participants with principled knowledge (why) and strategic information (how) in process oriented worked examples during the learning phase assisted with performance during the test phase. In addition, the inclusion of strategic information (how) assisted participants presented with product oriented worked examples compared to participants engaging in conventional problem solving.

4.5.2 Summary of Results for Cognitive Load and Task Difficulty during the Learning Phase

Research question two was when learning about the characteristics of substantive communication, do participants presented with the Process or Control condition, report higher perceived cognitive load and higher perceived task difficulty during the learning phase than participants presented with the Product condition during the learning phase? The results showed that there was no statistically significant difference between the Process and Product conditions during the learning phase in relation to perceived cognitive load or task difficulty. Hence, Hypothesis 3 and 4 were not confirmed**.** While there was no significant difference, the perceived mean mental effort and task difficulty ratings for the Process condition and Control condition had a higher mean than for the Product condition.

In analysing the two worked examples individually, results from the one-way ANOVA for perceived mental effort ratings during the learning phase indicated a significant main effect for Worked Example 2, with both Process and Product conditions significantly lower than the Control condition. Results from the one-way ANOVA for perceived task difficulty ratings during the learning phase indicated a significant main effect for Worked Example 2 with the Control condition significantly higher than both the Process and Product conditions.

Results for perceived mental effort ratings during the learning phase showed no statistically significant difference when comparing the Product and Control condition. Hence, Hypothesis 3 was not confirmed. While there was no significant difference, the mean mental effort ratings were in the right direction with the Control condition having a higher mean than the Product condition.

Results for perceived task difficulty ratings during the learning phase showed a statistically significant difference in the perceived task difficulty ratings when comparing the Product and Control conditions. Hence, Hypothesis 4 was confirmed, with the Control condition having the higher mean.

4.5.3 Summary of Results for Cognitive Load and Task Ratings Difficulty during the Test Phase

Research question three was when learning about the characteristics of substantive communication, do participants presented with the Process condition report lower perceived cognitive load and lower perceived task difficulty during the test phase than participants presented with the Product condition? The results, as included in Section 4.4.2, for perceived cognitive load showed that there was no statistically significant difference in the perceived mental effort ratings of the participants presented with the Process and Product conditions. As included in Section 4.4.3, results for perceived task difficulty showed that there was no statistically significant difference in the task difficulty ratings of the participants presented with the Process and Product conditions. Hence, Hypothesis 5 and 6 were not confirmed.

Research question four was when learning about the characteristics of substantive communication, do participants presented with Process or Product conditions report lower perceived cognitive load and lower perceived task difficulty during the test phase than participants presented with the Control condition? The results, as included in Section 4.4.2, for perceived cognitive load showed that there was no statistically significant difference in the perceived mental effort ratings during the test phase of the participants presented with the Process or Product conditions and participants presented with the Control condition. Hence, Hypothesis 7 was not confirmed. While there was no significant difference, the perceived mean mental effort ratings were in the right direction with the Control condition having the highest mean. Results for perceived task difficulty showed a statistically significant difference in the perceived task difficulty ratings during the test phase of the participants presented with Process or Product conditions and participants presented with the Control condition. Hence, Hypothesis 8 was confirmed, with the Control condition having the higher mean.

4.5.4 Overall Summary of Results

There were six overall key findings. Each finding is discussed in relation to the three aims of the experiment. The first aim was to investigate which instructional condition, Process condition or Product condition, supported the participants in identifying and applying knowledge of the NSW QTM element of substantive communication. The following are key findings in relation to the first aim:

- Total and Task 1 test performance scores of the Process condition significantly outperformed the Product condition.
- Process condition had the highest instructional efficiency.

The second aim was to investigate participants' perceived cognitive load for each instructional condition (Process condition, Product condition and Control condition). The following is the key finding in relation to the second aim:

- Mental effort ratings for Worked Example 2 during the learning phase for the Process and Product conditions were significantly lower than Control condition.

The third aim was to investigate participants' perceived task difficulty for each instructional condition (Process condition, Product condition and Control condition). The following are key findings in relation to the third aim:

- Task difficulty ratings during the learning phase for Control condition were significantly higher than the Product condition.
- Task difficulty ratings during the test phase for the Control condition were significantly higher than both Process and Product conditions.
- Task difficulty ratings for Worked Example 2 during the learning phase for the Control condition were significantly higher than both Process and Product conditions.

4.5.5 Limitations

There were four main limitations identified for Experiment 1, firstly, participant numbers in the Control condition. Secondly, the experiment's participants were all students from one university in Australia. Thirdly, the focus on one element of the NSW QTM, substantive communication. The fourth limitation was the inclusion of the pauses during the video recordings of the lessons in the Control condition that may be considered a form of scaffold.

The number of participants within each instructional condition was a limitation to the experiment. The small samples sample size for Experiment 1 raises the lack of generalisability of the findings. The number of participants in the Process and Product conditions was 40 and 32 participants respectively. However, the number of participants who engaged in the Control condition was smaller, 13 participants. The experiment conducted with the first year Master of Teaching participants was held during the evening. A number of participants left the experiment early due to the need to catch public transport. The Control condition for the 4th year Bachelor of Primary Education undergraduate pre-service teachers was held during the afternoon. Due to this timing, a number of students were unable to remain for the experiment. It may be posited that the impact on results was minimal as the researcher's focus was investigating which instructional condition, Process condition of Product condition, supported the participants in identifying and applying knowledge of the NSW QTM element of substantive communication.

A second limitation to the experiment was that the participants were all students from one university in Australia. This also raises the lack of generalisability of the findings. A consideration for further studies is to engage students from a variety of different universities to participate in the experiment.

A third limitation is that the focus on one element of the NSW QTM, substantive communication, also raises the lack of generalisability of the results. A consideration for further studies is to focus on other elements of the NSW QTM.

A fourth limitation was the inclusion of the pauses during the video recordings of the lessons in the Control condition that may be considered a form of scaffold. The pauses may have provided participants a hint that an instance of substantive communication had occurred. This is not a feature of conventional problem solving. The inclusion of the pauses adhered to the robustness of this research by ensuring consistency in the timing of the three instructional conditions, but may have provided a subtle queue for participants in the Control condition and provided a scaffold for learning.

4.6 SUMMARY

In this chapter, an overview of Experiment 1 was provided. Overall, Experiment 1 showed that the use of process oriented worked examples supported participants in developing the relevant schema to identify and apply knowledge when learning about the NSW QTM element of substantive communication. Experiment 1 also showed that the use of a product oriented worked example better supported participants in learning about the NSW QTM element of substantive communication when compared to participants engaging in conventional problem solving. The findings from Experiment 1 are consistent with existing research about process oriented and product oriented worked examples in a well-structured learning domain for novice participants. The findings showed that providing participants with principled knowledge (why) and strategic information (how) in process oriented worked examples during the learning phase assisted with performance during the test phase in an ill-structured learning domain. However, even though there were some significant results for the perceived mental effort and perceived task difficulty ratings of the participants, these were inconclusive. In addition, commentary from participants engaging in the Control condition indicated greater engagement and enjoyment than participants in the remaining two instructional conditions (Process and Product). These inconclusive results gave scope to investigate in more depth what participants were doing when engaging with worked examples in an ill-structured learning domain. The next chapter will present an overview of Study 2, which investigated the thought processes of both novice and expert participants when learning about the characteristics of the NSW QTM element of substantive communication, an ill-structured learning domain.

Chapter 5

STUDY 2

5.1 INTRODUCTION

The purpose of Study 2 was to investigate what participants did when engaging with a worked example in an ill-structured learning domain, specifically a process oriented or product oriented worked example. In Experiment 1, although there were some significant results for perceived mental effort and perceived task difficulty ratings, a number of the hypotheses were not confirmed, being Hypotheses 2, 5, 6 and 7; and part of Hypotheses 3 and 4 (See Table 4.13 for the wording and results of the Hypotheses). To summarise, there were six overall findings from Experiment 1, which aligned to the confirmed hypotheses. The first, participants presented with the Process condition out-performed participants presented with the Product condition on test items (Hypothesis 1). This showed that providing participants with principled knowledge (why) and strategic information (how) during the learning phase assisted with performance during the test phase. The second finding was the Process condition had the highest Instructional Efficiency. The third finding was the mental effort ratings for Worked Example 2 during the learning phase for the Process and Product conditions were significantly lower than the Control condition (Part of Hypothesis 3). The fourth finding was the task difficulty ratings during the learning phase for the Control condition were significantly higher than the Product condition (Part of Hypothesis 4). The fifth finding was the task difficulty ratings for Worked Example 2 during the learning phase for the Control condition were significantly higher than both the Process and Product conditions (Part of Hypothesis 4). In addition, the sixth finding was the task difficulty ratings during the test phase for the Control condition were significantly higher than both the Process and Product conditions (Hypothesis 8), demonstrating that additional information to support understanding provided by the process oriented and product oriented worked examples assisted participants' application during the test phase.

Hypothesis statements including perceived mental effort ratings during the learning and test phase were not confirmed. In addition, hypothesis statements comparing perceived task difficulty ratings between the Process and Product condition during the learning and test phase were also not confirmed. Further, commentary from participants participating in the Control condition indicated greater engagement and enjoyment than participants in the remaining two instructional conditions (Process and Product). In addition, the Instructional Efficiency analysis undertaken in Experiment 1 showed some evidence of the Process condition as an efficient way of learning for novice participants, but not at the significant level. These inconclusive results gave scope to investigate in more depth what participants were doing when engaging with worked examples in an ill-structured learning domain. Study 2 builds on the findings of Experiment 1 by investigating, using a qualitative research approach, the thought processes of participants when learning about the characteristics of the New South Wales Quality Teaching Model (NSW QTM) element of substantive communication. There has been little research investigating the use of worked examples in ill-structured learning domains (Sweller et al., 2011, p.102) and how learners engage with and make meaning from worked examples in ill-structured learning domains due to research in the field of Cognitive Load Theory (CLT) being mainly quantitative in nature (Leppink & van den Heuvel, 2015). This research addresses this gap by investigating the efficacy of process oriented and product oriented worked examples in an ill-structured learning domain and how participants engage with and make meaning from them.

The participants in Experiment 1, pre-service teachers, were considered novices. Conducting Study 2 presented the researcher the opportunity to introduce participants considered as experts. Study 2 included both pre-service teachers (novices) and practicing teachers (experts) to investigate whether any differences emerged. This enabled the researcher to examine the differences between novice and expert participants and learn more about how these two cohorts engaged with worked examples presented in an ill-structured learning domain. The same three instructional conditions used in Experiment 1 were used in Study 2: Process condition, Product condition and Control condition.

Experiment 1 participants were pre-service teachers enrolled in either their first year of a two-year post-graduate Masters of Teaching programme or their final year of a four year Bachelor of Primary Education programme at an Australian regional university. Due to their limited knowledge of the NSW QTM and limited experience of classroom teaching, these participants were considered to be novices.

Participants for Study 2 included both pre-service teachers (classified as novices) and practicing teachers (classified as experts). The ‘novice’ participants were five pre-service teachers enrolled in the fourth year Bachelor of Education degree from the same Australian regional university as the Experiment 1 participants. As per Experiment 1, these participants were considered to be novices. The ‘expert’ participants were six practicing teachers recruited from secondary schools within a regional Catholic Education Diocese. Schools within this Education Diocese used the NSW QTM as the basis for their Diocesan Learning and Teaching Framework. Due to the participants' experience as practicing teachers and familiarity with the NSW QTM, they were considered to be experts.

Study 2 investigated the differences between experts and novices when they engage with and make meaning from the three different instructional conditions, enabling the researcher to examine the differences between and learn more about how these two cohorts engaged with worked examples presented in an ill-structured learning domain. Expert participants were included in Study 2 to provide the opportunity to investigate whether an Expertise Reversal Effect would occur. This CLT effect states that what is considered as effective instructional techniques for novices may not be as effective for experts; and can "even have negative consequences when used with more experienced learners" (Sweller et al., 2003, p. 23). A detailed discussion of the Expertise Reversal Effect can be found in Section 2.4 of the Literature Review.

The aim of Study 2 was to investigate:

1. How experts and novices engaged with the three different instructional conditions; Process condition, Product condition and Control condition
2. How experts and novices made meaning from the three instructional conditions.

The following two exploratory questions guided Study 2:

Research Question 1: When learning about the characteristics of substantive communication, how do novice and expert participants engage with and make meaning from the three different instructional conditions; Process condition, Product condition or Control condition within an ill-structured learning domain?

Research Question 2: When learning about the characteristics of substantive communication, how do novice and expert participants who have engaged with one instructional condition perceive the other two instructional conditions?

Study 2 adopted a qualitative research approach; the rationale for this approach and the methodology is elaborated below.

5.2 METHODOLOGY

5.2.1 Qualitative Research Approach

Study 2 adopted a qualitative research approach. Qualitative research "collects and works with non-numerical data and that seeks to interpret meaning for these data that help understand social life through the study of targeted populations or places" (Crossman, 2020, para. 1). Through qualitative research the researcher attempts to "make sense of, or interpret, phenomena in terms of the meanings people bring to them" (Denzin & Lincoln, 2005, p. 3). This involves seeking to "build rapport and credibility with the individuals in the study" through "open-ended observations, interviews and documents" involving "text (or word) data and images (or picture) data" (Creswell, 2003, p. 181). A qualitative research approach was used for Study 2, as there is little known about how novice and expert learners engage with and make meaning from worked examples in an ill-structured learning domain and how participant understanding is then used to answer questions. This is a novel approach in CLT, as usually quantitative methodologies are used to understand learning.

Approval to conduct Study 2 was received from the Human Research Ethics Committee at the University of Wollongong (Appendix K). A letter of information (Appendix L) was provided to participants with information on the purpose, description and procedures of the experiment. Each participant signed a consent form (Appendix M) prior to participating in Study 2. Study 2 was conducted during June and July 2018 with the pre-service teachers (novices) and during August and September 2018 with the practicing teachers (experts).

5.2.2 Participants

Participants for Study 2 included five pre-service teachers enrolled in their fourth year of the Bachelor of Education degree at an Australian regional university and six practicing teachers who taught in regional Diocesan schools. The pre-service teachers were considered as novices and the practicing teachers were considered as experts. Table 5.1 below provides the demographics and background of the five novice participants.

Table 5.1

Study 2 – Novice participants

Participant Code	Age	Gender	Program of Study
Mark	21	Male	Secondary Physical Development, Health and Physical Education (PDHPE)
Steve	27	Male	Primary Education
Jodie	27	Female	Secondary Science Education
Mandy	42	Female	Secondary Science Education
Nadia	23	Female	Secondary Science Education

Table 5.2 below provides the demographics and background of the six expert participants.

Table 5.2

Study 2 – Expert participants

Participant Code	Age	Gender	Teaching Background	Years of Teaching
Jenny	30	Female	English and PDHPE teacher	6
Sonia	50	Female	Ancient History, Geography and Society and Culture teacher	14
Albert	60	Male	Mathematics teacher	38
Jackie	33	Female	Life Skills teacher	10
Patrick	51	Male	Science, Maths, Physics and Chemistry teacher	28
Paolo	40	Male	Religious Education and PDHPE teacher	19

5.2.3 Instructional Materials

There were three phases to Study 2:

Phase 1 – Participants engaged with one instructional condition similar as in Experiment 1.

Phase 2 – Participants were introduced to the other two instructional conditions.

Phase 3 – Participants were asked to share their perceptions of how they could use worked examples in their own teaching.

Each of the phases are explained below.

Phase 1 of Study 2 required participants to engage in learning activities and tasks related to one instructional condition, followed by participants providing perceptions on their experience. Phase 1 of Study 2 used similar instructional materials as in Experiment 1, which included the following:

- A sixteen-slide PowerPoint presentation that provided a general introduction to the NSW QTM and more detailed information about the characteristics of substantive communication (Appendix D). This was the same PowerPoint that was used in Experiment 1. See Section 4.2.3.1 for further information.
- A video recording of a PDHPE lesson used as part of the worked example for each instructional condition. This was the same video recording of the PDHPE lesson that was used in Experiment 1. See Section 4.2.3.2 for further information.
- A participant booklet that supported the worked example and set tasks allocated to the designated instructional condition. Video recordings of a Visual Arts, History and Science lesson were also used to support the completion of set tasks in the participant booklet. The participation booklet was similar to the booklet that was used in Experiment 1. The booklet for Study 2 did not include a second worked example and included an additional History test item. See Section 4.2.3.3 for further information.
- Three of the four tasks used in Study 2 were used in Experiment 1. The same marking criteria was used to score these tasks (see Appendix H). Study 2 introduced an additional task. Marking criteria was developed for this new task (see Table 5.6).

The following modifications were made for Study 2 during Phase 1:

1. Participants completed the tasks individually or in pairs as opposed to a class environment. Pairing of participants was undertaken due to time constraints for both secondary school teachers and pre-service teachers.
2. Only one video recording of a lesson was used as a worked example. This modification was necessary as teachers and pre-service teachers had approximately 75 minutes available to complete Study 2.
3. A three-minute video recording of a History lesson, that was not used in Experiment 1, was shown to introduce a Coding task. The Coding task enabled the researcher to further investigate how novices and experts engaged with and made meaning with worked examples from the three different instructional conditions. See Section 2.8.2 for more information about Coding.
4. The researcher verbally asked participants questions on how they engaged with and made meaning during their experiences interacting with the three instructional conditions. Post task questions aimed to understand participants' perceptions on the differences, similarities and ease of understanding of each instructional condition.

Phase 2 required participants to engage with the remaining two instructional conditions, not as extensively as in Phase 1, but rather in summary format. This was to familiarise participants with these other two instructional conditions in order for them to compare with the first instructional condition. For example, if in Phase 1 participants were presented with the Process condition, they would then be presented with the Product and Control conditions in Phase 2. The materials used for Phase 2 included the following:

- The first minute of the video recording of the PDHPE lesson for the remaining two instructional conditions.
- Hard copies of the tables including the Coding of the PHDPE lesson for each instructional condition (see Appendix N).
- Verbal post task questions asked by the researcher to gather participants' perceptions of the remaining two instructional conditions.

Phase 3 involved the researcher verbally asking the participants how involvement in Study 2 provided them with ideas on how they may use worked examples in their own teaching. Appendix O provides the script the researcher read through during Study 2 and Appendix P includes the verbal questions asked during the three phases.

As per Experiment 1, the video recording of the PDHPE lesson and the referencing table included in the participant booklet constituted the worked example. The referencing table indicated the level of substantive communication and other information depending on the instructional condition. See Appendix Q for examples of annotations provided during the video recording of the PDHPE lesson for the Process and Product conditions. In addition, see Appendix F for the referencing tables included in the participant booklet for each of the instructional conditions.

5.2.4 Procedure

Study 2 comprised of three phases and was conducted over a 75 minute time period. Figure 5.1 below provides an overview of the Study 2 procedure. Each phase of Study 2 as included in Figure 5.1 is detailed below.

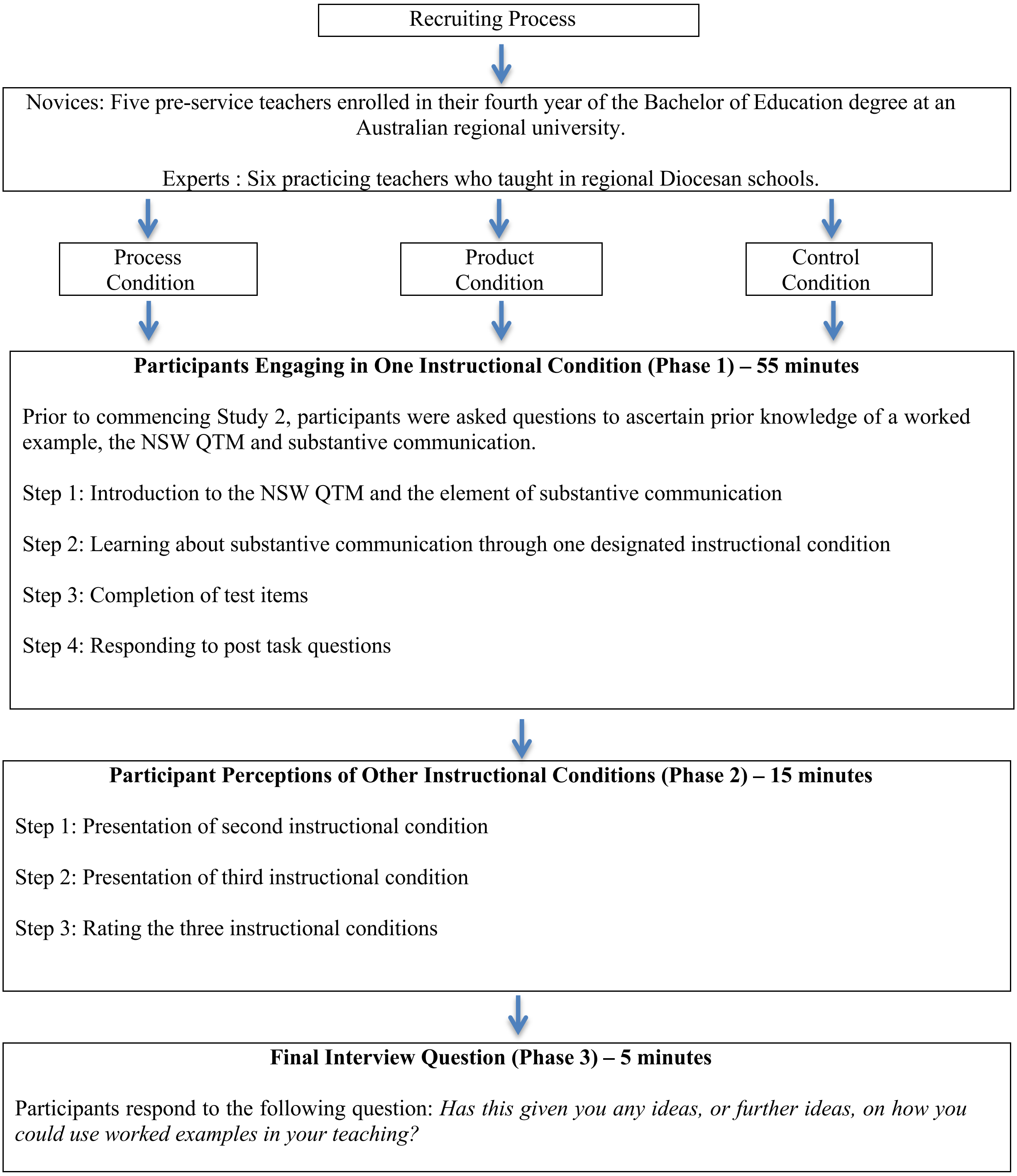

Figure 5.1. Study 2 procedure

5.2.4.1 Phase 1 – Participants Engaging in One Instructional Condition (55 minutes)

To commence Study 2, participants were organised in pairs and allocated to one of the three instructional conditions; Process, Product or Control. Pairing was undertaken due to time constraints for both secondary school teachers and pre-service teachers. There were two experts assigned to each of the three instructional conditions.

Two novices were assigned to the Process condition, but only one to the Control condition due to the unavailability of a second participant. There were two novices assigned to the Product condition, however due to changes in their availability, they completed the study individually. Table 5.3 below shows the initial instructional condition that novices were allocated to.

Table 5.3

Study 2 – Initial Instructional Conditions allocated to Novice participants

Participant Code	Instructional Condition
Mark	Process condition
Steve	Process condition
Jodie	Product condition
Mandy	Product condition
Nadia	Control condition

Table 5.4 below shows the initial instructional condition that experts were allocated to.

Table 5.4

Study 2 – Initial Instructional Conditions allocated to Expert participants

Participant Code	Instructional Condition
Jenny	Process condition
Sonia	Process condition
Albert	Product condition
Jackie	Product condition
Patrick	Control condition
Paolo	Control condition

As per Experiment 1, to ascertain the prior knowledge of each participant, prior to commencing the researcher asked the following questions:

1. What does the term 'Worked Example' mean to you?
2. Tell me what you know about the Quality Teaching Model?

3. Have you heard of the concept of substantive communication? What do you think it means?

For the purpose of Study 2, the researcher, based on his experience of the NSW QTM and substantive communication, developed a three-point scale to rate each participant's prior knowledge of substantive communication. Table 5.5 includes the criteria for each rating.

Table 5.5

Ratings of participants' prior knowledge of substantive communication

Ratings of Prior Knowledge of Substantive Communication	
High	Is able to clearly articulate the characteristics of substantive communication and the impact of substantive communication on learning in the classroom.
Medium	Familiar with the characteristics of substantive communication without specifically naming them and makes some reference to the impact of communication on learning in the classroom.
Low	Unfamiliar with the concept of substantive communication and makes limited to no reference to the impact of communications on learning in the classroom.

Phase 1 took 55 minutes and included the following steps:

Step 1: Introduction to the NSW QTM and the element of substantive communication

Irrespective of the instructional condition a participant was assigned, every participant received training on the NSW QTM with a focus on the element of substantive communication. The introductory training was presented by the researcher with the use of the same PowerPoint presentation used for Experiment 1 (see Section 4.2.3.1 and Appendix D).

Step 2: Learning about substantive communication through one designated instructional condition

As per Experiment 1, participants were assigned to an initial condition and were presented either the Process condition, Product condition or Control condition. As per Experiment 1, participants rated their perceived mental effort and perceived task difficulty after being presented with the worked example or engaging in conventional problem solving.

Step 3: Completion of Test items

Participants completed four tasks. Tasks 1, 3 and 4 were the same test items as administered during Experiment 1 (see Chapter 4, Table 4.3 for a description of these test items). As in Experiment 1, the descriptive data collected included the mean of task scores, perceived mental effort ratings and perceived task difficulty ratings. Even though the focus of Study 2 included qualitative data, these descriptives were calculated to provide further insight into the qualitative data. The marks allocated for Tasks 1, 3 and 4 were as per Experiment 1 (see Table 4.3 - note that Task 3 in Study 2 was administered as Task 2 in Experiment 1 and Task 4 in Study 2 was administered as Task 3 in Experiment 1).

Task 2 was introduced for Study 2. This task required participants to view a three-minute video recording of a History lesson. Following this, participants were required to Code the level of substantive communication present during the lesson and provide justification for their selection. Task 3 was allocated 3 marks. Table 5.6 below provides details as to how the three marks were allocated.

Table 5.6

Marking Criteria for Study 2 Task 2

TASK	NATURE OF QUESTION	MARK ALLOCATION	DESCRIPTION / EXAMPLES
Part A	Write written Code. The Correct Coding Score is 4.	Code 4 = 1 marks Code 5 = 0.5 marks Codes 1, 2 or 3 = 0 marks	The description for a Coding Score of 5 is much closer to the description for a Coding Score of 4, than is a Coding Score of 3.
Part B	Justification of Coding score to be given.	2 Marks	To score 2 marks, participants must provide detailed evidence i.e., gives more specific, not just generic descriptions. 2 Marks allocated only for a Code Score of 4 – the participant must give reasons as to why the Coding Score was not 5 e.g. more IRE at the beginning of the lesson. Substantive communication occurring for more than half the lesson must be include for a score of 2 marks – otherwise allocated a score of 1 mark. Justifications include substantive communication occurs for more than half the lesson, reference to low IRE, creates group discussions, asks students to elaborate etc.

Step 4: Responding to post task questions

Following the completion of the four tasks, participants were asked questions to ascertain how they (novices and experts) engaged with and made meaning from the Process condition, Product condition or Control condition within an ill-structured learning domain. The participant responses to the questions were audio recorded and later transcribed. Table 5.7 below includes the questions asked and the purpose of the questions.

Table 5.7

Phase 1 Post Task Questions

QUESTION	PURPOSE OF THE QUESTION
1. What did you do when the worked example was presented? Note: For the Control condition, the question was changed to "What did you do when the video lesson was presented?"	This question was asked to ascertain how the novice and expert participants were engaging with the worked example or engaging in conventional problem solving.
2. How did you use your time during the pauses?	This question was asked to investigate the thoughts of the novice and expert participants when reflecting on the annotations provided during the pauses in the video recordings of the PDHPE lesson.
3. Were the annotations during the pauses useful to you? Why? Note: The question in relation to annotations was not asked to participants during the Control condition.	This question was asked to further investigate how the principled knowledge (why) and strategic information (how) included in the Process and Product conditions supported novice and expert participants to make meaning.
4. Did the worked example help you understand the Coding Score that was given? Why? Note: For the Control condition, the question was changed to	This question was asked to ascertain if the worked example supported novice and expert participants to make meaning.

	"Did watching the video recording of the lesson help you understand the Coding Score that was given? Why?".	
5.	For the worked example, why did you rate the mental effort rating and the task difficulty rating as you did? Note: For the Control condition, the question was changed to "For the video recording of the PDHPE lesson, why did you rate the mental effort rating and the task difficulty rating as you did?".	This question was asked to ascertain why the novice and expert participants rated their mental effort and task difficulty as they did. This provides further information as to how beneficial the instructional condition they engaged in was.
6.	How did the worked example help or hinder you in answering the four tasks? Note: For the control condition, the question was changed to "How did watching the video recording of the PDHPE lesson help or hinder you in answering the four tasks?".	This question was asked to ascertain how useful the worked example or engaging in conventional problem solving was for novice and expert participants in the different instructional conditions to complete the related test items.

5.2.4.2 Phase 2 – Participant Perceptions of Other Instructional Conditions (15 minutes)

In Phase 2, participants were introduced to the remaining two instructional conditions. For example, if a participant assigned to the Process condition during Phase 1, which included watching the video recording of the PDHPE lesson, they then would be introduced to the Product condition and the Control condition during Phase 2. For each instructional condition in Phase 2, the participants viewed a one minute section of the video recording of the PDHPE lesson relevant to the instructional condition. Participants were also provided with the supporting documentation which included the relevant Coding information for the observed video recording of the lesson (Appendix N). Table 5.8 includes the order in which the instructional conditions were presented to the participants.

Table 5.8

Sequence of instructional conditions presented to participants

Instructional Condition 1 (Phase 1)	Instructional Condition 2 (Phase 2)	Instructional Condition 3 (Phase 2)
Process condition	Product condition	Control condition
Product condition	Process condition	Control condition
Control condition	Product condition	Process condition

Step 1: Presentation of the worked example for the second instructional condition

Participants viewed the first minute of the video recording of the PDHPE lesson for the second instructional condition. Participants were also shown the referencing table presented in the participant booklet corresponding to this instructional condition (Appendix N). Participants were then verbally asked a series of questions. Table 5.9 below includes the questions asked and the purpose of the questions.

Table 5.9

Phase 2 Task Questions for the Second Instructional Condition

QUESTION	PURPOSE OF THE QUESTION
1. This is a second type of worked example. Did you see any differences between the two worked examples presented, if so, what are they?	This question was asked to ascertain if the novice and expert participants were able to identify differences in the instructional conditions.
2. How did you use your time during the pauses?	As per Phase 1, this question was asked to investigate the thoughts of the novice and expert participants when reflecting on the annotations provided during the pauses in the video recordings of the PDHPE lesson.
3. Were the annotations during the pauses useful to you? Why? Note: The questions on annotations were asked for the Process and Product conditions only.	As per Phase 1, this question was asked to further investigate how the principled knowledge (why) and strategic information (how) included in the Process and Product conditions supported novice and expert participants to make meaning. Further, it enabled a comparison of how this instructional condition compared with the previous instructional condition the participant engaged in.
4. Of the two worked examples, which do you prefer? Why?	This question was asked to ascertain the preferred instructional condition for the novice and expert participants.

Step 2: Presentation of the worked example for the third instructional condition

Participants viewed the first minute of the video recording of the PDHPE lesson for the third instructional condition. Participants were also shown the referencing table presented in the participant booklet corresponding to this instructional condition (Appendix N). Participants were then verbally asked a series of questions. Table 5.10 below includes the questions asked and the purpose of the questions.

Table 5.10

Phase 2 Task Questions for the Third Instructional Condition

QUESTION	PURPOSE OF THE QUESTION
1. This is a third type of worked example. Did you see any differences to the other two worked examples presented? If so, what are they?	This question was asked to ascertain if the novice and expert participants were able to identify differences in the instructional conditions.
2. How did you use your time during the pauses?	As per Phase 1 and after being presented with the second instructional condition, this question was asked to investigate the thoughts of the novice and expert participants when reflecting on the annotations provided during the pauses in the video recordings of the PDHPE lesson.
3. Were the annotations during the pauses useful to you? Why? Note: The questions on annotations were asked for the Process and Product conditions only.	As per Phase 1, this question was asked to further investigate how the principled knowledge (why) and strategic information (how) included in the Process and Product conditions supported novice and expert participants to make meaning. Further, it enabled a comparison of how this instructional condition compared with the previous instructional conditions the participant engaged in.

Step 3: Rating the three instructional conditions

Participants were presented with screen shots of the different types of annotations included in the video recordings of the PDHPE lessons for the Process and Product conditions (Appendix Q). A screen shot of the corresponding Control condition was also presented (Appendix Q). In addition, the referencing table for each instructional condition indicating the level of substantive communication (Appendix N) was presented to the relevant participants. Participants were then verbally asked a series of questions. Table 5.11 below includes the questions asked and the purpose of the questions.

Table 5.11

Phase 2 Rating the Three Instructional Conditions

QUESTION	PURPOSE OF THE QUESTION
1. These are screen shots of the three worked examples that have been presented to you. Rate these 1 to 3, from the worked example you prefer the most to the worked example you prefer the least.	This question was asked to ascertain the preferred instructional condition for the novice and expert participants.
2. Why did you order the worked examples in this way?	This question was asked to ascertain why the novice and expert participants rated their preferences of the instructional conditions as they did.
3. Do you have suggestions on how these worked examples may be improved?	This question was asked to support the researcher better understand the needs of learners engaging with worked examples and the design of process oriented and product oriented worked examples.

5.2.4.3 Phase 3 – Final Interview Question (5 minutes)

The third phase of Study 2 took 5 minutes to complete. This phase involved participants responding to a question on how participation in Study 2 had provided them with ideas on how they may use worked examples in their own teaching. The exploratory question asked was: *Has this given you any ideas, or further ideas, on how you could use worked examples in your teaching?* This question was asked to determine how participants may apply learnings from Study 2 into their teaching practice.

5.3 DATA COLLECTION AND ANALYSIS

The researcher conducted face-to-face interviews with the participants and collected qualitative data (Creswell, 2014, p. 240). The interviews were audio recorded. The researcher audio recorded participant responses during Study 2; specifically step 4 of Phase 1, Phase 2 and Phase 3 of Study 2 (see Sections 5.2.4.1, 5.2.4.2 and 5.2.4.3). Further, when there were two participants, the researcher referred to them by name when they responded to aid in identifying them in the transcription. The transcripts allowed the researcher to analyse scripts for each of the participants and the instructional conditions. The researcher then checked the transcripts for accuracy by listening to each of the recordings. The researcher read the transcripts several times and completed a summary table with information for each participant for the following: Years of Experience, Discipline, Instructional Condition, Key Ideas, Summary of Key Issues and Notes on mental effort and task difficulty ratings.

Quantitative data was collected during Phase 1 of Study 2 comprising test performance scores, perceived mental effort ratings and perceived task difficulty ratings. This data was collected to triangulate the qualitative data. It is understood that the quantitative data represented non-statistically significant results and are presented to solely show trends in the data and accompany the qualitative data collected for Study 2. The researcher and the supervisors pilot marked the task responses to ensure validity of the marking criteria. The researcher analysed the quantitative data by comparing the trends of the collected data for the three instructional conditions.

The transcripts were analysed by performing qualitative coding. Coding is the "process of organising the material into 'chunks' before bringing meaning to those chunks" (Rossman & Rallis, 1998, p. 171). The researcher conducted qualitative coding to "identify different themes and the relationships between them" (Medelyan, 2020).

This included developing separate themes related to how the participants engaged with and made meaning from the three different instructional conditions. The researcher initially read through the transcripts several times to familiarise himself with the data (Nowell et al., 2017). Following this, the researcher coded the transcripts line by line and developed a series of codes (Nowell et al., 2017; Yi, 2018). Similar codes were then categorised allowing the researcher to "detect consistent and overarching themes" (Nowell et al., 2017; Yi, 2018). An example of how the researcher analysed the transcripts using qualitative coding to develop themes was using statements from participants such as "*that sort of altered how I approached the task"* to develop the theme of misconceptions. In this example, the participant's initial understanding of the level of substantive communication was incorrect. He had to alter his understanding based on the Coding Scale provided by the worked example. Appendix S shows an example of how the researcher analysed the transcripts using qualitative coding to develop themes.

An additional layer of analysis was conducted to explain how participants made meaning by relating what they said they did to the Bloom's Taxonomy to identify a 'learning approach' undertaken by each participant. The Bloom's Taxonomy aims to "classify educational goals and objectives and provide a framework for categorizing cognitive behaviors, which is an essential method in learning" (Ullah et al., 2020, p. 1629). In examining the transcripts, the researcher summarised what the participants did into verbs and identified that they followed a three-step pattern, for example, "Search, Match and Confirm". Thus, a three-word phrase was assigned to each participant to describe their learning approach. The learning approaches were not informed by previous research and were the interpretation of the researcher. The researcher then reviewed Bloom's Taxonomy to see how the verbs included in the learning approaches aligned with this framework. This enabled the researcher to order the verbs from highest order thinking to lowest order thinking. The order was also confirmed by two practicing expert teachers who taught in two different secondary schools from an Australian order of schools.

Figure 5.2 below is a diagram representing Bloom's Taxonomy and associated verbs. In the figure, LOTS represents lower order thinking skills and HOTS represents higher order thinking skills. An example of an approach adopted by a participant identified by the research is "reflect", a higher order thinking skill which is part of Evaluating.

Figure 5.2: Bloom's Taxonomy Verbs (TeachThought Staff, 2022).

5.4 SUMMARY

In this chapter, an overview of Study 2 was provided. The chapter commenced by outlining the purpose of conducting Study 2 which was to investigate what participants were actually doing when engaging with a worked example in an ill-structured learning domain, specifically a process or product oriented worked example. An account of the methodology then followed, which indicated that Study 2 focused on the analysis of qualitative data and introduced both the novice and expert participants. The expert participants were introduced in Study 2 to examine the differences between novice and expert participants and learn more about how these two cohorts engaged with worked examples presented in an ill-structured learning domain. Following this, a description of the instructional materials used for Study 2 and the procedure for Study 2 were presented. The procedure for Study 2 included three phases; participants engaging in one instructional condition, participants perceptions of other instructional conditions and final interview questions. The chapter then concluded with information on data collection and analysis, including information on the development of participant learning approaches. Chapter 6 presents the findings of the novice participants and Chapter 7 presents the findings of the expert participants.

Chapter 6

STUDY 2 – NOVICE PARTICIPANTS

6.1 INTRODUCTION

This chapter presents the findings of data collected from novice participants during the three phases of Study 2. The chapter firstly introduces each novice participant and then presents the findings from Phase 1 for each participant. This includes a summary of the non-statistical descriptive data for each novice participant, including test performance scores, perceived mental effort and perceived task difficulty ratings. Due to the sample size, the collected data represents non-statistically significant results and are presented to solely show trends in the data and accompany the qualitative data collected for Study 2. The term non-statistical descriptive data will be referred to as descriptive data throughout this chapter. This is then followed by a discussion on how each participant engaged with the learning materials in their instructional condition. Emerging themes from Phase 1 are then discussed. The chapter concludes with an analysis and findings of the novice participant responses from Phases 2 and 3 of Study 2 and an overall summary of key findings.

6.2 NOVICE PARTICIPANTS

Table 6.1 presents a summary of the five novice participants, in reference to participant's age, gender and enrolled university course. This is followed by a more detailed introduction for each participant, including a discussion on their prior knowledge of the New South Wales Quality Teaching Model (NSW QTM) and substantive communication. Refer to Chapter 5, Table 5.3 which includes the initial instructional condition allocated to each novice participant.

Table 6.1

Novice Participants

Participant	Age	Gender	Program of Study	Prior Knowledge
Mark	21	Male	Secondary Physical Development, Health and Physical Education (PDHPE)	Medium
Steve	27	Male	Primary Education	Low
Jodie	27	Female	Secondary Science Education	Low
Mandy	42	Female	Secondary Science Education	Low
Nadia	23	Female	Secondary Science Education	Low

Mark was a 21-year-old male pre-service teacher enrolled in his fourth year of a Bachelor of Physical Development, Health and Physical Education degree at an Australian regional university. When asked about his prior knowledge of the NSW QTM, he stated he knew the model comprised of Dimensions and Elements. He was able to state two of the Dimensions; Intellectual Quality and Quality Learning Environment. When asked about his prior knowledge of substantive communication, Mark demonstrated a medium understanding (see Table 5.5 for a definition of medium prior knowledge) as he was able to state one of the three characteristics of substantive communication; Reciprocal Communication, and made reference to the impact on learning in the classroom. Mark stated that he had learnt about the NSW QTM and the element of substantive communication in recent course lectures he had attended.

Steve was a 27-year-old male pre-service teacher enrolled in his fourth year of a Bachelor of Primary Education degree at an Australian regional university. When asked about his prior knowledge of the NSW QTM, he stated he knew one of the three Dimensions; Intellectual Quality, and two of the eighteen elements; Deep Understanding and Deep Knowledge. When asked about his prior knowledge of substantive communication, he demonstrated a low understanding of the concept of substantive communication as he was unable to refer to any of the three characteristics (see Table 5.5 for a definition of low understanding).

Jodie was a 27-year-old female pre-service teacher enrolled in her fourth year of a Bachelor of Science Education degree at an Australian regional university. When asked about her prior knowledge of the NSW QTM and substantive communication, she demonstrated a low understanding of both as she expressed that she was unfamiliar with the terms.

Mandy was a 43-year-old female pre-service teacher enrolled in her fourth year of a Bachelor of Science Education degree at an Australian regional university. When asked about her prior knowledge of the NSW QTM, Mandy stated she knew the model comprised of three Dimensions, which she referred to as "pillars". She was unable to name the three Dimensions. When asked about her prior knowledge of substantive communication, she demonstrated a low understanding as she stated she was unfamiliar with this term.

Nadia was a 23-year-old female pre-service teacher enrolled in her fourth year of a Bachelor of Science Education degree at an Australian regional university. When asked about her prior knowledge of the NSW QTM and substantive communication, she demonstrated a low understanding of both as she was unable to refer to any of the three characteristics of substantive communication.

6.3 FINDINGS FROM PHASE 1

The following section presents the descriptive data from Study 2. This includes the test performance scores, the perceived mental effort and perceived task difficulty ratings. Following this, a description of how each novice participant engaged with the worked example is included. The section concludes with a discussion on the identified themes and how they relate to the presented descriptive data.

6.3.1 Summary of Descriptive Data

The five novice participants completed four test items during Phase 1 of Study 2. The following section presents the descriptive data for these tasks.

Table 6.2 provides a description of each task.

Table 6.2

Test Item Descriptions

Task Number	Test Item Descriptions
Task 1	Name and identify the three characteristics of substantive communication from a vignette.
Task 2	Provide and justify a Coding Score for a lesson
Task 3	Indicate whether a characteristic of substantive communication was present, justify their response and provide strategies to enhance the presence of the characteristic.
Task 4	View a lesson and suggest strategies on how to enhance the presence of two characteristics.

Table 6.3 shows test performance scores for each novice participant.

Table 6.3

Test Performance Scores for Novice Participants

Performance Scores – Novices						
Instructional Condition	Participant	Total (16 Marks)	Task 1 (6 Marks)	Task 2 (3 Marks)	Task 3 (3 Marks)	Task 4 (4 Marks)
Process Condition (N=2)	Mark	11.5	4.0	1.5	3.0	3.0
	Steve	11.0	3.5	1.5	3.0	3.0
Product Condition (N=2)	Jodie	7.5	1.0	2.5	3.0	1.0
	Mandy	10.0	3.5	1.5	3.0	2.0
Control Condition (N=1)	Nadia	6.0	3.0	2.0	1.0	0.0

The test performance scores showed a trend towards the Process condition scoring the highest marks. The two participants from this instructional condition had the highest total test performance score of all participants. Conversely, the participant who engaged in the Control condition scored the lowest mark.

Participants in Study 2 rated their perceived mental effort and perceived task difficulty at the completion of the learning phase and after each test item during the Test Phase. Table 6.4 below shows the perceived mental effort ratings for the novice participants.

Table 6.4

Perceived Mental Effort Ratings for Novice Participants

Instructional Condition	Participant	Worked Example (9)	Task 1 (9)	Task 2 (9)	Task 3 (9)	Task 4 (9)	Mean of Tasks (9)
		Perceived Mental Effort Ratings – Novices					
Process Condition (N=2)	Mark	3.0	7.0	4.0	4.0	6.0	5.25
	Steve	6.0	6.0	5.0	3.0	4.0	4.5
Product Condition (N=2)	Jodie	6.0	8.0	2.0	4.0	4.0	4.5
	Mandy	3.0	8.0	8.0	3.0	4.0	5.75
Control Condition (N=1)	Nadia	4.0	7.0	8.0	7.0	6.0	7.0

The perceived mental effort ratings across the three instructional conditions for the worked example were similar. The highest individual perceived mental effort rating was rated by Jodie in the Product condition and Steve in the Process condition. Overall, the perceived mental effort rating across the test items was highest for Nadia from the Control condition. The participants from the Process and Product conditions rated similar perceived mental effort ratings for the test items.

Table 6.5 below shows the perceived task difficulty ratings for the novice participants.

Table 6.5

Perceived Task Difficulty Ratings for Novice Participants

Perceived Task Difficulty Ratings – Novices							
Instructional Condition	Participant	Worked Example (9)	Task 1 (9)	Task 2 (9)	Task 3 (9)	Task 4 (9)	Mean of Tasks (9)
Process Condition (N=2)	Mark	3.0	8.0	5.0	3.0	5.0	5.25
	Steve	7.0	8.0	3.0	4.0	6.0	5.25
Product Condition (N=2)	Jodie	5.0	8.0	2.0	3.0	7.0	5.0
	Mandy	2.0	6.0	7.0	3.0	4.0	5.0
Control Condition (N=1)	Nadia	6.0	7.0	7.0	6.0	7.0	6.75

Perceived task difficulty ratings for the worked example were highest for Steve in the Process condition and Nadia in the Control condition. The lowest ratings were for Mark in the Process condition and Mandy in the Product condition. Nadia from the Control condition rated the highest perceived task difficulty for the test items, and the ratings for the Process and Product conditions were similar.

The test performance scores indicated that the Process condition scored the highest marks, the rating for perceived mental effort for the worked example was highest for the Process condition and the overall perceived mental effort rating for the test items was highest for the Control condition. The overall perceived task difficulty rating for the test items was highest for the Control condition. Overall, this descriptive data is consistent with existing research findings for novices presented with worked examples in well-structured learning domains.

6.3.2 How Participants Engaged with and Made Meaning from their Assigned Instructional Condition

The following section explains how novice participants engaged with and made meaning from their assigned instructional condition. What participants reported verbally was coded by the researcher to identify key words to encapsulate each participant's thinking process and learning approaches they adopted to make meaning. Table 6.6 below defines and provides details on learning approaches adopted by the novice participants and includes a list of the approaches identified by the researcher based on the verbal protocols provided by the novice participants. The table also includes phrases made by the novice participants that the researcher used to align with the included approaches. These were developed from the responses to questions provided by the participants during Study 2. Further, the approaches are listed from highest to lowest cognitive order using Bloom's Taxonomy (Stanny, 2016). The researcher used lists of associated verbs contained in models of Bloom's Taxonomy, such as Figure 5.2, to make a decision on the cognitive order of the approaches. See Section 5.3 for further details.

Table 6.6

Definitions of Key Words for Approaches Adopted by Novice Participants to Make Meaning

Key word	Definition (Bloom's Taxonomy Thinking Skill)	How this was identified from the data	Example of an excerpt from the data (Novices)
1. Modify	To make partial changes in; change somewhat. (Creating)	The participant refers to altering their prior understanding of a concept	*I disagreed with the book's scale but I compared the two and then used that to alter my responses in the future (Steve, Process).*
2. Reflect	To think; meditate, ponder and deliberate. (Evaluating)	Use of the word reflect by the participant.	*It gave me a bit of time to reflect and in my head, tick off… you know. (Nadia, Control).*
3. Compare	To find out how things are alike and how they are different. (Analyzing)	Use of the word compare by the participant. The participant refers to comparing prior knowledge with information provided in the worked example.	*I disagreed with the book's scale but I compared the two and then used that to alter my responses in the future (Steve, Process).*
4. Identify	To recognize as being a particular person or thing. (Analyzing)	Use of the word identify by the participant.	*… that helped identify where in the lesson the substantive communication actually occurred (Mark, Process).*

5.	Confirm	To prove to be true or correct. (Applying)	The participant makes a statement indicating an understanding of the level of substantive communication.	*Yes, so they were useful to me as I was able to use those to reflect on the snippet prior to that, and go, ok yes that explains what happened, and then relate it to the actual element of the Quality Teaching Framework (Mark, Process).*
6.	Match	To find items that correspond. (Understanding)	The participant refers to matching annotations on the video recording to information in the referencing table or interactions during the video recording.	*I used the video and the annotations on it, and then I referred back to the pages (Steve, Process).*
7.	Interpret	To understand or construe in a particular way. (Understanding)	The participant makes reference to thinking and reflecting on own understanding to make meaning.	*After every answer from the teacher or the student, it flicked on the screen what was "evident" and what was not, and it was pretty obvious that if the teacher didn't expand on it or ask another open question to explore what the student meant, then that was a "non-evident" communication (Mandy, Product).*
8.	Search	To examine in order to discover. (Understanding)	The participant makes a statement referring to seeking for elements of substantive communication.	*I guess it was good to have this here so I could look at the video and say, "Oh, substantive interactions, yes, that's been done (Nadia, Control).*
9.	Check	To prove true or right by comparing or examining. (Understanding)	The participant makes a statement in relation to reading and agreeing with provided information.	*I was reading the text on the screen and yeh, agreeing with most of them (Jodie, Product).*
10.	Observe	To see and note; notice. (Remembering)	The participant refers to watching the video and not engaging with any other material.	*When the video was on, I was just trying to engage with the video and I didn't actually refer to the sheet or anything else; just focusing on just one thing at a time (Mandy, Product).*

11. Memorise	Commit to memory; learn by heart. (Remembering)	The participant refers to committing information to memory.	*Just maybe trying to remember all the definitions of the code because I knew I'd have to recall it later but I don't know if I did that well enough (Mandy, Product).*

6.3.3 Mark - Process Condition

Mark's strategy of how he interacted with the Process condition can be deduced as an "identify, match and confirm" learning approach. This was identified from the verbal protocols provided by Mark. Mark engaged with the Process condition by reading the annotations in the video and the information in the referencing table to identify occurrences of substantive communication. Mark stated that he reviewed the Coding Score included in the referencing table before and after the video recording of the lesson. This enabled him to connect and match the information in the referencing table with the annotations on the video recording and supported him in confirming and understanding the reasoning behind the Coding Score. The following statement demonstrated Mark *identifying* key occurrences of substantive communication;

> *… that helped identify where in the lesson the substantive communication actually occurred.*

The following statement demonstrated Mark *matching* the annotations during the video recording to the information provided in the referencing table;

> *I used the video and the annotations on it, and then I referred back to the pages.*

The following statement demonstrated how Mark *confirmed* his understanding of substantive communication;

> *Yes, so they were useful to me as I was able to use those to reflect on the snippet prior to that, and go, ok yes that explains what happened, and then relate it to the actual element of the Quality Teaching Framework.*

Mark added that the principled knowledge (why) provided by the additional information included in the process oriented worked example through the annotations, supported him in engaging with the worked example and to make meaning of the concept of substantive communication;

> *By looking at the Coding Scale before, and then using the Coding Scale we could look at why it was ranked 4, so you could annotate it on the lesson where and why they had given that.*

Mark said that whilst watching the process oriented worked example, he was able to focus on the lesson and did not need to think about the level of substantive communication present due to the annotations providing this information. However, due to the length of the Process condition, he indicated that he was only able to focus on one of the three elements (characteristics) of substantive communication, shown by the following;

> *I was trying to think of what the things were and I think I focused on one of the three.*

The Process condition hindered Mark in completing the four test items as he indicated that he was reliant on the annotations provided by the process oriented worked example, as shown by:

> *… the worked example hindered what I could do in the other four tasks due to the fact that I was kind of reliant on the annotations to make some decisions about it.*

In summary, Mark adopted an "identify, match and confirm" learning approach to make meaning of the Process condition. The principled knowledge (why) provided by the annotations and in the referencing table, supported Mark to make meaning. In addition, Mark's prior knowledge of substantive communication, identified as a medium understanding, may have also supported Mark in engaging with the process oriented worked example. The length of the process oriented worked example was a hinder to Mark as he focused on only one of the three characteristics of substantive communication. Mark's statements showed that he relied on the annotations provided during the process oriented worked example.

6.3.4 Steve - Process Condition

Steve's strategy of how he interacted with the Process condition can be deduced as a "compare, interpret and modify" learning approach. This was identified from the verbal protocols provided by Steve. Steve engaged with the Process condition by drawing upon his own medium prior knowledge of substantive communication and compared this to the information provided in the referencing table and the annotations in the video recording of the lesson. He then used this to interpret and modify his understanding of substantive communication. The following statement demonstrated how Steve initially *compared* his own understanding of substantive communication with the information provided in the referencing table;

> *So, I compared to what I had my understanding of it, to what the book scale was.*

The following statement demonstrated how Steve *interpreted* occurrences of substantive communication during the process oriented worked example based on his own prior knowledge;

> *I actually disagreed with the scale used in the book because although they asked for elaborations with substantive communication, they then dropped back to using IRE with the student responses. So, in my mind that didn't qualify as substantive communication to me.*

The following statement demonstrated how Steve *modified* his understanding of substantive communication;

> *I disagreed with the book's scale but I compared the two and then used that to alter my responses in the future.*

This is further shown by;

> *So, even though they gave it a four, I would personally have given it a lower score, and so, I guess that sort of altered how I approached the task.*

Steve indicated that the principled knowledge (why) provided by the additional information included in the process oriented worked example through the annotations, supported him in engaging with the worked example and making meaning of the concept of substantive communication;

They were useful because they gave me a guideline on what sort of things you pay attention to for substantive communication, also, what other people consider substantive communication to be.

The support provided by the process oriented worked example annotations is further shown by Steve's comment;

It did help give you clarity to why.

The multiple references to the characteristics of substantive communication also supported Steve in engaging and making meaning;

I didn't get all of this and so it makes it a bit more challenging, but over the worked examples, because we did multiples of them, they got easier each time.

The length of the process oriented worked example hindered Steve in completing the test items, specifically the test items that did not reference key words of the characteristics of substantive communication;

Because of the length it initially hindered me on the tasks where it didn't give a definition of what it was or like the key words, so for tasks that told you that substantive communication or substance, I found them easy because it triggered what I am looking for in my mind, but for tasks where it didn't, I had mind mental blanks.

Steve added that he focused on only one of the three characteristics of substantive communication during the Process condition as he could not remember the others;

I completely forgot about substance and focused only on sustained interaction … I couldn't talk about the topics or the components of substantive communication, because I couldn't remember the names for them, and so that really affected my capacity to answer those questions.

Steve also indicated that the Process condition hindered him in completing the four tasks as he was reliant on the annotations provided by the worked example, as shown by:

You sort of aren't fully engaging with it because you've got all the answers provided. You just sort of look at it, and go, oh yeah, I get this, I get this, and then when it comes to you doing it, you're actually, I didn't get all of this.

In summary, Steve adopted a "compare, interpret and modify" learning approach to make meaning of the Process condition. The principled knowledge (why) provided by the annotations and in the referencing table and the multiple references to the characteristics of substantive communication supported Steve to make meaning after initially disagreeing with the information provided. What is evident is that the annotations challenged Steve's prior knowledge, and he modified his prior understandings. The length of the process oriented worked example hindered Steve as he focused on one of the three characteristics of substantive communication as he was unable to remember the others. Steve said he relied on the annotations provided during the worked example.

6.3.5 Jodie - Product Condition

Jodie's strategy of how she interacted with the Product condition can be deduced as a "check, interpret and modify" learning approach. This was identified from the verbal protocols provided by Jodie. Jodie engaged with the Product condition by checking her own understanding of key occurrences of substantive communication, interpreting occurrences that she did not agree with and then modifying her understanding. Jodie demonstrated a low prior knowledge of the concept of substantive communication. The following statement demonstrated how Jodie *checked* her understanding of substantive communication by reading the annotations provided during the video recording;

I was reading the text on the screen and yeh, agreeing with most of them.

The following statement demonstrated Jodie *interpreting* the information provided during the video recording;

> *I tried to align why, if I did not understand one of the examples had a certain word on the screen for communication, understanding why I didn't initially think that, by looking at the table when the definitions were there.*

The following statement demonstrated how Jodie *modified* her understanding of substantive communication;

> *There was one where I was still a little confused. But having this example and realising that the coding score of four is half, familiarising my mind with that, yeh it was a good way of understanding what a four would look like in the classroom.*

This is further evidenced by the following statement;

> *I think the ones where originally, I wouldn't have considered it substantive, like a high level of substantive communication, it made me reconsider if my definition in my head was correct.*

Jodie also indicated that she found it difficult to understand the complexity of the concept of substantive communication. The lack of principled knowledge (why) added to the complexity of the task;

> *Yes, I think I was still trying to fully understand the complexity of substantive communication … Understanding the logic in the ratings that were given on the screen was the harder part.*

Contrary to how Jodie stated that she found difficulty in understanding the complexity of substantive communication, she added that the information provided by the product oriented worked example, including the referencing table, supported her to make meaning;

> *Because I think I had the definitions in front of me to refer to, I found them very handy.*

This is further shown by the following;

> *Yes, I feel the worked example helped me in understating how to define substantive communication.*

While engaging with the product oriented worked example, Jodie indicated that she disagreed with some of the annotations based on her own prior knowledge and understanding. She used the worked example to modify her understanding of the concept of substantive communication to make meaning;

> *I think the ones where originally I wouldn't have consider it substantive, like a high level of substantive communication, it made me reconsider if my definition in my head was correct. So, I guess having the sheet in front of me with the definitions was good, for that purpose.*

The above comments indicate that the Product condition supported Jodie in defining substantive communication, but the lack of principled knowledge (why) hindered her in understanding why.

Jodie indicated that the product oriented worked example supported her to understand how to define substantive communication, but stated that she developed a reliance on the annotations and preferred to have access to the referencing table when completing the test items, as shown by;

> *… it may have also hindered me because I felt like I wanted to refer to these definitions again, and have the table ready for me to go.*

The inability to write notes during Study 2 also hindered Jodie in engaging and making meaning, as shown by the following;

> *I wish I could have had a pen in my hand to go, ok, well that's when I'm ticking this box and so on, to then, I guess mark as I go as opposed to watch and then have to think, I guess that's just my way of thinking, the way I am.*

In summary, Jodie adopted a "check, interpret and modify" learning approach to make meaning of the Product condition. The strategic information (how) provided by the annotations and in the referencing table, supported Jodie to make meaning and define substantive communication. Jodie made reference to requiring the inclusion of principled knowledge (why) in the worked example to further support her to make meaning and developed a reliance on the annotations provided during the product oriented worked example.

6.3.6 Mandy - Product Condition

Mandy's strategy of how she interacted with the Product condition can be deduced as an "observe, memorise and interpret" learning approach. This was identified from the verbal protocols provided by Mandy. Mandy engaged with the Product condition by reading the annotations in the video. She demonstrated a low prior knowledge of substantive communication. Mandy indicated that while watching the video recording of the lesson during the Product condition, she focused on one concept at a time and tried to memorise definitions and characteristics. While reading the annotations during the video recording, Mandy interpreted the annotations and presence of substantive communication based on her observations of the video to make meaning. The following statement demonstrated Mandy *observing* for key occurrences of substantive communication during the video recording;

> *When the video was on, I was just trying to engage with the video and I didn't actually refer to the sheet or anything else; just focusing on just one thing at a time.*

The following statement demonstrated Mandy attempting to *memorise* information provided during the learning phase;

> *Just maybe trying to remember all the definitions of the code because I knew I'd have to recall it later but I don't know if I did that well enough.*

This is further evidenced by the following statement;

> *Yes, the worked sample was useful and I used it mentally just to remember, you know, reciprocal and open questions or the fact that the teacher asked other students to add to the answers.*

The following statement demonstrated Mandy *interpreting* the information provided during the video recording;

> *After every answer from the teacher or the student, it flicked on the screen what was "evident" and what was not, and it was pretty obvious that if the teacher didn't expand on it or ask another open question to explore what the student meant, then that was a "non-evident" communication.*

Mandy referred to the annotations as "useful" as they indicated the presence or absence of substantive communication;

> *Yes, they were very useful because it was just scaffolding the answers – what was evident and what wasn't evident.*

This is further shown by the following;

> *It definitely helped because it was so scaffolded that you could use it to kind of relate as to what was good and what wasn't.*

Mandy indicated that even though she found the annotations useful as they scaffolded the answers for her, the annotations did not provide the principled knowledge (why) for her to understand why the Coding Score was given. This is shown by the following;

> *Not really because the coding is quite complex; there's a lot of definitions, whereas the video is just "evident" or "not evident" and you had to really explain why. You couldn't discern between the zero to five. I mean it was just "evident" or "not evident" basically.*

The lack of principled knowledge (why) hindered Mandy to make meaning is also shown by;

It was difficult to discern what level you'd give it … I think I gave one of them a three and it was only maybe a four-minute video and I was supposed to assume that was only one or two interactions, whether that could have occurred or not.

Mandy indicated that including the Coding Scores with the annotations on the screen would have supported her further in understanding the different levels of substantive communication;

Probably attach a code, like the number to it, whether it was zero or five.

Different Key Learning Areas including PDHPE, History, Visual Arts and Science, presented in the test items also hindered Mandy's engagement and ability to make meaning;

It's difficult to say because it became History and then Art and then Science and they were completely different subjects.

In summary, Mandy adopted an "observe, memorise and interpret" learning approach to make meaning of the Product condition. The strategic information (how) provided by the annotations and in the referencing table, supported Mandy to make meaning and define substantive communication. Mandy used memorization as a strategy to remember key concepts and then matched these to events during the video recording of the lesson. Mandy made reference to requiring the inclusion of principled knowledge (why) in the worked example to further support her to make meaning. The different Key Learning Areas (subject areas) presented during the Product condition hindered Mandy's engagement and ability to make meaning. This provided further evidence of Mandy as a novice learner as the characteristics of substantive communication are consistent across different Key Learning Areas.

6.3.7 Nadia - Control Condition

Nadia's strategy of how she interacted with the instructional material during the learning phase can be deduced as a "search, reflect and guess" learning approach. This was identified from the verbal protocols provided by Nadia. Nadia engaged in the Control condition of conventional problem solving by watching the video and reading the information in the referencing table. As there were no annotations included, Nadia used this time to reflect on the presence of substantive communication during the video recording of the lesson and then guessed to make meaning of substantive communication. Nadia demonstrated a low prior knowledge of substantive communication. The following statement demonstrated Nadia *searching* for key occurrences of substantive communication;

> *I guess it was good to have this here so I could look at the video and say, "Oh, substantive interactions, yes, that's been done".*

The following statement demonstrated how Nadia *reflected* on the presence of substantive communication:

> *I guess it gave me a bit of time to reflect and in my head, tick off… you know, "No, there was none of reciprocal but there was some of this and there was some of that".*

The following statement demonstrated how Nadia used an approach *of guessing*;

> *It's super annoying to have to break that down to be able to understand that because it's so pedantic, but, I guess that part I just kind of have to guess and I could have a complete misunderstanding from it but we don't know I guess.*

This is further evidenced by the following statement;

> *When I watched it, I can guess what they're referring to with the ones that did and didn't happen … You know, maybe I thought that Reciprocal Communication wasn't happening but it was and it was actually another thing and I had a complete misunderstanding of it.*

Nadia added that the video recording of the lesson and the referencing table provided her with a scaffold that she used to support her to make meaning. She recognized that she was required to identify and make judgements on the three characteristics of substantive communication, as shown by the following;

> *I guess it helped because it gave me a kind of scaffold to work off mentally.*

The lack of principled knowledge (why) and strategic information (how) provided by conventional problem solving hindered Nadia to make meaning;

You know, it says it in the description, but it doesn't really explain why, it doesn't say, "Well in this part where the teacher asked a 'question and the student just said, 'Yep' and the teacher went, 'Okay'." They didn't really describe why.

The lack of principled knowledge (why) and strategic information (how) also caused Nadia to question her own understanding and judgment of the level of substantive communication present, as shown by the following;

You know, maybe I thought that Reciprocal Communication wasn't happening but it was and it was actually another thing and I had a complete misunderstanding of it.

Nadia's uncertainty as to why a Coding Score of 4 was allocated caused her to "guess" to make meaning;

So, it's super annoying to have to break that down to be able to understand that because it's so pedantic but I guess that part I just kind of have to guess and I could have a complete misunderstanding from it but we don't know I guess.

Nadia added that the pauses during the video recordings supported her in engaging and making meaning as she used the time to reflect on why a Coding Score of 4 was allocated and was matching characteristics of substantive communication to events during the video recording of the lesson;

I guess it was good because it broke up little bits, like little tiny snippets and I could say, "Yep, that didn't happen, that did happen, that did happen, but it's all contextual". So, I guess it gave me a bit of time to reflect and in my head, tick off.

Further to the comment above, Nadia indicated that the absence of pauses included in the video recordings during the test items hindered her to make meaning as she was trying to remember the characteristics of substantive communication during successive tasks without the time to reflect. This is shown by;

> *There were no pauses … I guess it doesn't really have anything to do with the worked example. My problem is just that it was difficult to be able to define things as "Yes", "No" or "Maybe" … there was no time to reflect.*

Nadia also stated that she was reliant on the referencing table while completing the test items;

> *I wanted to refer back to the writings and they're not there. I want to look at the wordings and then tick them off looking at the words, not just off my memory". So, I would say it made me dependent on using them but no, that was so necessary in the first place.*

In summary, Nadia adopted a "search, reflect and guess" learning approach to make meaning. The information provided by the referencing table supported Nadia in defining substantive communication. Nadia made reference to requiring the inclusion of principled knowledge (why) to further support her make meaning. The pauses during the video recording of the lesson supported Nadia as it gave her time to think. However, the absence of pauses while completing the test items hindered Nadia in making meaning, as she was unable to reflect on the presence of substantive communication during the lesson. Nadia indicated increased difficulty in remembering characteristics while completing successive tasks and developed a reliance on the referencing table and the pauses during the video.

6.3.8 Emergent Themes

From the qualitative data analysis conducted (refer to section 5.3), three themes emerged from Phase 1:

1. The approach adopted to make meaning was influenced by the instructional condition.
2. Participant prior knowledge and the length of the worked example influenced engagement and meaning making.
3. The descriptive data aligned with findings about worked examples in well-structured learning domains.

These are discussed as follows.

6.3.8.1 The Approach Adopted to Make Meaning was Influenced by the Instructional Condition

A summary of the overall learning approach adopted by each participant and their prior knowledge is listed below in Table 6.7. The table includes each participant's name, the instructional condition they engaged in, their prior knowledge of substantive communication and their identified learning approach. The rank of each key word, as provided in Table 6.6 is included to show how the learning approach adopted by each participate relates to the cognitive order or level of thinking based on Bloom's Taxonomy.

Table 6.7

Summary of Learning Approaches Adopted by Novice Participants to Make Meaning

Participant	Instructional Condition	Prior Knowledge	Learning approach
Mark	Process condition	Medium	Identify (#4), match (#6) and confirm (#5)
Steve	Process condition	Low	Compare (#3), interpret (#7) and modify (#1)
Jodie	Product condition	Low	Check (#9), interpret (#7) and modify (#1)
Mandy	Product condition	Low	Observe (#11), memorise (#10) and interpret (#7)
Nadia	Control condition	Low	Search (#8), reflect (#2) and guess (#12)

This table provides insight about the learning approach each participant undertook to make meaning and shows a pattern where higher order thinking was more evident from participants in the Process condition than participants in the Product and Control conditions. For example, the learning approach adopted by Steve (Process condition) represents a higher level of thinking than the learning approach adopted by Mandy (Product condition) and Nadia (control condition) based on the ranking of key words listed in Table 6.6. This suggests that the principled knowledge (why) and strategic information (how) provided by the Process condition supported participants to engage in a deeper manner than participants in the other instructional conditions because the worked example solution was made explicit and thus the participants did not have to search, memorise and guess, as did Mandy (Product condition) and Nadia (Control condition).

The learning approach of "search" was used only by Nadia (Control condition). This may be due to the inclusion of the principled knowledge (why) and strategic information (how) in the Process and Product conditions, which reduced the need for these participants to search for information to make meaning. Due to the participants not being required to "search" to make meaning, as this information is provided, this may have reduced the burden on their working memory (WM), thus enabling the participants to use their limited WM resources in a concentrated meaningful way to better understand the problem.

Mark and Steve (Process condition), who did not use a "search" approach, both stated they became reliant on the annotations included in the process oriented worked example when completing the test items. This may be a contributing factor to the participants stating they became reliant on the annotations included during the worked example while completing the test items. In addition, Jodie and Mandy (Product condition) also did not use the "search" approach to support them to make meaning. The inclusion of the strategic information (how) in the product oriented worked example may have reduced the need for the participants to search for information to make meaning allowing them to use their limited WM resources in a more meaningful way. Further, the lack of principled knowledge (why) included in the Product condition and the participants' limited prior knowledge prevented them from confirming their understanding with confidence. Overall, the learning approaches adopted by Jodie and Mandy included approaches that illustrated higher order thinking, as listed in Table 6.6. However, Table 6.7 shows that their learning approaches are slightly lower in terms of higher order thinking compared to the Process condition and overall, higher than the Control condition.

Nadia's limited prior knowledge, coupled with the lack of principled (why) and strategic information (how) included in the Control condition, did not enable her to engage deeply with the learning phase instructional material or make an informed decision on the level of substantive communication. This is shown by how she stated she had to "guess" to make meaning. Further, due to the lack of information provided by the instructional condition, Nadia used "search" and "guess" as approaches, demonstrating the use of a means-ends analysis approach to make meaning.

Overall, the findings suggest that the principled knowledge (why) and strategic information (how) included in the process oriented worked example allowed participants to engage more deeply with the worked example than participants presented with other instructional conditions. The researcher did not identify the "search" approach from the four novice participants who were presented with either the Process or Product condition. The participants were using other similar approaches to "search". These included identify, compare and observe. This may be due to the inclusion of the principled knowledge (why) and/or strategic information (how) providing participants with the information they required through the annotations, removing their need to "search". In addition, it may be due to the participants' low prior knowledge not enabling them to search to make connections with prior knowledge, but using these other approaches to make connections between the presented information. The findings suggest that worked examples, in particular process oriented worked examples, support novice participants to engage and make meaning within an ill-structured learning domain.

6.3.8.2 Participant Prior Knowledge and the Length of Worked Example Influenced Engagement and Meaning Making

The participant's prior knowledge and length of worked example may have influenced engagement and meaning making. The higher test performance scores and lower perceived task difficulty ratings of the participant with medium prior knowledge showed how participant prior knowledge may have influenced engagement and meaning making. The higher perceived mental effort rating of one the participants of the Process condition and commentary made by both participants of this instructional condition, showed how the length of the worked example may have influenced their engagement with the instructional material.

Steve (Process condition) rated the highest perceived mental effort rating during the Learning Phase, which he attributed to the length of the worked example and the need to modify his prior understanding of substantive communication. This result may align with findings from recent studies in CLT showing that time for completing tasks may also be a form of extraneous cognitive load (Barrouillet & Camos, 2012; Puma et al., 2018). Mark (Process condition) stated that due to the length of the worked example, he was only able to focus on one of the three elements (characteristics) of substantive communication. However, Mark's total performance score of 11.5/16 was the highest of the participants. This result does not support his comment that he focused on only one characteristic, as there were three characteristics and the test items included questions on each of these.

Mark and Steve (Process condition) stated they both focused on one of the three characteristics of substantive communication while engaging with the process oriented worked example. They stated that they found it difficult to remember all three characteristics due to the length of the process oriented worked example. In previous Cognitive Load Theory (CLT) research such as the Modality Effect (Rummer et al., 2011) and Transient Information Effect (Wong et al., 2012), the length of instruction has been shown to hinder learning. This also aligns with CLT in that it "asserts that learning is hampered when WM capacity is exceeded in a learning task" (de Jong, 2010, p. 106), as humans only having the capacity to process a finite amount of information in the auditory and visual channels (Mayer & Moreno, 2003).

Mark's medium prior knowledge may also have been a factor in how he engaged with the Process condition. This is evidenced by how he stated that he was able to "confirm" his understanding to make meaning. Without prior knowledge, he would have been unable to confirm his understanding. In contrast, Steve who demonstrated low prior knowledge, stated that he had to "modify" his understanding. Due to the process oriented worked example including principled knowledge (why) and strategic information (how), Steve was able to use this information to modify his understanding and any misconceptions he had on what constituted substantive communication.

The lowest perceived task difficulty ratings were scored by Mark (Process condition) and Mandy (Product condition). The principled knowledge (why) and prior knowledge supported Mark. Mandy stated familiarization with the concept of substantive communication supported her, even though she demonstrated low prior knowledge. The influence of prior knowledge, perceived mental effort and perceived task difficulty ratings on test performance scores are reflected by Mark achieving the highest total performance score and Mandy's total performance score of 10.5/16, which was just below Steve's (Process condition) result of 11/16.

In summary, the participant's prior knowledge and length of worked example may have influenced engagement and meaning making. The prior knowledge is reflected in Mark's higher test performance scores and lowest perceived task difficulty ratings. Further, the participants' low prior knowledge did not enable them to confirm or validate their understanding. The participants were able to modify misconceptions they may have had about substantive communication, interpret information that was provided or guess to make meaning. The length of the worked example may have influenced the participant's perceived mental effort rating.

6.3.8.3 The Descriptive Data Aligned with Findings About Worked Examples in Well-structured Learning Domains

The results of Study 2 descriptive data aligned with existing worked example research within a well-structured learning domain. The descriptive data results showed that the Process condition scored the highest test performance scores, the ratings for perceived mental effort for the worked example were highest for the Process and Product conditions and the overall perceived mental effort rating for the test items was highest for the Control condition. The overall perceived task difficulty rating for the test items was highest for the Control condition.

Research involving worked examples in well-structured learning domains has shown that novice learners who are provided with worked examples to study perform better on tests than learners not presented with worked examples (Carroll 1994; Cooper & Sweller 1987). Process oriented worked examples support novice participants with their learning, as not only do they contain the solution steps (strategic information), they also state the rationale of the steps (principled knowledge) (Van Gog et al., 2004; Van Gog et al., 2008). A similar pattern is evidenced from the descriptive data from the five participants.

The test performance scores showed a trend towards the Process condition scoring the highest marks. Mark's total performance score was 11.5/16 and Steve's was 11/16. Nadia, who engaged in the Control condition scored the lowest mark, 6/16. Mandy and Jodie, both presented with the Product condition, achieved test performance scores of 10.5/16 and 7.5/16 respectively. These test performance scores were lower than the Process condition, but higher than the participant presented with the Control condition. Jodie's test performance scores for Tasks 1 and 4 were the lowest of all participants. Her ratings for perceived mental effort and perceived task difficulty for these individual tasks were the highest. These results provide evidence that learners are able to perceive their mental effort required to solve a problem.

Nadia (Control condition), rated similar perceived mental effort and perceived task difficulty as other participants during the learning phase, where she stated that she "didn't have to write anything down". In contrast, she rated higher perceived mental effort and perceived task difficulty during the test phase than other participants because she had limited knowledge to answer the test items, which also reinforces her approach of guessing. Nadia's higher perceived mental effort rating during the test phase aligns with CLT, which suggests that this higher rating is due to the lack of extra information provided during the learning phase (Paas & van Merriënboer, 1994). Further, Nadia's highest perceived task difficulty rating during the test phase aligned with her total test performance score of 6/16, the lowest participant performance score.

Mark's (Process condition) highest individual perceived mental effort rating and perceived task difficulty rating were for Task 1. This involved him naming and identifying the three characteristics of substantive communication. This aligns with his commentary above where he stated that he focused on only one characteristic during the worked example, therefore he would have found it difficult to answer a question which required him to know all three characteristics of substantive. Similar to Mark, Steve also stated that he focused on only one of the three characteristics of substantive communication during the worked example as he could not remember the others. This aligns with Steve's perceived task difficulty rating during the learning phase. Steve's perceived task difficulty rating of 7 was the highest of the participants.

In summary, the patterns of Study 2 descriptive data aligned with existing research within a well-structured learning domain and suggest that a process oriented worked example supports novice participants to engage and make meaning within an ill-structured learning domain.

6.4 FINDINGS FROM PHASES 2 AND 3

6.4.1 Findings from Phase 2

Phase 2 of Study 2 required participants to engage with the remaining two instructional conditions, not as extensively as in Phase 1, but rather in summary format to familiarise participants with the other two instructional conditions in order for them to compare with the first instructional condition. See Section 5.2.4.2 for a description of Phase 2.

Table 6.8 includes the order in which the instructional conditions were presented to the novice participants. During Phase 2 of Study 2, participants were asked to rate their preference of instructional condition. This information is included in Table 6.9.

Table 6.8

Sequence of Instructional Conditions Presented to Participants

Participants	Instructional Condition 1 (Phase 1)	Instructional Condition 2 (Phase 2)	Instructional Condition 3 (Phase 2)
Mark & Steve	Process condition	Product condition	Control condition
Jodie & Mandy	Product condition	Process condition	Control condition
Nadia	Control condition	Product condition	Process condition

Table 6.9 below provides a summary of the order of preference of instructional conditions for each novice participant. The table includes each participants' name and their order of preference of instructional conditions.

Table 6.9

Order of Preference of Instructional Conditions

Participants	Preference 1	Preference 2	Preference 3
' Mark	Process condition	Product condition	Control condition
Steve	Process condition	Product condition	Control condition
Jodie	Product condition	Control condition	Process condition
Mandy	Process condition	Product condition	Control condition
Nadia	Process condition	Product condition	Control condition

The novice participants indicated a preference for the Process condition due to the inclusion of the principled knowledge (why) which supported them to make meaning. The lack of additional information and guidance provided by the Control condition was stated as the reason as to why this instructional condition was preferred the least.

Mark and Steve both engaged with the Process condition during Phase 1. Of the three instructional conditions, they both preferred the Process condition the most, due to the inclusion of principled knowledge (why), followed by the Product condition and then the Control condition. The lack of principled knowledge (why) and strategic information (how) contained in the Control condition influenced their lowest rating, as they stated they would be guessing to make meaning due to the lack of guidance provided. Mark stated;

> *To me the most useful example would be worked example type three (process) …. then worked example type two (product) next, because it said "yes it was" or "no it wasn't", and type one (conventional problem solving) … it was up to me to decide whether or not what components were actually present.*

Steve added the following;

> *I prefer number three (process) the most because, the detailed one, because I am not an expert in identifying substantive communication …. Type 1 (conventional problem solving) is a hindrance at the moment because it does not provide me with any guidance.*

Jodie and Mandy both engaged with the Product condition during Phase 1. Of the three instructional conditions, Jodie stated she preferred the Product condition as the strategic information (how) which stated whether substantive communication was either evident or not, allowed her to further engage to make meaning. This was followed by the Control condition as it included insufficient information to make meaning and then the Process condition, which provided too much information, which she stated did not allow her to think to make meaning. This is shown by the following;

> *Having this sort of example (Product* condition*) which engages and provokes thought was far more effective than either of the other two examples … whereas I feel like the control was maybe a little bit too brief. Whereas this other one (Process* condition*) was too much of a spoon feeding example.*

Mandy stated that she preferred the Process condition, followed by the Product condition and then the Control condition. Mandy rated them in this order due to her preference for the inclusion of principled knowledge (why) to make meaning. This is shown by the following;

> *With the detailed annotations (Process* condition*), the tables were more detailed too so it gave you an example of why sustained interactions were determined.*

Mandy added that the inclusion of principled knowledge can support overcome misunderstandings;

> *It just negates any other misconceptions or misunderstandings that I may have.*

Mandy also stated that the additional information provided by the principled knowledge (why) supported her as a novice to make meaning. This is shown by the following;

> *I like a lot of information so I can absorb it in, especially for topics like this when I haven't even touched on it so the more the better, you know, in the beginning is my style.*

Nadia engaged with the Control condition during Phase 1. Of the three instructional conditions, Nadia preferred the Process condition, as the principled knowledge (why) supported her to make meaning, followed by the Product condition, as it provided the strategic information (how) without explaining why, and then the Control condition. She recognised that the Control condition was not a worked example, and did not provide any guidance to support participants to make meaning;

> *Just because of the actual presence of a description of why they rated it a certain way; the first one (Conventional problem solving) wasn't really a worked example – it was just "Here's an example of an answer"... This (Process* condition*), actually says what happens and what that means; it actually gives meaning to things.*

In summary, the key finding from Phase 2 of Study 2 was that four of the five participants indicated a preference for the Process condition due to the inclusion of the principled knowledge (why) which supported them to make meaning.

6.4.2 Findings from Phase 3

Phase 3 of Study 2 required participants to share their perceptions of how they could use worked examples in their own teaching practice. The participants all acknowledged the importance of using worked examples in their own practice to support student learning.

Mark stated that he would use worked examples in his own practice, as based on his own learning experiences, worked examples supported him in achieving his learning goals. Mark spoke about the use of worked examples in general, and did not refer to the type of worked examples, such as a process oriented or product oriented worked example;

> *… by having a worked example, I actually learned more, so if you transfer that into a classroom setting by providing worked examples for your students on what the outcome, or project or whatever you're trying to reach looks like, they may have more, a better understanding of what they need to do …*

Steve stated that he would use worked examples in his practice to show students the steps to the end product and to enable students to refer back to while completing tasks;

> *… we can use worked examples to like show the students the steps, or a guide to the end product, and then through showing them that they can then refer back to the guide to guide them on their way to completing the task.*

Steve also referred to presenting the worked example by gradual release;

Ideally, I would have enjoyed a step by step process, where it goes through the video and then the teacher / instructor does like half of it, step by step with you and then sends you to do the rest so you get a feel of what it is in real time.

Jodie responded to the question stating that the worked example allowed her to reflect on her own practice and needing to be more conscious of the level of substantive communication in her classes;

I know in my critique last semester that's just finished, I definitely skipped on too quickly.

Mandy stated that "it takes a lot of effort to produce a good worked example" and she would need to consider scaffolding worked examples to support the learning needs of students in her classes.

Nadia stated that the use of worked examples confirmed for her the importance of providing principled knowledge (why) to students. Nadia added that it was important that students understand what they are learning, not just remember the information that has been presented to them;

This is why this kind of thing is good" – it explains it, you know, makes it make sense. It's not just teaching it for remembering things sake; it's actually understanding stuff.

In summary, the participants acknowledged the importance of worked examples and all stated they would use them in their own teaching practice.

6.5 SUMMARY OF FINDINGS

The following section includes a discussion of the overall key findings of the three phases of Study 2. The section includes Phase 1 findings, Phase 2 and 3 findings and a conclusion to this chapter.

6.5.1 Phase 1 Findings

In summary, Study 2, a small-scale qualitative study involving novice participants resulted in three main findings from Phase 1. The first finding was that the learning approach used to make meaning was influenced by the instructional condition, with a pattern that shows more higher order thinking evident in the Process condition than in the Product and Control condition. Further, the participant presented with the Control condition used a "search" approach, demonstrating a means-ends analysis approach to make meaning. The second finding was that participant prior knowledge and length of worked example influenced engagement and meaning making, for example, higher prior knowledge may have influenced test performance scores and perceived task difficulty ratings. Participants with low prior knowledge were unable to confirm or validate their understanding. However, the principled knowledge (why) contained in the process oriented worked example enabled participants to overcome misconceptions they may have had about substantive communication. The length of the worked example may have influenced the participant's perceived mental effort rating. The third finding was the results of the descriptive data aligned with worked example research in well-structured learning domains, that is novice participants would find a process worked example beneficial to learning. The findings confirm that a process-worked example supports novice participants to engage and make meaning within an ill-structured learning domain.

6.5.2 Phase 2 and 3 Findings

The key finding from Phase 2 of Study 2 was that four of the five novice participants indicated a preference for the Process condition due to the inclusion of the principled knowledge (why) which supported them to make meaning. The lack of additional information and guidance provided by the Control condition was stated as the reason as to why this instructional condition was preferred the least. This preference of instructional condition aligns with CLT research for well-structured learning domains. The key finding from Phase 3 of Study 2 was that the participants acknowledged the importance of worked examples and all stated they would use them in their own teaching practice.

6.5.3 Conclusion

In this chapter, an overview of Study 2 was provided for novice participants. Overall, Study 2 provided insight into the thought processes of how novice learners engaged with materials within designated instructional conditions in an ill-structured learning domain. What Study 2 has found is that the instructional conditions influenced how participants engaged with the worked examples to make meaning. Further, the results of the five novice participants for test items, perceived mental effort and perceived task difficulty ratings were consistent with existing CLT research findings regarding worked examples in well-structured learning domains with novice participants. The Process condition was the most preferred by four of the five novice participants, followed by the Product condition and then the Control condition. This validated the instructional materials used as authentic process oriented worked examples, product oriented worked examples and conventional problem solving. Study 2 descriptive data and verbal protocols provided by participants, confirmed the need for novice learners to understand the principled knowledge (why) and strategic information (how) when engaging with instructional materials in an ill-structured learning domain, including the completion of test items. The principled knowledge (why) and strategic information (how) enabled the novice participants to modify any misconceptions they may have had in relation to the concept of substantive communication. The next chapter will present the findings of the data collected from the expert participants during the three phases of Study 2.

Chapter 7

STUDY 2 – EXPERT PARTICIPANTS

7.1 INTRODUCTION

This chapter presents the findings of data collected from expert participants during the three phases of Study 2. The chapter firstly introduces each expert participant and then presents the findings from Phase 1. This includes a summary of the non-statistical descriptive data for each expert participant, including test performance scores, perceived mental effort and perceived task difficulty ratings. Due to the sample size, the collected data represents non-statistically significant results and are presented to solely show trends in the data and accompany the qualitative data collected for Study 2. The term non-statistical descriptive data will be referred to as descriptive data throughout this chapter. This is then followed by a discussion on how each participant engaged with the learning materials in their instructional condition. Emerging themes from Phase 1 are then discussed. The chapter concludes with an analysis and findings of the expert participant responses from Phases 2 and 3 of Study 2 and an overall summary of key findings.

7.2 EXPERT PARTICIPANTS

Table 7.1 presents a summary of the six expert participants, in reference to participant's age, gender, teaching background and prior knowledge of substantive communication. This is followed by a more detailed introduction for each participant, including a discussion on their prior knowledge of the New South Wales Quality Teaching Model (NSW QTM) and substantive communication. Refer to Table 5.4 in Study 2 which includes the initial instructional condition allocated to each expert participant.

Table 7.1

Expert Participants

Participant	Age	Gender	Teaching Background	Prior Knowledge
Jenny	30	Female	English and Physical Development, Health and Physical Education (PDHPE) teacher	Medium
Sonia	50	Female	Ancient History, Geography and Society and Culture teacher	Medium
Albert	60	Male	Mathematics teacher	Low
Jackie	33	Female	Life Skills teacher	Low
Patrick	51	Male	Science, Mathematics, Physics and Chemistry teacher	High
Paolo	40	Male	Religious Education and PDHPE teacher	High

Jenny was a 30-year-old female secondary English and Personal Development, Health and Physical Education teacher who taught in a regional Diocesan school. When asked about her prior knowledge of the NSW QTM, she stated she knew the model comprised of three Dimensions and eighteen elements. She was able to articulate how teachers use the model to support the delivery of quality lessons. When asked about her prior knowledge of substantive communication, Jenny demonstrated a medium understanding (see Table 5.5 for a definition of medium understanding) as she was able to explicitly describe the impact on learning through the way teachers communicate with students and their colleagues, being “explicit, clear and meaningful”.

Sonia was a 50-year-old female secondary Ancient History, Geography and Society and Culture teacher who taught in a regional Diocesan school. When asked about her prior knowledge of the NSW QTM, she stated that she was familiar with the model and it was used to support pedagogical practices. When asked about her prior knowledge of substantive communication, Sonia initially stated she was unfamiliar with the term. However, she then demonstrated a medium understanding by being able to articulate the impact of substantive communication on learning, adding it involved deep questioning in the classroom and "opportunities for students to talk through their learning".

Albert was a 60-year-old male secondary Mathematics teacher who taught in a regional Diocesan school. When asked about his prior knowledge of the NSW QTM, he stated he was aware of the model but had not read it in detail. He was able to articulate how teachers use the model to support them in delivering quality lessons. When asked about his prior knowledge of substantive communication, Albert demonstrated a low understanding (see Table 5.5 for a definition of low understanding) stating that it related to the way teachers and students communicate with each other.

Jackie was a 33-year-old female secondary Life Skills teacher who taught in a regional Diocesan school. When asked about her prior knowledge of the NSW QTM, she stated the model comprised of three Dimensions. She was able to identify the Dimension of Quality Learning Environment and the element of high engagement. When asked about her prior knowledge of substantive communication, Jackie stated that she had heard of the concept a few years earlier and demonstrated a low understanding stating how it related to the quality of communication between students and teachers to improve learning.

Patrick was a 51-year-old male secondary Science, Mathematics, Physics and Chemistry teacher who taught in a regional Diocesan school. When asked about his prior knowledge of the NSW QTM, he stated that he had a thorough understanding of the model, the Coding process and how it is used to improve pedagogical practice. When asked about his prior knowledge of substantive communication, Patrick demonstrated a high understanding (see Table 5.5 for a definition of high understanding) by clearly articulating how high-level substantive communication in the classroom promotes learning.

Paolo was a 40-year-old male secondary Religious Education and PDHPE teacher who taught in a regional Diocesan school. When asked about his prior knowledge of the NSW QTM, he stated that he had a thorough understanding of the model and how it is used to improve pedagogical practice. In describing the impact of the model on pedagogical practice, he referred to the Dimensions of Intellectual Quality and the element of high expectations. When asked about his prior knowledge of substantive communication, Paolo demonstrated a high understanding by clearly articulating how high levels of substantive communication in the classroom promotes learning.

7.3 FINDINGS FROM PHASE 1

The following section presents the descriptive data from Study 2. This includes the test performance scores, the perceived mental effort and perceived task difficulty ratings. Following this, a description of how each expert participant engaged with the worked example is included. The section concludes with a discussion on the identified themes and how they relate to the presented descriptive data.

7.3.1 Summary of Descriptive Data

The six expert participants completed four test items during Phase 1 of Study 2. The following section presents the descriptive data for these tasks. Table 7.2 below provides a description of each task.

Table 7.2

Test Item Descriptions

Task Number	Test Item Descriptions
Task 1	Name and identify the three characteristics of substantive communication from a vignette.
Task 2	Provide and justify a Coding Score for a lesson
Task 3	Indicate whether a characteristic of substantive communication was present, justify their response and provide strategies to enhance the presence of the characteristic.
Task 4	View a lesson and suggest strategies on how to enhance the presence of two characteristic.

Table 7.3 shows test performance scores for each expert participant.

Table 7.3

Test Performance Scores for Expert Participants

Instructional Condition	Participant	Total (16 Marks)	Task 1 (6 Marks)	Task 2 (3 Marks)	Task 3 (3 Marks)	Task 4 (4 Marks)
		Performance Scores – Experts				
Process condition (N=2)	Jenny	10.5	3.0	2.5	3.0	2.0
	Sonia	13.0	5.5	2.5	3.0	2.0
Product condition (N=2)	Albert	11.5	2.0	2.5	3.0	4.0
	Jackie	7.5	4.0	2.5	1.0	0.0
Control condition (N=2)	Patrick	6.5	2.0	1.5	1.0	2.0
	Paolo	8.5	4.0	1.5	1.0	2.0

The test performance scores show a trend towards the Process condition scoring the highest marks. The two participants from this instructional condition and one from the Product condition scored the highest total performance scores. Conversely, on average, the participants who engaged in the Control condition scored the lowest marks.

Participants in Study 2 rated their perceived mental effort and perceived task difficulty at the completion of the learning phase and after each test item during the test phase. Table 7.4 below shows the perceived mental effort ratings for the expert participants.

Table 7.4

Perceived Mental Effort Ratings for Expert Participants

Perceived Mental Effort Ratings – Experts							
Instructional Condition	Participant	Worked Example (9)	Task 1 (9)	Task 2 (9)	Task 3 (9)	Task 4 (9)	Mean of Tasks (9)
Process condition (N=2)	Jenny	4.0	7.0	7.0	2.0	4.0	5.0
	Sonia	2.0	4.0	2.0	3.0	2.0	2.8
Product condition (N=2)	Albert	6.0	2.0	2.0	7.0	7.0	4.5
	Jackie	6.0	6.0	6.0	6.0	6.0	6.0
Control condition (N=2)	Patrick	4.0	7.0	6.0	6.0	7.0	6.5
	Paolo	5.0	6.0	6.0	5.0	6.0	6.0

The descriptive results show a trend towards the Product condition rating the highest perceived mental effort for the worked example and the Process condition rating the lowest perceived mental effort for the worked example. The participants who engaged in the Control condition rated the higher perceived mental effort for the test items and the participants of the Process condition rated the lowest perceived mental effort for the test items.

Table 7.5 below shows the perceived task difficulty ratings for the expert participants.

Table 7.5

Perceived Task Difficulty Ratings for Expert Participants

Instructional Condition	Participant	Worked Example (9)	Task 1 (9)	Task 2 (9)	Task 3 (9)	Task 4 (9)	Mean of Tasks (9)
		Perceived Task Difficulty Ratings – Experts					
Process condition (N=2)	Jenny	3.0	3.0	4.0	2.0	4.0	3.3
	Sonia	2.0	3.0	2.0	2.0	2.0	2.3
Product condition (N=2)	Albert	4.0	2.0	2.0	6.0	6.0	4.0
	Jackie	4.0	5.0	3.0	3.0	5.0	4.0
Control condition (N=2)	Patrick	2.0	4.0	3.0	3.0	4.0	3.5
	Paolo	4.0	6.0	6.0	5.0	6.0	5.8

Overall, perceived task difficulty ratings for the worked example were highest for the Product condition and lowest for the Process condition. Perceived task difficulty ratings for the test items were highest for the Control condition. The lowest ratings for the test items were for the Process condition.

Considering the limited number of expert participants, overall, the descriptive data for the test performance scores were consistent with the results for novice participants in Experiment 1. The participants presented with the Process condition scored the highest test performance scores and the participants presented with the Control condition scored the lowest. The descriptive data for the perceived mental effort ratings and perceived task difficulty ratings were similar with Experiment 1 results. Experiment 1 and Study 2 perceived mental effort ratings for experts were lowest during the learning phase for participants engaging in the Process condition. In addition, Experiment 1 and Study 2 perceived mental effort and perceived task difficulty ratings for experts were highest during the test phase for participants presented with the Control condition.

7.3.2 How Participants Engaged with and Made Meaning from their Assigned Instructional Condition

The following section explains how novice participants engaged with and made meaning from their assigned instructional condition. What participants reported verbally was coded by the researcher to identify key words to encapsulate each participant's thinking process and learning approaches they adopted to make meaning. Table 7.6 below defines and provides details on approaches adopted by the novice participants and includes a list of the approaches identified by the researcher based on the verbal protocols provided by the novice participants. The table also includes phrases made by the novice participants that the researcher used to align with the included approaches. These were developed from the responses to questions provided by the participants during Study 2. Further, the approaches are listed from highest to lowest cognitive order using Bloom's Taxonomy (Stanny, 2016). The researcher used lists of associated verbs contained in models of Bloom's Taxonomy, such as Figure 5.2, to make a decision on the cognitive order of the approaches. See Section 5.3 for further details.

Table 7.6

Definitions of Key Words for Approaches Adopted by Expert Participants to Make Meaning

Key word	Definition (Bloom's Taxonomy Thinking Skill)	How this was identified from the data	Example of an excerpt from the data (Experts)
1. Reflect	To think; meditate, ponder and deliberate. (Evaluating)	Use of the word reflect by the participant.	*I was trying to reflect on what that first table was telling me (Albert, Product).*
2. Infer	To find out by reasoning, come to believe after thinking. (Analyzing)	Use of the word infer by the participant.	*I've got to extrapolate that from the video to see that's why it was rated or coded at a four level … I think there's a lot of inferential requirement because the Coding Scale talked about that the elements existed … but it's because I was able to infer what the Coding Scale meant and what I was looking for in the video (Paolo, Control).*
3. Confirm	To prove to be true or correct.	The participant makes a statement indicating an	*I think it did in that you were looking at the video and you were sort of seeing*

		(Applying)	understanding of the level of substantive communication.	*the elements there that were in the table and then you were seeing a good alignment between what the table was saying in front of you and what you were seeing in reality (Patrick, Control).*
4.	Match	To find items that correspond. (Understanding)	The participant refers to matching annotations on the video recording to information in the referencing table or interactions during the video recording.	*At the start in your PowerPoint presentation, you presented the coding score, and five was consistent throughout the lesson whereas four was 50% or most of the lesson and that clip, it was clear that it wasn't a five because there was no evidence appearing… (Jackie, Product).*
5.	Interpret	To understand or construe in a particular way. (Understanding)	The participant makes reference to engaging with the material and thinking and reflecting on own understanding to make meaning.	*When she didn't respond to student answers, that's when I could see "Okay, when she didn't do that, it would come up as 'not evident'." (Jackie, Product).*
6.	Search	To examine in order to discover. (Understanding)	The participant makes a statement referring to seeking for elements of substantive communication.	*When the video was on, I was re-reading the instructions and just trying to extract as much as I could, then going back to the video and trying to extract as much as I could from it (Patrick, Control).*
7.	Recall	To call back to mind, remember. (Remembering)	Use of the word recall by the participant and making reference to trying to remember information .	*… as I was watching the video, I was trying to remember examples that were reflected in that table. And then, for the task, the reflection, I was trying to remember the definitions of specific elements that we discussed before the videos in the PowerPoint. I was trying to recall those aspects of substantive communication (Sonia, Process).*

7.3.3 Jenny - Process Condition

Jenny's strategy of how she interacted with the Process condition can be deduced as a "recall, match and confirm" learning approach. This was identified from the verbal protocols provided by Jenny. Jenny engaged with the Process condition by attempting to recall characteristics of substantive communication during the pauses. She then matched key occurrences from the video recordings to the referencing table and PowerPoint and then confirmed the presence of substantive communication based on the principled knowledge (why) provided by the annotations and her prior knowledge. For example, the following statement demonstrated Jenny *recalling* characteristics of substantive communication;

> *When engaging with the worked example, I was attempting to recall the elements of the substantive communication to inform how I would respond in the reflection component.*

The following statement is a response from Jenny when asked the question, "Were you referring back to the PowerPoint presentation as well?" This demonstrated how Jenny *matched* annotations during the video recording of the lesson to the referencing table and PowerPoint;

> *Yes, of course, as reflected in the whole booklet.*

The following statement demonstrated how the annotations supported Jenny in *confirming* her understanding of the level of substantive communication;

> *I mean whilst I felt I didn't need the annotations within the clip, I guess it still assisted in knowing that, visually, it's good to validate that there is a coding system and to see it in action.*

Jenny added that her experience as a teacher also supported her in engaging and making meaning during the process oriented worked example and while completing the test items;

> *I think it would have been fine with no annotations as well because the reality is in teaching that you're not going to have annotations, therefore, you're relying upon listening and looking.*

Jenny added that the structure and format of the Process condition supported her to answer the test items;

> *It definitely assisted and I think what I appreciated was that the structure of the required responses was repeated throughout this whole process. That's what benefited me, knowing that that's how I was expected to respond in the following tasks.*

Jenny stated that engaging with the worked example without being provided with the principled knowledge (why) or strategic information (how) to commence with would have further supported her to make meaning;

> *I guess to provide more of a challenge for me, or any student, maybe to do it the other way around, watched it without it first, and not be distracted by the annotations and then, for the second viewing, to present it to confirm and validate what you had seen.*

In summary, Jenny adopted a "recall, match and confirm" learning approach to make meaning of the Process condition. The principled knowledge (why) and strategic information (how) were not required to make meaning due to Jenny's prior knowledge and experience as a teacher. The annotations provided during the video recording of the lesson were referred to as a distraction. However, her comments suggested that the annotations supported Jenny's engagement with the process oriented worked example enabling her to confirm her understanding and providing a structure to respond to the test items.

7.3.4 Sonia - Process Condition

Sonia's strategy of how she interacted with the Process condition can be deduced as a "recall, match and confirm" learning approach. This was identified from the verbal protocols provided by Sonia. Sonia engaged with the Process condition by initially reading the information in the referencing table and connecting it to the Coding Score. She then made links to the referencing table during the video recording of the lesson by aiming to recall the included information and confirm her understanding. The following statement demonstrated Sonia *recalling* characteristics of substantive communication;

… as I was watching the video, I was trying to remember examples that were reflected in that table. And then, for the task, the reflection, I was trying to remember the definitions of specific elements that we discussed before the videos in the PowerPoint. I was trying to recall those aspects of substantive communication.

The following statement, which is included in the above quotations, demonstrated how Sonia *matched* annotations during the video recording of the lesson to the referencing table;

I was just trying to absorb the information and understand how it was rated initially and then, as I was watching the video, I was trying to remember examples that were reflected in that table.

This is further evidenced by the following statement:

So, I did find them useful to be able to see the interactions in the video and then relate it to the annotations at the bottom.

The following statement demonstrated how the annotations supported Sonia in *confirming* her understanding of the level of substantive communication;

Yeah, it did help me understand why the coding score was given because after I read the reason why the coding score was given, I could see that interaction in the video with the specific examples.

Sonia stated that the principled knowledge (why) and strategic information (how) provided by the annotations during the video recording supported her to make meaning as they enabled her to match the occurrences to the annotations on the screen;

… because they explained how that moment previous to the pause was an example of reciprocal interaction or good substantive communication or not an example of reciprocal interaction. So, I did find them useful to be able to see the interactions in the video and then relate it to the annotations at the bottom, so yes, I did find them useful.

Sonia stated that the Process condition supported her to answer the test items as the visual representation of the annotations further supported her understanding of substantive communication. This is shown by the following reference to the process oriented worked example;

> *Visually, it helped for me because I'd seen it once; it was very clear in the next three videos when there were reciprocal or sustained interactions, when there wasn't, when it was focused on the substance of the content.*

Sonia added that the Process condition did not enable her to recall the characteristics of substantive communication while completing the test items. This is shown by the following;

> *It didn't help me recall these elements of substantive communication because I have a bad memory so that's probably why in all these, I was really concentrating but when it came time to write my own responses to some of these things and how I would do it, I couldn't remember the terminology …*

Sonia confirmed that the annotations provided during the process oriented worked example supported her initially in answering the test items, but did not need these annotations as she was able to identify when substantive communication was present;

> *It helped me initially, like I said, but I didn't need the annotations; I could pick up when there was sustained interaction or not or of those other elements.*

In summary, Sonia adopted a "recall, match and confirm" learning approach to make meaning of the Process condition. The principled knowledge (why) provided by the annotations and the visual representation of the annotations supported Sonia in engaging and making meaning. Due to Sonia's prior knowledge and experience as a teacher, she stated that even though the annotations supported her initially, she did not require the principled knowledge (why) and strategic information (how) to identify substantive communication.

7.3.5 Albert - Product Condition

Albert's strategy of how he interacted with the Product condition can be deduced as a "reflect, match and confirm" learning approach. This was identified from the verbal protocols provided by Albert. Albert engaged with the Product condition by reflecting on occurrences of substantive communication, comparing occurrences during the video recording of the lesson to the referencing table and then confirming his understanding of substantive communication. The following statement demonstrated Albert *reflecting* on the characteristics of substantive communication while engaging with the product oriented worked example;

> *I was trying to reflect on what that first table was telling me.*

The following statement demonstrated Albert *matching* the presence of substantive communication during the video recording to his reflection and the referencing table;

> *… what I remembered from the first table, and trying to say, "Is that person doing what it's telling me, like was it very minimal" which it wasn't. She's questioning the kids quite a lot into the how and the why and "How did you get the response" etc. So, I was thinking in my head, "Is that going to be a four or is that going to be a five"…*

The following also shows how Albert *matched* occurrences of substantive communication during the test items to occurrences during the product oriented worked example;

> *I found myself comparing all the other tasks to that first video and trying to remember what she was doing specifically to get that four and I was trying to relate that to the other videos.*

The following statement demonstrated Albert *confirming* his understanding;

> *So, I was thinking in my head, "Is that going to be a four or is that going to be a five" even though they told us the answer. I was thinking, why they gave it a four. So, it gave me more of an opportunity to say, "Yep, I can understand where that four's coming from".*

Albert stated the lack of principled knowledge (why) included in the annotations during the video recording frustrated him as he wanted to know the reason why the Coding Score was allocated. He also stated he would have preferred the opportunity to discuss the Coding Score for the lesson. This is shown by the following;

> *I found it frustrating. I was looking at it first, then I actually switched off when it came on later in the video for that reason. I wanted to know why did they come to the conclusion and I would like to have the chance to discuss why amongst ourselves but we didn't have that opportunity, but I understand that, so I found it a bit frustrating.*

Albert added the following;

> *I was always trying to go back to that table where the definition was that we got. There were times when I thought, "Oh no, I thought it was sustained communication but I was wrong. I thought, "Well what I did wrong" and that's why I wanted to know the answer, or the reasoning.*

In summary, Albert adopted a "reflect, match and confirm" learning approach to make meaning of the Product condition. The information included in the Coding Scale table and the referencing table supported Albert in engaging and making meaning with the concept of substantive communication. While answering the test items, Albert compared key occurrences during the test item videos to the product oriented worked example video recording of the lesson. The lack of principled knowledge (why) included in the annotations during the video hindered Albert in engaging and making meaning as he wanted to know why the Coding Score was allocated.

7.3.6 Jackie - Product Condition

Jackie's strategy of how she interacted with the Product condition can be deduced as a "reflect, interpret and match" learning approach. This was identified from the verbal protocols provided by Jackie. Jackie engaged with the Product condition by reflecting on key occurrences during the video recording. She then made an interpretation on the level of substantive communication at key occurrences and compared these to information provided in the PowerPoint. The following statement demonstrated Jackie *reflecting* on the level of substantive communication at key occurrences during the video recording;

When the video was presented, there were pauses at different intervals that would say "evident" or "not evident" and I was making that connection, "Okay, why is this 'evident" and why is that 'not evident'?"

Jackie then continued to say the following, which demonstrated how she made an *interpretation* on the level of substantive communication;

When she didn't respond to student answers, that's when I could see "Okay, when she didn't do that, it would come up as 'not evident'."

The following statement demonstrated how Jackie *matched* occurrences during the video to information provided in the PowerPoint presentation during the learning phase;

At the start in your PowerPoint presentation, you presented the coding score, and five was consistent throughout the lesson whereas four was 50% or most of the lesson and that clip, it was clear that it wasn't a five because there was no evidence appearing…

Jackie stated that the pauses during the video recording of the lesson supported her to make meaning as they included annotations which indicated the presence or absence of substantive communication. However, she was hindered by the lack of principled knowledge (why) provided by the annotations. This is shown by the following;

They were useful and not useful. When they did pause, it was telling me that it was "evident" or "not evident" but then there was no further explanation as to why it was "evident" or "not evident" – we had to make that connection ourselves.

The lack of principled knowledge (why) caused her to question her judgement of why substantive communication was evident during the lesson;

I was sort of questioning myself, "Have I got the correct answer here?" It would have been good to have it in black and white on paper to compare whether my feeling was right.

Jackie stated that the Coding Scale table included in the PowerPoint presentation during the introductory phase supported her to make meaning. An example of how Jackie made meaning included how she aligned a Coding Score of four to substantive communication being evident for at least half the lesson. This is shown by the following;

> *At the start in your PowerPoint presentation, you presented the coding score, and five was consistent throughout the lesson whereas four was 50% or most of the lesson and that clip, it was clear that it wasn't a five because there was no evidence appearing, but it was most of the time.*

Jackie stated that the product oriented worked example supported her in answering the test items by being able to compare occurrences of substantive communication between the two;

> *That was an initial worked example that was more explicit and that sort of set the benchmark in terms of our understanding of what sustained communication was and substantive communication. So that example provided a benchmark for our understanding which we were able then to use that understanding and apply it to the next four tasks.*

This is further supported by;

> *When she didn't reply initially to everybody's answers, it come up as "not evident", so then when I saw that mirrored in other clips, then that helped me make that judgement as well.*

In summary, Jackie adopted a "reflect, interpret and match" learning approach to make meaning of the Product condition. The information included in the Coding Scale table and the referencing table supported Jackie in engaging and making meaning with the concept of substantive communication as she was able to align occurrences during the video to the information provided in the referencing table. The annotations included in the pauses supported Jackie to make meaning, but she was hindered by the lack of principled knowledge (why) included.

7.3.7 Patrick – Control condition

Patrick's strategy of how he interacted with the instructional material during the learning phase can be deduced a "search, match and confirm" learning approach. This was identified from the verbal protocols provided by Patrick. Patrick engaged in the Control condition of conventional problem solving by searching and matching occurrences of substantive communication in the video recording with the referencing table. He used the information presented during the learning phase to confirm his understanding. The following statement demonstrated Patrick *searching* for information from key occurrences of substantive communication by extracting information during the video recording;

> *When the video was on, I was re-reading the instructions and just trying to extract as much as I could, then going back to the video and trying to extract as much as I could from it.*

The following statement demonstrated how Patrick *matched* occurrences during the video to the instructional material presented during the learning phase to support him to make meaning;

> *… trying to extract as much as I could from it, so what I could recall from the previous worked example and just pick out and analyse the video as much as I could.*

This is further shown by the following:

> *I think it did in that you were looking at the video and you were sort of seeing the elements there that were in the table and then you were seeing a good alignment between what the table was saying in front of you and what you were seeing in reality.*

The following statement, which was Patrick's response to whether the information provided during the learning phase helped him understand why the Coding Score was given, demonstrated how Patrick *confirmed* occurrences during the video to information provided in the referencing table;

> *I think it did in that you were looking at the video and you were sort of seeing the elements there that were in the table and then you were seeing a good alignment between what the table was saying in front of you and what you were seeing in reality.*

Patrick added that the information included in the PowerPoint presentation during the learning phase supported him to make meaning. He stated that the amount of information provided was not too much to remember while engaging with the video recording of the lesson. This is shown by the following;

> *I felt that the work that we'd done prior on the presentations and the PowerPoint meant that it was very clear in my head and I didn't have any trouble retaining that amount of information; it wasn't too much so then I felt that that made it a lot easier in terms of the task that I was being presented with doing.*

Patrick added that he did not require the pauses during the video recordings. He stated that the pauses did not enhance his engagement with the video to make meaning with the concept of substantive communication. This is shown by the following;

> *I don't know that I needed the pauses; I felt that I was trying to see the elements of substantive communication as I went through and for me, it didn't really enhance it for me.*

In summary, Patrick adopted a "search, match and confirm" learning approach to make meaning. The video recording and the referencing table supported Patrick to make meaning as he was comparing occurrences of substantive communication during the lesson to information included in the referencing table. Further, viewing the presentation during the learning phase and being provided with the Coding Score prior to watching the video also supported Patrick engaging and making meaning. Patrick stated that he did not find the amount of information provided during the learning phase too much to recall. He added that he did not require the pauses during the video as he was making connections between the video and the referencing table throughout the whole video.

7.3.8 Paolo – Control condition

Paolo's strategy of how he interacted with the instructional material during the learning phase can be deduced a "search, match and infer" learning approach. This was identified from the verbal protocols provided by Paolo. Paolo engaged in the Control condition of conventional problem solving by searching and matching occurrences of substantive communication in the video recording with the referencing table and the Coding Score. He used this to infer the levels of substantive communication. Paolo then used this inference to compare the level of substantive communication evident in other sections of the video recording. The following statement demonstrated Paolo *searching* for key occurrences of substantive communication and matching the learning phase referencing table with the video recording;

> *I was trying to create a connection between the worked example, the rating that was provided and what I was seeing in the video …*

The following statement demonstrated how Paolo *matched* levels of substantive communication during the video recording with the Coding Score ratings;

> *… to try and correlate where the four sat in terms of the rating scale and that was the four - what things for me made that four, so that when I was required to do it again in the next couple of stages, I could actually make a correlation between the fours or scale points below or above.*

The following statement demonstrated how Paolo *inferred* levels of substantive communication;

> *I've got to extrapolate that from the video to see that's why it was rated or coded at a four level … I think there's a lot of inferential requirement because the Coding Scale talked about that the elements existed … but it's because I was able to infer what the Coding Scale meant and what I was looking for in the video.*

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Paolo stated that the lack of principled knowledge (why) caused him to draw upon his prior knowledge and experience to infer levels of substantive communication. This is shown by the following;

I think there's a lot of inferential requirement because the Coding Scale talked about that the elements existed – it didn't explicitly say "At this point or at this point or at this point" so you're trying to tease that out of the video and being relatively experienced, and having prior experience in the classroom, you know what that looks like or you've got a feel for that …

Paolo indicated that he did not need to fully engage with the video recording of the lesson as he was given the Coding Score prior to watching the video. Paolo added that he knew the characteristics of substantive communication that needed to be identified. However, he stated that he needed to determine the reasons why a Coding Score of four was allocated. This is shown by the following;

In terms of the mental effort, because the worked example or the description of the coding rating that was being provided for us was there, for me, there was no pressure, there was no need to really engage in a mental task. I knew what I was looking for; I was trying to find the reasons why it was the four.

In summary, Paolo adopted a "search, match and infer" learning approach to make meaning. Paolo recognized the lack of principled knowledge (why) provided and used his prior knowledge and experience to determine the reasoning of the Coding Score. Paolo added that the lack of principled knowledge (why) required him to infer occurrences of substantive communication during the lesson.

7.3.9 Emergent Themes

From the qualitative data analysis conducted (refer to section 5.3), three themes emerged from Phase 1:

1. The process oriented worked example was useful for the participants enabling them to confirm and validate their prior knowledge.
2. Participant prior knowledge and the instructional condition influenced engagement and meaning making.
3. The patterns of the descriptive data and qualitative data aligned with research about process oriented and product oriented worked examples in well-structured learning domains for novices.

These are discussed as follows.

7.3.9.1 The Process Oriented Worked Example was Useful for the Participants Enabling them to Confirm and Validate their Prior Knowledge

The qualitative data suggested the process oriented worked example supported the participants in engaging with the Process condition. This is contrary to research on experts engaging with worked examples in well-structured learning domains as the expectation would be that the Process condition would provide extraneous cognitive load (ECL) (Kalyuga, 2007). The following section provides an overview of how the learning approach adopted by each participant during Study 2 supported them to make meaning. Table 7.6 defines each of the learning approaches and are listed from highest to lowest cognitive order using Bloom's Taxonomy (Stanny, 2016), as interpreted by the researcher.

A summary of the overall learning approach adopted by each participant and their prior knowledge is listed below in Table 7.7. The table includes each participant's name, the instructional condition they engaged in, their prior knowledge of substantive communication and their identified learning approach. The rank of each key word, as provided in Table 7.6. is included to show how the learning approach adopted by each participate relates to the cognitive order or level of thinking based on Bloom's Taxonomy.

Table 7.7

Summary of Learning Approaches Adopted by Expert Participants to Make Meaning

Participant	Instructional Condition	Prior Knowledge	Learning approach
Jenny	Process condition	Medium	Recall (#7), match (#4) and confirm (#3)
Sonia	Process condition	Medium	Recall (#7), match (#4) and confirm (#3)
Albert	Product condition	Low	Reflect (#1), match (#4) and confirm (#3)
Jackie	Product condition	Low	Reflect (#1), interpret (#5) and match (#4)
Patrick	Control condition	High	Search (#6), match (#4) and confirm(#3)
Paolo	Control condition	High	Search (#6), match (#4) and infer (#2)

This table provides insight about the learning approaches the expert participants undertook with the different instructional conditions to make meaning. Jenny and Sonia, the participants who engaged in the Process condition adopted "recall, match and confirm" learning approaches. As evidenced through the qualitative data, the principled knowledge (why) within the process oriented worked examples may have enabled the expert participants to validate and confirm their understanding. Further evidence of the process oriented worked example being useful to the participants are the test performance scores. The mean test performance scores were highest for the participants presented with the Process condition (Mean of 11.75), compared to participants presented with the Product condition (Mean of 9.5) and the Control condition (Mean of 7.5). In addition, in the learning approaches identified by the researcher (Table 7.7), each participant exercised some higher order thinking. This can be seen by the ranks of the key words in Table 7.7 for participants in each instructional condition.

The participants presented with the Product condition, Albert and Jackie, adopted "reflect, match and confirm" and "reflect, interpret and match" learning approaches respectively. Both participants demonstrated low prior knowledge of substantive communication. However, both had over ten years of teaching experience. They rated the highest perceived mental effort during the Learning Phase (Mean of 6.0), compared to participants presented with the Process condition (Mean of 3.0) and Control condition (Mean of 4.5). As the product oriented worked example did not include principled knowledge (why), their higher perceived mental effort ratings during the learning phase may indicate high engagement with the worked example. This may be due to their low prior knowledge and lack of principled knowledge (why) included in a product oriented worked example, the participants may be exerting additional effort in engaging with the strategic information (how) to interpret and confirm their understanding of occurrences of substantive communication.

Patrick and Paolo, who were presented with the Control condition, adopted "search, match and confirm" and "search, match and infer" learning approaches. The learning approaches adopted by Patrick and Paolo illustrated similar higher order thinking as Jenny and Sonia, the participants presented with the Process condition (see Table 7.7). In addition, Patrick and Paolo who both displayed high prior knowledge, used "search" as an approach to make meaning. Prior knowledge may enable participants to search for connections between their prior knowledge and elements of the instructional material, supporting their understanding, facilitating participants to make meaning and reduce element interactivity.

Overall, the findings suggest that the principled knowledge (why) and strategic information (how) included in the process oriented worked example enabled the participants to confirm and validate their prior knowledge. The expert participants found the Process condition most useful. However, participants also indicated that the strategic information (how) in the Product condition may also have assisted engagement with the instructional material. In summary, the findings suggest that an expert engaging in the Process condition in an ill-structured learning domain is able to use the principled knowledge (why) and strategic information (how) included in the process oriented worked example to confirm and validate their prior knowledge.

7.3.9.2 Participant Prior Knowledge and the Instructional Condition Influenced Engagement and Meaning Making

These participants were considered experts in this field. Of the six participants, two demonstrated high prior knowledge, two demonstrated medium prior knowledge and two demonstrated low prior knowledge. However, the two participants who demonstrated low prior knowledge of substantive communication, Albert and Jackie, each had at least ten years of teaching experience which they were able to draw upon to make meaning of substantive communication (see Table 5.2 and Table 7.1).

All six expert participants used “match” as part of their learning approach and four of the six participants used “confirm”. This demonstrated how the participants were able to use their prior knowledge to examine the relationship between the material presented in each instructional condition to make meaning and then confirm or validate their understanding. In addition, at least one approach identified for each participant was considered higher order. This suggests that the expert participants were engaged in a high level of cognitive processing while engaging with the worked examples. This can be shown by the perceived mental effort ratings provided by the expert participants. The mean learning phase perceived mental effort ratings by the expert participants in Study 2 for the Product condition and the Control conditions, 6.00 and 4.50 respectively, were higher than the corresponding mean ratings for the novice participants in Experiment 1, 2.52 and 3.54 respectively. The mean perceived mental effort ratings for the Process condition were similar between the Study 2 expert and Experiment 1 novice participants, 3.00 and 2.89 respectively.

7.3.9.3 The Patterns of the Descriptive Data and Qualitative Data Aligned with Research About Process Oriented and Product Oriented Worked Examples in Well-structured Learning Domains for Novices

The findings show that the additional principled knowledge (why) provided by the Process condition supported participants to validate and confirm their prior knowledge and understanding. Table 7.8 includes comments made by participants supporting this. The comments are taken from Phase 1 (see Section 7. 3) and Phase 2. Phase 2 will be expanded in Section 7.4 and includes participants rating their preference of instructional condition and commentary related to this.

Table 7.8

Comments Made By Participants Supporting the Process Condition

Participant	Instructional Condition	Study 2 Phase 1	Study 2 Phase 2
Jenny	Process condition	*It definitely assisted and I think what I appreciated was that the structure of the required responses was repeated throughout this whole process.*	-
Sonia	Process condition	*Yeah, it did help me understand why the coding score was given because after I read the reason why the coding score was given, I could see that interaction in the video with the specific examples.* *... because they explained how that moment previous to the pause was an example of reciprocal interaction or good substantive communication or not an example of reciprocal interaction. So, I did find them useful to be able to see the interactions in the video and then relate it to the annotations at the bottom, so yes, I did find them useful.*	*Personally, I prefer worked example one (Process) ... I like to make those deeper connections ... I prefer the detailed explanations because it helps me engage with the video and find that information.*
Albert	Product condition	*I wanted to know why did they come to the conclusion ...*	*The second video by far (Process). Because they did give you the explanation when a response was given by a student and what the teacher was doing at the time so you could pick it up fairly quickly and if you quickly look at your table, the second table we've got, I can get more of a picture ...*
Jackie	Product condition	*I was sort of questioning myself, "Have I got the correct answer here?"*	*I prefer the second clip (Process) and table and I would prefer that because it was more validation for us in terms of "Is what we're thinking correct?" It gave us more feedback as to why it was substantive or not substantive.*
Patrick	Control condition	-	*It's three (Process), two (Product), one (Conventional problem solving) for me. The reason why I like three is that ... three really scaffolds in such a way as I cannot get it wrong, you know, my*

			misunderstandings are being corrected.
Paolo	Control condition	-	*…all the reasoning, I think that gives you a greater basis from which you can use the knowledge that you've attained to apply to develop your own understanding of other examples that you could apply it to … I would prefer number three (Process) because it certainly gives me an opportunity to delve deeper into the process.*

The patterns of the descriptive data and qualitative data aligned with previous research about worked examples in well-structured learning domains for novices. With the participants being regarded as experts, there was an expectation that the Process condition may have been considered as adding ECL based on past CLT research of process oriented worked examples in well-structured learning domains (Kalyuga, 2007). Cognitive Load Theory (CLT) refers to this as the Expertise Reversal Effect and states that "designs and techniques that are effective with low-knowledge individuals can lose their effectiveness and even have negative consequences for more proficient learners" (Kalyuga, 2007, p. 510). Taking into consideration the small number of participants, the test performance scores suggested the Process condition was beneficial to the participants' understanding of substantive communication. The participants presented with the Process condition performed the best (Jenny 10.5/16 and Sonia 13/16), followed by the participants presented with the Product condition (Albert 11.5/16 and Jackie 7.5/16), then the participants presented with the Control condition (Patrick 6.5/16 and Paolo 8.5/16). In addition, the experts' perceived mental effort ratings from Study 2 (Table 7.4) showed on average, the Process condition had the lowest ratings during the test phase. The participants presented with the Control condition rated the highest perceived mental effort scores during the test phase (Table 7.4). Further, recent studies have shown that the absence of an expertise reversal effect in some studies may indicate that expert learners may benefit from the use of worked examples in an ill-structured learning domain (Sentz & Stefaniak, 2018). Nievelstein et al. (2013) conducted research with novice and more advanced students in the context of learning to reason about legal cases, an ill-structured learning domain. The results showed that both novice and more advanced students benefitted more from the use of worked examples than from problem solving. In this case, no expertise reversal effect was evident.

The expert participants indicated the Process condition supported them to validate and confirm their understanding. The Product condition presented to the participants supported them to make meaning but did not enable them to confirm their understanding. In summary, the patterns of the descriptive data and qualitative data aligned with past research of worked examples in well-structured learning domains for novice participants and suggests that a process oriented worked example supports expert participants to engage and make meaning within an ill-structured learning domain.

7.4 FINDINGS FROM PHASES 2 AND 3

7.4.1 Findings from Phase 2

Phase 2 of Study 2 required participants to engage with the remaining two instructional conditions, not as extensively as in Phase 1, but rather in summary format to familiarise participants with these other two instructional conditions in order for them to compare with the first instructional condition. See Section 5.2.4.2 for a description of Phase 2.

Table 7.9 includes the order in which the instructional conditions were presented to the expert participants. During Phase 3, participants were asked if their involvement in Study 2 had provided them with ideas on how they could use worked examples in their own practice.

Table 7.9

Sequence of Instructional Conditions Presented to Participants

Participants	Instructional Condition 1 (Phase 1)	Instructional Condition 2 (Phase 2)	Instructional Condition 3 (Phase 2)
Jenny & Sonia	Process condition	Product condition	Control condition
Albert & Jackie	Product condition	Process condition	Control condition
Patrick & Paolo	Control condition	Product condition	Process condition

Table 7.10 below provides a summary of the order of preference of instructional conditions for each expert participant. Participants were required to rank their preference of the three instructional conditions during Phase 2 of Study 2.

Table 7.*10*

Order of Preference of Instructional Conditions

Participants	Preference 1	Preference 2	Preference 3
‘			
Jenny	Product condition	Process condition	Control condition
Sonia	Process condition	Product condition	Control condition
Albert	Process condition	Product condition	Control condition
Jackie	Process condition	Product condition	Control condition
Patrick	Process condition	Product condition	Control condition
Paolo	Process condition	Product condition	Control condition

Five of the six expert participants indicated a preference for the Process condition due to the inclusion of the principled knowledge (why) which supported them to make meaning through validating and confirming their understanding. The lack of additional information and guidance provided by the Control condition was stated as the reason as to why this instructional condition was preferred the least. Table 7.8 includes comments made by participants in relation to Process condition. The following expands on comments made by each participant during Phase 2 of Study 2.

Jenny and Sonia both engaged with the Process condition during Phase 1. Jenny preferred the Product condition the most, followed by the Process condition and then the Control condition. Jenny stated that as an experienced educator, she would not require the principled knowledge provided by the process oriented worked example;

Because as experienced teachers and through our experience in the classroom, we should be able to identify these more so than someone who isn't.

Jenny added that the information provided by the Product condition supported her to confirm her understanding as the strategic information (how) provided by the annotations allowed her to do this. This is shown by the following;

I think whilst it's obvious and clear that you could clearly work with the control, I still like the idea of there being a brief description of each of these characteristics underneath – like a reminder or a checklist.

Jenny added that the additional information provided by the Process condition would hinder her engagement due to the lack of thinking required, as the answers would already be provided. This is shown by the following;

I would feel like the work has been done for me and I don't need to do anything with it.

Sonia preferred the Process condition the most, followed by the Product condition and then the Control condition. Sonia stated that the additional information provided by the process oriented worked example supported her in engaging with the material and supported her to make meaning. This is shown by the following;

Personally, I prefer worked example one (Process) … I like to make those deeper connections … I prefer the detailed explanations because it helps me engage with the video and find that information.

Sonia stated that the lack of information provided by the Control condition made the task more mentally challenging for her, as she needed to recall information from the previous instructional conditions that were presented. This is shown by the following;

I was actually trying to recall the information that we've been given previously and see it in my own way here in the video. Yeah, so in that sense, it was more mentally challenging.

Albert and Jackie were presented with the Product condition during Phase 1. Both preferred the Process condition the most, followed by the Product condition and then the Control condition. Albert indicated that the principled knowledge (why) included in the process oriented worked example supported him to make meaning. This is shown by the following;

> *The second video by far (Process). Because they did give you the explanation when a response was given by a student and what the teacher was doing at the time so you could pick it up fairly quickly and if you quickly look at your table, the second table we've got, I can get more of a picture …*

Albert added that the lack of principled knowledge included in the Product condition would hinder him to make meaning. This is shown by the following;

> *The product is less so; even though you've got some information, you haven't got it all, so it's a bit more difficult to process because you're still trying to work out, "Well what does that really mean," whereas in the process, you had a more clear definition.*

Albert stated that the lack of principled knowledge (why) and strategic information (how) in the Control condition would not support him to make meaning. This is shown by the following;

> *… you're left to your own devices so you could be on the right track or the wrong track; you really don't know.*

Jackie stated that the principled knowledge (why) included in the process oriented worked exampled supported her to validate her understanding of substantive communication;

> *I prefer the second clip (Process) and table and I would prefer that because it was more validation for us in terms of "Is what we're thinking correct?" It gave us more feedback as to why it was substantive or not substantive.*

Patrick and Paolo both engaged with the Control condition during Phase 1. They both preferred the Process condition the most, followed by the Product condition and then the Control condition.

Patrick confirmed his preference for the Process condition and stated that the principled knowledge (why) would support him to confirm and validate his understanding and overcome any misconceptions. This is shown by the following;

> *It's three (Process), two (Product), one (Conventional problem solving) for me. The reason why I like three is that … three really scaffolds in such a way as I cannot get it wrong, you know, my misunderstandings are being corrected.*

Paolo confirmed his preference for the Process condition and stated that the principled knowledge (why) would support him to further develop and confirm his understanding. This is shown by the following;

> *…all the reasoning, I think that gives you a greater basis from which you can use the knowledge that you've attained to apply to develop your own understanding of other examples that you could apply it to … I would prefer number three (Process) because it certainly gives me an opportunity to delve deeper into the process …*

In summary, the key finding from Phase 2 of Study 2 was five of the six expert participants indicated a preference for the Process condition due to the inclusion of the principled knowledge (why) which supported them to make meaning enabling them to validate and confirm their understanding.

7.4.2 Findings from Phase 3

Phase 3 of Study 2 required participants to share their perceptions of how they could use worked examples in their own teaching practice. The participants all acknowledged the importance of using worked examples in their own practice to support student learning.

Jenny stated that she would use the three instructional conditions as classroom differentiation strategies. For a high ability class with prior knowledge, she would use the Control condition, and for a lower ability class, she would use the process oriented worked example;

> *I would use it as a tool for differentiation; those requiring extensive support would receive this example, those kind of mediocre would sit in the middle and those that can afford to be extended or work independently will receive this one.*

Sonia stated that she would use the process oriented worked example when introducing a new concept to her students, and would use the Control condition when presenting previously learned concepts to her students;

> *If I was learning a new concept, the model of which I would use in class, if I was just trying to revise previously-learned concepts and try to evaluate student knowledge, I would probably use this type of worked example.*

Albert stated Study 2 allowed him to reflect on his own questioning techniques and he recognised he needed to give students more time to respond to questions;

> *I think we do that a lot, is we're trying to prompt and prompt and prompt but the teacher asked the question but never actually ever waited for a response and then when he got a response, he never really wanted to develop from that response.*

Jackie stated that the experience had made her more mindful and cautious as to how she would use worked examples in her teaching;

> *I was thinking about my own teaching practices so I will be more mindful now of how I deliver a worked example and this sort of experience will stay with me so it will make me more cautious as to how I deliver.*

Patrick stated that his involvement in Study 2 had provided him with further strategies to meet the learning needs of students he taught, one strategy including a stepped-wise approach in presenting worked examples to students.

Patrick was referring to a gradual release model which involves initially presenting the process oriented worked example, followed by the product oriented worked example and then conventional problem solving. This is shown by the following;

> *… having been exposed to that is giving me some ideas in terms of building a stepped-wise approach in my own approaches.*

Paolo stated that involvement in Study 2 had confirmed for him the importance of differentiating learning experiences and providing appropriate challenge and rigour for all students he taught;

> *Three examples there … are good examples of tiered activities in the classroom and it's differentiated as you speak.*

In summary, the participants acknowledged the importance of worked examples to support student learning. Participation in Study 2 enabled the participants to consider the different instructional conditions as forms of classroom differentiation strategies. The use of worked examples is dependent on student prior knowledge and the process oriented and product oriented worked examples can be used as a differentiation strategy. Further, Phase 3 has highlighted the importance of teachers to be continuous learners and participating in an experience like Study 2 supported teachers' reflection on how they use learning strategies within their own teaching practice to improve student learning outcomes.

7.5 SUMMARY OF FINDINGS

The following section includes a discussion of the overall key findings of the three phases of Study 2.

7.5.1 Phase 1 Findings

In summary, Study 2, a small-scale qualitative study involving six expert participants resulted in three main findings for Phase 1. The first finding was that process oriented worked examples are useful for expert participants enabling them to confirm and validate their prior knowledge. The second finding was that prior knowledge and the instructional condition influenced engagement and meaning making. The third finding was the patterns of the limited descriptive data and qualitative data aligned with CLT research about process oriented and product oriented worked examples in well-structured learning domains for novices. This does not support the trend with how experts engage in well-structured learning domains and does not indicate the presence of the expertise reversal effect. The expert participants stated they found the Process condition useful and supported them to validate and confirm their understanding. This is not consistent with findings in CLT research within well-structured learning domains, which states that process oriented worked examples become less useful as participants gain expertise, that is, the expertise reversal effect. Further, the participants presented with the Product condition stated the worked example supported them to make meaning, but did not enable them to confirm their understanding due to the lack of principled knowledge (why) included in a product oriented worked example. The qualitative data from Study 2 suggests process oriented worked examples are perceived as useful by participants in ill-structured learning domains, and the limited descriptive data provides some support for the qualitative data, and this is contrasting to findings on the use of process oriented worked examples in well-structured learning domains.

7.5.2 Phase 2 and 3 Findings

The key finding from Phase 2 of Study 2 was that five of the six expert participants indicated a preference for the Process condition due to the inclusion of the principled knowledge (why) which supported them to validate and confirm their understanding. One participant, Jenny, who demonstrated a medium prior knowledge, indicated a preference for the Product condition as the strategic information (how) enabled her to confirm her understanding. From Phase 3, the key finding was that participants' engagement in Study 2 enabled them to reflect on the learning strategies within their own teaching practices and how to best present the three instructional conditions, including process oriented and product oriented worked examples, to improve student learning outcomes.

7.5.3 Conclusion

In this chapter, an overview of Study 2 was provided for expert participants. Overall, Study 2 provided insight into the thought processes of how expert learners engaged with materials within designated instructional conditions in an ill-structured learning domain and has uncovered that the process oriented worked example is useful for participants to confirm and validate understanding. What Study 2 has found, is that how expert participants engage with process oriented worked examples in ill-structured learning domains to make meaning is not consistent with how expert participants engage in well-structured learning domains. The test performance scores and verbal protocols from the qualitative data show there was no expertise reversal effect as may have been expected going on past CLT research of process oriented worked examples in well-structured learning domains.

The Process condition supported expert participants learning best and was the most preferred by five of the six participants, followed by the Product condition and then the Control condition. Worked examples in well-structured learning domains have solutions that are either correct or incorrect. In an ill-structured learning domain, there is an element of interpretation and judgment. This may have influenced the experts' preference for the Process condition, because it provided the answer, an interpretation and principled knowledge (why). The principled knowledge (why) enabled the participants to validate and confirm their prior knowledge and understanding of substantive communication.

Chapter 8

GENERAL DISCUSSION

8.1 INTRODUCTION

The aim of this research was to investigate which type of instructional condition, Process condition, Product condition or Control condition, best supported student learning in an ill-structured learning domain. The Process condition participants were presented with process oriented worked examples, the Product condition participants were presented with product oriented worked examples and the Control condition participants engaged in conventional problem solving. The ill-structured learning domain was the New South Wales Quality Teaching Model (NSW QTM) element of substantive communication. Previous research has primarily focused on the use of worked examples in a well-structured learning domain, where problem states and required problem solving operators can be clearly identified (Simon, 1973) and where there is a one correct solution to the problem. In ill-structured learning domains, there are multiple possible pathways to solutions and elements of interpretation (Simon, 1973).

This research comprised of two studies – Experiment 1 and Study 2. Experiment 1 used a quantitative research experimental design to investigate the effectiveness of process oriented and product oriented worked examples for pre-service teachers (novices) learning about the characteristics of substantive communication. Study 2 built on the findings of Experiment 1 by using a qualitative research experimental design to investigate the thought processes of pre-service teachers (novices) and practicing teachers (experts) learning about the characteristics of substantive communication using process oriented and product oriented worked examples.

The research is novel as firstly there has been little research investigating the use of worked examples in ill-structured learning domains (Sweller et al., 2011) and secondly, there is limited understanding on how learners engage with and make meaning from worked examples in ill-structured learning domains (Leppink & van den Heuvel, 2015).

8.2 EXPERIMENT 1

Experiment 1 involved novice participants learning about substantive communication through one of three instructional conditions. The participants (n=85) were pre-service teachers enrolled in either their first year of a two-year post-graduate Masters of Teaching programme or their final year of a four-year Bachelor of Primary Education programme at an Australian regional university. The instructional conditions during the learning phase involved the participants being presented with process oriented worked examples, product oriented worked examples or engaging in conventional problem solving. Following the instructional condition, participants were administered three test items and an evaluation. During Experiment 1, participants rated their perceived mental effort and perceived task difficulty during the learning phase and at the completion of each test item during the test phase. The aim of Experiment 1 was three-fold:

1. To investigate participants' test performance scores for the three instructional conditions.
2. To investigate participants' perceived cognitive load for the three instructional conditions.
3. To investigate participants' perceived task difficulty for the three instructional conditions.

8.2.1 Experiment 1 Research Questions

There were four research questions for Experiment 1:

Research Question 1: When learning about the characteristics of substantive communication, do participants presented with the Process condition achieve higher test performance scores during the *test phase* than participants presented with the Product condition, and do participants presented with the Product condition achieve higher test performance scores during the *test phase* than participants presented with the Control condition?

Research Question 2: When learning about the characteristics of substantive communication, do participants presented with the Process condition or Control condition, report higher perceived cognitive load and higher perceived task difficulty during the *learning phase* than participants presented with the Product condition during the *learning phase*?

Research Question 3: When learning about the characteristics of substantive communication, do participants presented with the Process condition report lower perceived cognitive load and lower perceived task difficulty during the *test phase* than participants presented with the Product condition?

Research Question 4: When learning about the characteristics of substantive communication, do participants presented with the Process condition or Product condition report lower perceived cognitive load and lower perceived task difficulty during the *test phase* than participants presented with the Control condition?

8.2.2 Experiment 1 – Overview of Findings

This section provides an overview of findings from Experiment 1, answering the four research questions. Table 8.1 provides a summary of the results in terms of the research questions, related hypothesis numbers, variables, hypothesis summaries and findings (see Section 3.3 in Chapter 3 for the full wording of the hypotheses).

Table 8.1

Experiment 1: Summary of Experiment 1 Findings: Research Questions, Related Hypotheses, Variables and Findings

Experiment 1: Research Questions, Related Hypotheses, Variables and Findings				
Research Question	Related Hypothesis Number	Data	Hypothesis Summaries	Findings
1	1	Test Performance Scores	Process Condition > Product Condition	Confirmed
	2	Test Performance Scores	Product Condition > Control Condition	Not confirmed
2	3	Perceived Mental Effort Rating (Learning Phase)	Process Condition > Product Condition	Not confirmed.
	3	Perceived Mental Effort Rating (Learning Phase)	Control Condition > Product Condition	Not confirmed. (Confirmed for Worked Example 2)
	4	Perceived Task Difficulty Rating (Learning Phase)	Process Condition > Product Condition	Not confirmed
	4	Perceived Task Difficulty Rating (Learning Phase)	Control Condition > Product Condition	Confirmed (Including for Worked Example 2)
3	5	Perceived Mental Effort Rating (Test Phase)	Process Condition < Product Condition	Not confirmed
	6	Perceived Task Difficulty Rating (Test Phase)	Process Condition < Product Condition	Not confirmed
4	7	Perceived Mental Effort Rating (Test Phase)	Process or Product Condition < Control Condition	Not confirmed
	8	Perceived Task Difficulty Rating (Test Phase)	Process or Product Condition < Control Condition	Confirmed

8.2.2.1 Experiment 1 – Research Question 1

Research Question 1, and associated hypotheses 1 and 2, proposed when learning about the characteristics of substantive communication, participants presented with the Process condition would achieve higher test performance scores than participants presented with Product condition. Further, participants presented with the Product condition would achieve higher test performance scores than participants presented with the Control condition. Results for total test performance scores showed a statistically significant difference as the Process condition outperformed the Product condition. Hence, Hypothesis 1 was confirmed. This result is consistent with previous research in well-structured learning domains (Ohlsson & Rees, 1991, Van Gog et al., 2008) that found that process oriented worked examples promote novice learners' construction and automation of cognitive schemata enabling better performance than product oriented worked examples (Van Gog et al., 2008, p. 213). In addition, whilst results for total test performance scores were in the direction as per Hypothesis 2 with the mean scores in the Product condition being higher than the scores in the Control condition, there was no significant difference. Hence, Hypothesis 2 was not confirmed.

8.2.2.2 Experiment 1 – Research Question 2

Research Question 2, and associated hypotheses 3 and 4, proposed when learning about the characteristics of substantive communication during the *learning phase*, participants presented with the Process condition or Control condition would report higher perceived cognitive load and perceived task difficulty than participants presented with the Product Condition. While the results were in the right direction with the perceived mental effort and task difficulty ratings of participants in the Process and Control conditions being higher than the ratings of participants in the Product condition during the learning phase, the only statistically significant result was for perceived task difficulty ratings, comparing the Product and Control conditions. Overall, Hypotheses 3 and 4 were not confirmed.

Upon examination of each worked example in Experiment 1, the results for Worked Example 2, the video recording of the Japanese languages lesson, the perceived mental effort ratings indicated a statistically significant difference. For Worked Example 2, the Process and Product conditions rated a lower perceived mental effort mean rating compared to the Control condition. This aligns with part of Hypothesis 3 which stated that during the learning phase, the Product Condition would report lower perceived cognitive load than the Control condition.

Further, the perceived task difficulty ratings of participants for Worked Example 2 indicated a statistically significant difference, with the perceived task difficulty rating for the Control condition significantly higher than the two other instructional conditions. This aligns with part of Hypothesis 4, which stated that during the learning phase, the Product Condition would report lower perceived task difficulty than the Control condition. The higher task difficulty rating for the Control condition may have been caused by the lack of information which resulted in difficulty in the development of appropriate schemas.

8.2.2.3 Experiment 1 – Research Question 3

Research Question 3, and associated hypotheses 5 and 6, proposed when learning about the characteristics of substantive communication during the *learning phase*, participants presented with the Process condition would report lower perceived cognitive load and perceived task difficulty during the *test phase* than participants presented with the Product condition. This is due to less cognitive capacity required by participants during the test phase as process oriented worked examples support schemata to be developed by participants during the learning phase (Paas, 1992). Results for perceived mental effort and perceived task difficulty ratings during the test phase indicated no statistically significant difference and the mental effort and task difficulty ratings of the Process condition were higher than the Product condition. Hence, Hypotheses 5 and 6 were not confirmed. This may have been due to the Process condition participants engaging with the additional information provided in the process oriented worked example, which may have resulted in Process condition participants experiencing a higher cognitive load thus reporting higher task difficulty ratings.

8.2.2.4 Experiment 1 – Research Question 4

Research Question 4, and associated hypotheses 7 and 8, proposed when learning about the characteristics of substantive communication during the *learning phase*, participants presented with the Process or Product conditions would report lower perceived cognitive load and perceived task difficulty during the *test phase* than participants presented with the Control condition. This is due to less cognitive capacity required by participants during the test phase in the Process or Product conditions as both worked examples support schemata to be developed by participants during the learning phase (Paas, 1992), compared to participants in the Control condition. Results for perceived mental effort ratings during the test phase, whilst in the direction as per Hypothesis

7, indicated no statistically significant difference in the Process or Product conditions compared to the Control condition. Hence, Hypothesis 7 was not confirmed.

Results for perceived task difficulty ratings during the test phase showed a statistically significant difference as the Process and Product conditions had a lower mean than the Control condition. Thus, Hypothesis 8 was confirmed. The process oriented and product oriented worked examples provided the participants with a step-by-step solution to the problem, whereas the participants of the Control condition may have used a means-ends problem solving strategy which inhibits schema development (Sweller et al., 2011; Cooper & Sweller, 1987 & Sweller & Cooper, 1985).

8.2.3 Experiment 1 – Summary of Findings

Experiment 1 found that in an ill-structured learning domain, the Process condition outperformed the Product condition on test performance scores, and whilst not statistically significant, the test performance scores for the Product condition were higher than the Control condition. Further, the perceived task difficulty ratings during the test phase for both the Process and Product conditions were statistically significantly lower than for the Control condition. This suggests that the use of Process and Product worked examples during the learning phase enabled the novice participants to develop relevant schema to then apply in responding to the test items during the test phase. In addition, an Instructional Efficiency analysis was undertaken in Experiment 1, while not statistically significant, results provided some evidence of the Process condition supporting novice participants' learnning in an ill-structured domain.

These test performance scores results align to previous research showing that novice learners provided with worked examples in well-structured learning domains perform better on tests than novice learners not presented with worked examples (Carroll 1994; Cooper & Sweller 1987). See Section 2.3.5 for a discussion on the worked example effect. Experiment 1 showed that worked examples, in particular process oriented worked examples, support novice learners in an ill-structured learning domain. Worked examples provided the learner with problem-solving schemas to be stored in long-term memory (LTM). Once stored in LTM, the stored schema can be accessed to solve problems (Cooper & Sweller, 1987; Sweller et al., 2011) and enhance automation, leading to improved performance. Further, worked examples reduce extraneous cognitive load (ECL) by focusing on problem states and steps to solution (Plass et al., 2010). In summary, the Process condition was more effective that the Product and Control conditions. This finding aligns with existing CLT research findings for process oriented worked examples in a well-structured learning domain (Van Gog et al., 2008).

8.3 STUDY 2

Study 2 investigated the differences between novices (pre-service teachers) and experts (practicing teachers) when they engaged with and made meaning from the three different instructional conditions, enabling the researcher to examine the differences between and learn more about how experts and novices engaged with worked examples presented in an ill-structured learning domain. The novice participants were five pre-service teachers enrolled in the fourth year Bachelor of Education degree from the same Australian regional university as in Experiment 1. The expert participants were six participants who were practicing teachers recruited from secondary schools within a regional Catholic Education Diocese. Due to the inconclusive results of Experiment 1, in particularly the perceived mental effort ratings of the participants, the researcher wanted to further explore what the participants were doing when engaging with worked examples and conditional instructions. Further, the contradictory results between the descriptive data collected during Experiment 1 and the ratings and commentary given by participants during the evaluation provided the rationale for conducting Study 2.

There has not been a lot of research on the use of worked examples in ill-structured learning domains, including what they look like and how people engaged with them. Hence, Study 2 allowed an in-depth exploration of what participants were doing when engaging with worked examples in an ill-structured learning domain. Worked examples in a well-structured learning domain provide sequential steps to solution, whereas in an ill-structured learning domain, this is not the case. An ill-structured learning domain provides multiple possible pathways to solution and elements of interpretation (Simon, 1973). This added further rationale to investigate what participants did when engaging with the worked examples.

8.3.1 Study 2 - Research Questions

The two research questions for Study 2 were as follows:

Research Question 1: When learning about the characteristics of substantive communication, how do novice and expert participants engage with and make meaning from the three different instructional conditions; Process condition, Product condition or Control condition within an ill-structured learning domain?

Research Question 2: When learning about the characteristics of substantive communication, how do novice and expert participants who have engaged with one instructional condition perceive the other two instructional conditions?

8.3.2 Study 2 – Overview of Findings

Study 2, Exploratory Question 1 investigated how novice and expert participants engaged with and made meaning from the three instructional conditions within an ill-structured learning domain. This section provides an overview of findings from Study 2, answering the two research questions and providing a summary of the findings. This is then followed by a comparison of findings between Experiment 1 and Study 2.

8.3.2.1 Study 2 – Exploratory Question 1 (Novice Participants)

The following provides a summary of three themes that emerged for the novice participants.

1. **The approach adopted to make meaning was influenced by the instructional condition:** The learning approaches identified for each participant showed that there was a pattern demonstrating more higher order thinking evident in the Process condition than in the Product and Control condition. In addition, the learning approaches identified for the Product condition participants were higher order than the learning approaches identified for the Control condition participant. For example, the identified learning approaches used by Mark and Steve (Process condition), "identify, match and confirm" and "compare, interpret and modify" respectively, illustrated a higher level of thinking than Nadia's approach (Control condition), which included a "guess" strategy. In addition, the approaches used by Mark and Steve, overall were higher order that the approaches used by Jodie and Mandy (Product Condition), who used "check, interpret and modify" and "observe, memorise and interpret" respectively. Refer to Section 6.3.8.1 for further information.

2. **Participant prior knowledge and the length of worked example influenced engagement and meaning making:** Participant prior knowledge may have influenced test performance scores and ratings for perceived task difficulty. Participants with low prior knowledge presented with the Process condition were able to modify misconceptions they may have had about substantive communication. For example, Steve (Process condition) modified his understanding of substantive communication based on the included principled knowledge presented with the process oriented worked example (refer to Section 6.3.4 for details). In addition, the length of the process oriented worked example may have influenced participant engagement, suggesting that the time for completing the tasks may have been a form of ECL (Barrouillet & Camos, 2012; Puma et al., 2018). Refer to Section 6.3.8.2 for further information.
3. **The descriptive data aligned with findings about worked examples in well-structured learning domains:** Research about worked examples in well-structured learning domains has shown that process oriented worked examples best support novice participants with their learning compared to participants presented with product oriented worked examples (Ohlsson & Rees, 1991, Van Gog et al., 2008). A similar pattern was evident in the descriptive data. For example, test performance scores for the participants of the Process condition were higher than the other two instructional conditions, the perceived mental effort ratings were highest for the Process and Product conditions during the learning phase and highest for the Control condition during the test phase. The ratings for perceived task difficulty during the test phase were highest for the Control condition (refer to Section 6.3.8.3 for details). This suggests, although it is acknowledged that this data is limited and statistically non-significant, that the novice participants found the Process condition best supported them to understand and apply the concepts of substantive communication.

In summary, patterns showed more higher order thinking evident in the Process condition than in the Product and Control conditions. The commentary showed that novice participants found the Process condition most effective and reported that the process oriented worked example enabled them to modify any misunderstanding or misconception they may have had in relation to the concept of substantive communication.

8.3.2.2 Study 2 – Exploratory Question 1 (Expert Participants)

The following provides a summary of three overall themes that emerged for the expert participants.

1. **The process oriented worked example was useful for the participants enabling them to confirm and validate their prior knowledge:** The scaffolding of the process oriented worked example enabled the expert participants, who already had schema to make meaning, the opportunity to use their expertise to enhance the way they engaged and made meaning. The process oriented worked example enabled the expert participants to validate and confirm their understanding, challenge their thinking and explore the "why", the rationale behind the solution. The participants with high prior knowledge of substantive communication used "search" as an approach to make meaning. This may have enabled the participants to make connections with their prior knowledge, schema in LTM, by bringing elements of the instructional material together to make meaning and reduce ECL. Refer to Section 7.3.9.1 for further information.
2. **Participant prior knowledge and the instructional condition influenced engagement and meaning making:** All expert participants used the "match" approach as part of their learning approach and five of the six participants used the "confirm" approach. This demonstrated how the participants were able to use their expertise, schemas in LTM, to examine the relationship between the material presented in each instructional condition to make meaning and then confirm or validate their understanding. Higher order approaches were identified for each expert participant, however, verbal protocols indicated that the principled knowledge included in the Process condition enabled the participants to make deeper connections between information presented and their prior knowledge and experience increased engagement. Refer to Section 7.3.9.2 for further information.
3. **The patterns of the descriptive data and qualitative data aligned with research about process oriented and product oriented worked examples in well-structured learning domains for novices**: Research about worked examples in well-structured learning domains has shown that as the expertise of a learner increases and the level of element interactivity decreases, the use of the worked example may lose effect for expert learners (Kalyuga, 2007). This pattern was not evident in the descriptive data. For example, test performance scores for the participants of the Process condition were higher than the other two instructional conditions, the perceived mental effort ratings were highest for the Control

condition during the test phase and lowest for the Process condition. The ratings for perceived task difficulty during the test phase were highest for the Control condition and lowest for the Process condition (refer to Section 7.3.9.3 for detail). This suggests, although it is acknowledged that this data is limited and statistically non-significant, that similar to the novice participants, the expert participants found the Process condition best supported them to understand and apply the concepts of substantive communication.

In summary, the results showed that all expert participants engaged with some high level of cognitive processing when presented with the three instructional conditions. Further, the expert participants, with their prior knowledge of substantive communication and experience as practicing teachers, indicated they found the process oriented worked example supported their understanding as they were able to validate and confirm their understanding of substantive communication. The Product condition presented to the participants supported them to make meaning but did not enable them to confirm their understanding.

8.3.2.3 Study 2 – Exploratory Question 2

Exploratory Question 2 investigated how novice and expert participants who engaged with one instructional condition, perceived the other two instructional conditions. Four of the five novice participants indicated a preference for the Process condition due to the inclusion of the principled knowledge (why) which supported them to make meaning. In addition, four of the five novice participants indicated that they preferred the Control condition the least. Five of the six expert participants indicated a preference for the Process condition due to the inclusion of the principled knowledge (why) which supported them to validate and confirm their understanding of substantive communication. Further, all six expert participants indicated that they preferred the Control condition the least. Overall, the novice and expert participants preferred the Process condition the most and the Control condition the least. The lack of additional information and guidance provided by the Control condition was stated as the reason as to why this instructional condition was preferred the least.

8.3.3 Study 2 – Summary of Findings

Overall, Study 2 found the Process condition was beneficial for both novice and expert participants. The Process condition enabled the participants to engage more deeply than participants presented with the remaining instructional conditions, in particular, the Control condition. The novice participants found the Process condition useful as they were able to modify misconceptions and make meaning from the included principled knowledge. The expert participants found the Process condition useful as the principled knowledge enabled them to confirm and validate their prior understanding of substantive communication. Further, the descriptive data (acknowledged as limited and statistically non-significant) and commentary provided by novice participants aligned with worked example research in a well-structured learning domain and suggested that the Process condition was the preferred instructional condition. In contrast, the descriptive data and commentary provided by expert participants did not align with research about process oriented and product oriented worked examples in well-structured learning domains, that is, the expert participants found the Process condition supported their learning best (See Section 2.4 for a discussion on the expertise reversal effect).

8.4 STUDY 2 – COMPARING NOVICE AND EXPERT PARTICIPANTS

Exploratory Question 1 investigated how novice and expert participants engaged with and made meaning from the three instructional conditions within an ill-structured learning domain. The following section compares findings for both novice and expert participants. The descriptive results are first considered followed by a comparison of strategies used by both novice and expert participants.

8.4.1 Comparing Novice and Expert Participants – Descriptive Data

Descriptive data, including the mean of test performance scores, perceived mental effort ratings and perceived task difficulty ratings were calculated. Due to the low participant numbers, these were presented solely to show trends and accompany Study 2 qualitative data.

Overall, the patterns of the descriptive data showed that the results for test items, perceived mental effort and perceived task difficulty ratings for novice participants were consistent with existing research findings regarding novice participants engaging with process oriented worked examples in well-structured learning domains (Van Gog et al., 2008). However, the results were not consistent with research findings regarding expert participants engaging with process oriented worked examples in well-structured learning domains. Research has shown that as a learner's expertise increases through the use of process oriented worked examples, the worked example becomes redundant or negatively impacts learning outcomes (Leslie et al., 2012; Pachman et al., 2013; Yeung et al., 1998). This is known as the expertise reversal effect. Yet, in Study 2, in addition to the patterns of the descriptive data, expert participants reported they found the Process condition useful. The expertise reversal effect is not evident for the expert participants in the current research, which provides evidence that process oriented worked examples presented in an ill-structured learning domain supports both novice and expert participants with their learning.

8.4.2 Comparing Novice and Expert Participants – Learning Approaches Used

Learning approaches adopted by both the novice and expert participants are discussed in Section 6.3 and Section 7.3. Table 8.2 summarises the learning approaches used by both novice and expert participants enabling a comparison of adopted approaches between the two. The participants' prior knowledge of substantive communication is also included. In the table, IC represents "Instructional Condition".

Table 8.2

Learning Approaches and Prior Knowledge of Novice and Expert Participants

IC	Participant (Novice)	Prior Knowledge (Novice)	Learning Approach (Novice)	Participant (Expert)	Prior Knowledge (Expert)	Learning Approach (Expert)
Process	Mark	Medium	Identify, match and confirm	Jenny	Medium	Recall, match and confirm
Process	Steve	Low	Compare, interpret and modify	Sonia	Medium	Recall, match and confirm
Product	Jodie	Low	Check, interpret and modify	Albert	Low	Reflect, match and confirm
Product	Mandy	Low	Observe, memorise and interpret	Jackie	Low	Reflect, interpret and match
Control	Nadia	Low	Search, reflect and guess	Patrick	High	Search, match and confirm
Control				Paolo	High	Search, match and infer

The learning approaches identified, based on Bloom's Taxonomy, demonstrated that for novice participants, there is a pattern that showed more higher order thinking evident in the Process condition than in the Product and Control conditions. The Process condition learning approaches included "identify, match and confirm" and "compare, interpret and modify". The Product condition learning approaches included "check, interpret and modify" and "observe, memorise and interpret" and the learning approach for the Control condition was "search, reflect and guess". The commentary and learning approaches used by the novice participants, demonstrated they were able to modify misconceptions and make meaning from the included principled knowledge in the process oriented worked example.

In relation to expert participants, it can be seen from the learning approaches identified by the researcher in Table 8.2, each participant exercised some higher order thinking strategies. These included "reflect", "infer", "interpret", in addition to “match” and “confirm”. All six expert participants used the “match” approach and four used the “confirm” approach. The commentary and learning approaches used by the expert participants, demonstrated that they found the Process condition useful as they were able to confirm and validate their prior understanding of substantive communication.

The qualitative data indicated that the expert participants found the Process condition best supported their learning. This is not in line with research on expertise and process oriented worked examples in well-structured learning domains. Unlike a well-structured learning domain which provides the steps to solution and supports schema construction for the learner (Sweller et al., 2011; Sweller & Cooper, 1985), an ill-structured learning domain provides multiple possible pathways to solution and elements of interpretation (Simon, 1973). The process oriented worked example, coupled with prior knowledge, enabled the expert participants to validate and confirm their understanding, challenge their thinking and explore the rationale behind the solution. It is suggested that the expert participants, due to their teaching experience, had more working memory (WM) capacity as they had higher developed schema in the area of quality teaching than the novice participants. In addition, the Process condition may also have reduced the need for the expert participants to search LTM for possible solutions, leading to less cognitive load on WM. Further, the learning approaches showed that more higher order thinking was evident in the Process condition than in the Product and Control conditions for the novice participants. For the expert participants, all instructional conditions demonstrated some learning approaches involving higher order thinking. However, verbal protocols suggested that the principled knowledge included in the Process condition enabled the expert participants to make deeper connections between information presented and their prior knowledge and experience increased engagement.

8.5 KEY FINDINGS – EXPERIMENT 1 AND STUDY 2

Overall, there are three main findings from Experiment 1 and Study 2.

Firstly, a key finding from Experiment 1 is that process oriented worked examples best supported novice learners in an ill-structured learning domain, which is consistent with CLT research of worked examples in well-structured learning domains. However, there were some inconclusive results in relation to perceived mental effort and perceived task difficulty ratings. Thus Study 2 was designed to examine in depth through the use of a qualitative research approach, how novice and experts engaged with the different instructional conditions. The novice participants' pattern of test performance scores and verbal protocols in Study 2 also supported Experiment 1 results and were consistent with CLT research of worked examples in well-structured learning domains (Van Gog et al., 2004; Van Gog et al., 2008).

Secondly, Study 2 novice and expert participants both indicated a preference for the Process condition. This aligns with research about novices engaging with worked examples in a well-structured learning environment, but, this is a novel finding for expert learners in an ill-structured learning domain. CLT research has shown that as a learner's expertise increases through the use of worked examples, the worked example becomes redundant or negatively impacts learning outcomes (Leslie et al., 2012; Pachman et al., 2013; Yeung et al., 1998). However, Study 2 indicated that experts found the Process condition useful as a way to confirm and validate their understanding. Overall, Study 2 demonstrated that both novice and expert participants found that the Process condition supported their learning and preferred it over the other two instructional conditions. This is in contrast to previous research in well-structured learning domains, where worked examples show an expertise reversal effect for expert participants (Kalyuga et al., 1999; Leslie et al., 2012; Pachman et al., 2013; Yeung et al., 1998).

Thirdly, Study 2 indicated the instructional condition and prior knowledge influenced how each participant engaged and made meaning. The learning approaches adopted by the participants were influenced by their prior knowledge and instructional condition they engaged in. Overall, for novices there was a pattern that showed more higher order thinking was evident in the Process condition than in the Product and Control conditions. For the experts, participants in all three instructional conditions engaged in some higher thinking skills, with expert participant commentary suggesting the principled knowledge included in the process oriented worked example enabled deeper connections between information presented and their prior knowledge and increased engagement.

In summary, worked examples in an ill-structured learning domain seem to have the potential to support intellectual engagement by supporting learners to make connections between new information and existing information that participants have in their LTM, and further develop their schemata. It is important to note that Study 2 was a small-scale exploratory study, but these findings provide possible insight into the stimulation of germane cognitive load (GCL) (See Section 8.6 below). Further research is required to investigate process oriented and product oriented worked examples in an ill-structured learning domain and if they support engagement and motivation, leading to a higher level of thinking, schema development and using Bloom's Taxonomy to understand how participants are thinking.

8.6 THEORETICAL CONTRIBUTIONS FOR COGNITIVE LOAD THEORY

There are five theoretical contributions for Cognitive Load Theory that can be drawn from this thesis. Firstly, this current research takes a novel approach to examine the use of worked examples in an ill-structured learning domain. Research in the field of Cognitive Load Theory (CLT) has primarily been conducted in well-structured learning domains. The current research investigated what type of worked example best supported participants learning and applying the characteristics of substantive communication, an element of the NSW QTM, in an ill-structured learning environment.

Secondly, this current research takes a novel approach to investigate the thought processes of novice and expert participants engaging in the three instructional conditions – Process condition, Product condition and the Control condition. Experiment 1, a quantitative experimental design, was followed by a qualitative approach in Study 2 to enable the investigation of the thought processes of participants. The analysis of the commentary provided by the participants enabled the researcher to identify learning approaches adopted by each of the participants. The learning approaches adopted by the experts showed they were engaging with the Process condition by validating and confirming their prior knowledge to make meaning. Further, the learning approaches adopted by the novices showed they were modifying misconceptions to make meaning.

Thirdly, the results in Experiment 1 for novice participants engaging in an ill-structured learning domain aligned to what would be expected in well-structured learning domains. The test performance scores were consistent with CLT research of worked examples in well-structured learning domains with statistically significant results. Further, Experiment 1 perceived task difficulty results were statistically significant and aligned with the researcher's hypothesis when comparing the Control condition and the Product condition during the learning phase (Control condition > Product condition), and when comparing the Control condition with both the Process condition and the Product conditions during the test phase (Control condition > Process and Product condition). However, other perceived task difficulty ratings and perceived mental effort ratings were inconclusive. In addition, Study 2 participant commentary and patterns of the descriptive data suggested results for novices engaging in ill-structured learning domains aligned with research about worked examples in well-structured learning domains for novices (Van Gog et al., 2008).

The fourth implication is that the expert participants found the Process condition beneficial. This is evident through Study 2 descriptive data and verbal protocols suggesting that expert participants found the Process condition beneficial as it enabled them to validate and confirm their prior understanding of substantive communication. This result is not aligned with previous CLT research of worked examples in a well-structured learning domain, where experts are hindered by the principled knowledge (why) and strategic information (how) included in process oriented worked examples due to the expertise reversal effect (Darabi & Nelson, 2004; Kalyuga, 2007; Van Gog et al., 2008).

The fifth implication is that the qualitative data from Study 2 suggests that GCL was stimulated when the participants were engaging with Process condition. This is evident through the learning approaches adopted by participants presented with the Process condition indicating higher levels of thinking. The identified learning approaches were based on Bloom taxonomy and associated verbs (refer to Section 5.3 for further information). For both novice and expert participants, the Process condition supported the bringing together of connections between WM processing and LTM domain knowledge to develop new understanding. GCL is defined as "the mental resources devoted to acquiring and automating schemata in long-term memory" (DeBue and van de Leemput, 2014, p. 2). Some cognitive load theorists argue that GCL redistributes WM resources from extraneous tasks to aspects intrinsic to the learning task (Leppink, 2020), as opposed to other cognitive load theorists assuming GCL imposes its own cognitive load (Sweller et al., 2019; Leppink, 2020). In addition, Costley and Lange (2017) argue that GCL represents student understanding of content, linking to learning. They add that "some research claims that germane load reflects the effort to gain a better understanding of the processed information" (Costley & Lange, 2017, p. 176). Further, in considering GCL, the construction of schema occurs through approaches including interpreting, classifying, inferring and organising information (De Jong, 2010). This aligns with the identified learning approaches by participants in Study 2, which included interpreting and inferring. DeBue and van de Leemput (2014) state that research by Schnotz and Kürschner (2007) consider ICL as task performance and GCL not dealing with schema formation, "but rather a formation of a set of learning strategies employed by students" (Costley & Lange, 2017, p. 176). This relates to this current research where Bloom's Taxonomy was used to identify learning approaches adopted by participants when engaging with the instructional material to make meaning. This current research suggests that a process oriented worked example presented in an ill-structured learning domain may stimulate GCL and supports engagement in learning.

In summary, this current research is one of the first that examined worked examples in an ill-structured learning domain and has shown what an ill-structured worked example looks like. Qualitative research techniques were used to explore how participants engaged within the Process, Product and Control conditions. Results showed that novices engaging with worked examples in an ill-structured learning domain were consistent with CLT in a well-structured learning domain, but was not the case for expert participants. Further, the qualitative approach enabled the uncovering of each participant's learning approach to show how the Process condition facilitated higher order thinking from the novice participants as they were able to make meaning and overcome misconceptions. In contrast, all expert participants demonstrated higher order thinking, with verbal protocols indicating the Process condition enabled expert participants to make deeper connections between information presented and their prior knowledge. This current research suggests that a process oriented worked example presented in an ill-structured learning domain may stimulate GCL, and as a result, future studies need to consider further understanding of how to promote and measure GCL.

8.7 IMPLICATIONS FOR PRACTICE

The results from Experiment 1 and Study 2 suggest that process oriented worked examples in ill-structured learning domains can benefit both novice and expert learners. As a result of this current research, including evaluations and feedback from participants, there are three recommendations for the instructional design and use of process oriented worked examples in an ill-structured learning domain. The process oriented worked example in this current research consisted of a video of a concept to be learned and accompanying textual information that supports the learning of the concept made available for the learner in hardcopy. The video included annotations at key points providing information on the concept to improve learning (refer to Section 4.2.3.2 for further information on the videos and annotations).

1. When developing an ill-structured process oriented worked example using video and text annotations, ensure the text annotations are concise and are displayed immediately after the concept is demonstrated in the video.

2. When developing an ill-structured process oriented worked example using video and text annotations, allow the learner to be able to pause and rewind the video.
3. When developing an ill-structured process oriented worked example using video and text annotations, allow the learner to control the playback speed of the video by operating a video speed controller.

Teacher Professional Learning is becoming essential within schools and school systems (Nielsen et al., 2021). This current research has provided professional learning to practicing teachers on the NSW QTM, with a specific focus on substantive communication. The process and product oriented worked examples may inform the design of teacher Professional Learning in the future, with process and product oriented worked example scaffolding both novice and expert learning. If Professional Learning resources are provided to teachers in the form of the three instructional conditions as presented in this research, teachers could have the choice of which instructional condition to use based on their current understandings i.e., the Process condition, the Product condition or the Control condition (conventional problem solving).

A form of teacher Professional Learning that promotes collaboration amongst practicing teachers is the Quality Teaching Rounds (Gore, 2018). The model has been developed by Professor Jenny Gore and Dr Julie Bowe from the University of Newcastle, Australia. The model involves teachers working collaboratively in a small team, viewing each other's teaching practice and using the Coding Scale to provide feedback on the quality of the lesson to each other after the observation. This concept could be adapted with the use of the worked examples used in the current research. Commentary from participants in this current research stated a preference to being given an opportunity to engage in learning conversations with other participants while engaging with the worked examples. Teachers could work collaboratively in small teams and view the video recordings of lessons focusing on different elements of the NSW QTM. This would then provide the opportunity for the video recordings to be paused, allowing for a conversation between the participating teachers.

8.8 LIMITATIONS

Four key limitations have been identified for this current research. Firstly, the small sample size for the Control condition in both Experiment 1 and Study 2. Due to the timing of the Control condition, a number of participants were unable to remain for the experiment. It may be posited that the impact on results was minimal as the researcher's focus was investigating which instructional condition, Process condition or Product condition, best supported participant learning. A second limitation was that the Experiment 1 participants and Study 2 novice participants were all students from one university. Further, the expert participants for Study 2 were teachers from one school system in a regional area in Australia, this also raises the lack of generalisability of the findings. A consideration for further studies is to engage students from a variety of different universities and teachers from different systems of schools to participate in the experiment. A third limitation is that the focus on one element of the NSW QTM, substantive communication, also raises the lack of generalisability of the results. A fourth limitation, as discussed in Chapter 4, was the inclusion of the pauses during the video recordings of the lessons in the Control condition that may be considered a form of scaffold. The inclusion of the pauses adhered to the robustness of this research, but may have provided a subtle queue for participants in the Control condition and provided a scaffold for learning.

8.9 FURTHER RESEARCH

The following section provides an overview of four areas for further research investigating the use of worked examples in ill-structured learning domains. These include prior knowledge of participants, germane cognitive load, different ill-structured learning domains and the length of the process oriented worked example.

Firstly, Experiment 1 and Study 2 did not have a detailed measure of prior knowledge of the participants. Further research could administer a pre-assessment of prior knowledge to obtain a statistical variable, before the participants engage with the instructional material. The prior knowledge may be of interest to further investigate the impact of prior knowledge on participant preference of instructional design.

Secondly, CLT traditionally investigates participant learning quantitatively, but because the decision was made to use a qualitative and exploratory approach for Study 2, this enabled the opportunity to investigate and understand what was happening when the participants engaged with the worked examples. Even though this was a small-scale exploratory study, findings suggested that the use of worked examples in ill-structured learning domains reduce ECL and support the use of GCL in contrast to worked examples in well-structured learning domains, which reduce ECL. Both novice and expert participants found the worked examples useful, but the verbal protocols indicated the presence of higher order thinking while participants were engaging with the Process condition. These findings may provide possible insight into the stimulation of GCL. This is the first study of this kind and further studies are needed to investigate GCL in regards to the use of worked examples in an ill-structured learning domain.

Thirdly, the current research findings are unique as they demonstrated that process oriented worked examples are supportive for both novice and expert participants. Further research is required in other ill-structured learning domains, apart from quality teaching, to further explore how the different instructional conditions can support participants to engage and make meaning in the relevant context. This research was conducted in the university sector with university students regarded as novice participants and secondary teachers as experts. A further recommendation is to undertake research in other education settings, such as considering Early Career Teachers in primary and secondary school settings as novices. This may enable the development of strategies to better support Early Career Teachers with their classroom practice as well as support the learning of more experienced teachers. In addition, this current research focused on the NSW QTM element of substantive communication. There are eighteen elements included in the NSW QTM, future research may focus on other elements.

A fourth area for further research is the length of the process oriented worked example. The two novice participants presented with the Process condition both indicated that the length of the worked example impacted their learning as they were only able to focus on one of the three characteristics of substantive communication. This result may align with findings from recent studies in CLT showing that time for completing tasks may also be a form of ECL (Barrouillet & Camos, 2012; Puma et al., 2018). Another consideration is the importance of participant or student agency. Student agency can be defined as "when students make choices, act on their intentions, and take actions in their efforts to develop their own stance in the learning context" (Vaughn, 2020, p.116). If students were able to determine their own pauses during the video recordings of the lesson, this would then reduce the length of the video. Further research could be undertaken in relation to the impact of the length of process oriented worked examples on the perceived mental effort ratings of participants presented with these.

The current empirical research was undertaken between 2016 and 2018. Since 2018, there has been continued research focusing on worked examples. The following provides an overview of recent research and how this may inform further development of this current research and contribute to Cognitive Load Theory.

Kusuma and Retnowati (2021) investigated the use of faded examples. Faded examples initially provide learners with a complete worked example, followed by gradual removal of the steps to solution as the learner continues to engage with the learning material, with the learner eventually engaging with an unsolved problem. Kusuma and Retnowati (2021) provided an example of how a faded example could be designed to facilitate the learning of algebraic long division, a well-structured learning domain. Further research could be undertaken that builds on this research plus the current study by exploring the use of faded examples in an ill-structured learning domain.

Jaeger et al. (2020) investigated the use of erroneous examples in promoting understanding of science, technology, engineering and mathematics (STEM) concepts. Erroneous examples are similar to worked examples as they present steps to solution. However, some of the steps are incorrect. Jaeger et al. (2020) found that even though the "erroneous examples were more beneficial than copying correct diagrams, it did not show that erroneous examples led to greater gain than sketching" (Jaeger et al., 2020, p. 855). Further research could be undertaken that builds on this work and the current study whereby worked examples, could include erroneous information. The participant would then need to decide whether the information is correct or incorrect, before being presented with the correct information.

Retnowati et al. (2017) conducted an investigation which focused on the benefits of providing opportunities for learners to engage collaboratively with peers when presented with worked examples. Their investigation was focused on solving algebraic problems, a well-structured learning domain, and the results were inconclusive. Further research could be undertaken that builds on this work and this current research by allowing participants the opportunity to engage collaboratively with peers when presented with the process oriented and product oriented worked examples. Providing an opportunity for teachers to engage collaboratively with worked examples is discussed in Section 8.7. Further, the worked examples in this current research are presented in an ill-structured learning domain, as opposed to the well-structured learning domain in the investigation conducted by Retnowati et al. (2017).

8.10 CONCLUSION

This research showed that the use of process oriented worked examples is beneficial to both novice and expert participants when engaging in ill-structured learning domains. The principled knowledge (why) and strategic information (how) included in the process oriented worked examples supported participants to make meaning. The novice participants were able to use this information to make meaning and overcome misunderstandings or misconceptions, whereas the expert participants were able to use this information to validate and confirm their prior knowledge. In summary, the findings showed:

- The results for novice participants in ill-structured learning domains were consistent with CLT in well-structured learning domains.
- The results for expert participants in ill-structured learning domains were not consistent with CLT in well-structured learning domains.
- Expert participants are able to validate and confirm prior knowledge with the use of process oriented worked examples in an ill-structured learning domain.

The implications of these findings have relevance for instructional design decisions within ill-structured learning domains. This research suggests there is a further need to investigate the three instructional conditions in other learning domains to validate the findings of this research. In summary, this research has shown that ill-structured and well-structured learning domains cannot be treated the same in terms of worked examples, as novice and expert participants do not engage with the instructional conditions in the same manner. While novice and expert participants preferred the same instructional condition, the reasons were different. The principled knowledge (why) included in process oriented worked examples supported novices to make meaning and overcome misconceptions, whereas experts were able to validate and confirm their prior knowledge. This research has shown that worked examples operate differently in ill-structured learning domains than in well-structured learning domains, and the process oriented worked example has been just as valuable for experts as it has been for the novices, which is different in the empirical work of well-structured learning domains.

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Appendices

APPENDIX A

Ethics Approval Notification (Experiment 1)

APPROVAL LETTER
In reply please quote: HE15/360

11 September 2015

Mr Gerardo Sozio

Dear Mr Sozio

Thank you for your response dated 7 September 2015 to the HREC review of the application detailed below. I am pleased to advise that the application has been approved.

Ethics Number:	HE15/360
Project Title:	Investigating the Effectiveness of Product-Oriented and Process-Oriented Worked examples to Support re-service Teachers understanding of the NSW Quality Teaching Model.
Researchers:	Mr Gerardo Sozio, Dr Shirley Agostinho, Dr Sharon Tindall-Ford
Documents Reviewed/	Initial Application
Approved:	Certificate of Participation
	Consent Form for Pilot Study Participants, 5 Sept 2015
	Consent Form for Participants, 5 Sept 2015
	Pilot Group Participation Information Sheet, 5 Sept 2015
	Participation Information Sheet, 5 Sept 2015
	The NSW Quality Teaching Model, Participant Code G1, Aug 2015
	The NSW Quality Teaching Model, Participant Code G3, Aug 2015
	The NSW Quality Teaching Model, Participant Code G2, Aug 2015
	Test Phase Lesson Codes and Marking Criteria for Enhancement Strategies, Aug 2015
	SOLS invitation, Aug 2015
	Text of email to subject co-ordinator
	Quality Teaching in NSW public schools. A classroom practice guide, NSW DET 2003
Approval Date:	11 September 2015
Expiry Date:	10 September 2016

The University of Wollongong/Illawarra Shoalhaven Local Health District Social Sciences HREC is constituted and functions in accordance with the NHMRC *National Statement on Ethical*

Ethics Unit, Research Services Office
University of Wollongong NSW 2522 Australia
Telephone (02) 4221 3386 Facsimile (02) 4221 4338
Email: rso-ethics@uow.edu.au Web: www.uow.edu.au

Conduct in Human Research. The HREC has reviewed the research proposal for compliance with the *National Statement* and approval of this project is conditional upon your continuing compliance with this document.

Approval by the HREC is for a twelve month period. Further extension will be considered on receipt of a progress report prior to expiry date. Continuing approval requires:

- The submission of a progress report annually and on completion of your project. The progress report template is available at http://www.uow.edu.au/research/ethics/human/index.html. This report must be completed, signed by the researchers and the appropriate Head of Unit, and returned to the Research Services Office prior to the expiry date.
- Approval by the HREC of any proposed changes to the protocol including changes to investigators involved
- Immediate report of serious or unexpected adverse effects on participants
- Immediate report of unforeseen events that might affect continued ethical acceptability of the project.

If you have any queries regarding the HREC review process, please contact the Ethics Unit on phone 4221 3386 or email rso-ethics@uow.edu.au.

Yours sincerely

Associate Professor Melanie Randle
Chair, UOW Social Sciences
Human Research Ethics Committee

cc: Dr Shirley Agostinho & Dr Sharon Tindall-Ford

APPENDIX B

Participant Information Sheet (Experiment 1)

University of Wollongong

PARTICIPATION INFORMATION SHEET

Dear student,

This is an invitation to participate in a study conducted by Dr Shirley Agostinho, Dr Sharon Tindall-Ford and Mr Gerry Sozio. The research is called *Investigating the Effectiveness of Product-Oriented and Process-Product Oriented Worked Examples to Support Pre-Service Teachers Understanding of the NSW Quality Teaching Model* (QTM). The purpose of this research is to explore the most effective methods for you to learn about the elements of the NSW Quality Teaching Framework to support your pedagogy.

INVESTIGATORS

Shirley Agostinho Faculty of Education shirleya@uow.edu.au	Dr Sharon Tindall-Ford Faculty of Education sharontf @uow.edu.au	Mr Gerry Sozio Faculty of Education gerry.sozio@dow.catholic.edu.au

WHAT WE WOULD LIKE YOU TO DO

If you choose to participate, you will be involved in an experiment of approximately 60 minutes in duration that will be conducted by a researcher with experience in delivering professional learning to teachers.

Prior to the experiment, Mr Gerry Sozio will provide participants with an overview of the experiment. During the experiment, you will learn about the Dimensions and Elements of the NSW Quality Teaching Model. You will engage in activities that will involve applying the characteristics of a targeted QTM element and rating the quality of an identified QTM Element through watching video recordings of lessons being taught and then completing a Mental Effort Rating assessment.

If you choose to participate, the experiment will run on the following dates. You will only participate in an experiment on one of these dates. The dates are:

Wednesday 9 March 2016	5:30pm-6:30pm
Wednesday 4 May 2016	5:30pm-6:30pm
Wednesday 11 May 2016	5:30pm-6:30pm

You will be provided with documentation to record information about the identified QTM Element. Your participation in the research will be confidential.

POSSIBLE RISKS, INCONVENIENCES AND DISCOMFORTS

We cannot see any risks for you through participating in this study.

You are free to decide if you want to be involved in this study or not and you can stop participating at any time. If you choose to not participate in the research, you will be provided with information on the NSW Quality Teaching Model. If you decide to stop participating, any information you have given will not be used. This research is based in the Interdisciplinary Educational Research Institute, University of Wollongong and is funded by the University Research Council, University of Wollongong. If you decide to participate in this study, you will make a valuable contribution to research in cognition (thinking processes) and improving students' learning.

By participating in this study, you will demonstrate evidence towards the Australian Professional Standards for Teachers. These include:

Standard 1: Know Students and How They Learn

1.2.1 – Demonstrate knowledge and understanding of research into how students learn and the implications for teaching.

Standard 3: Plan for and Implement Effective Teaching and Learning

3.6.1 - Demonstrate broad knowledge of strategies that can be used to evaluate teaching programs to improve student learning.

Standard 6: Engage in Professional Learning

6.2.1 - Understand the relevant and appropriate sources of professional learning for teachers.

6.4.1 - demonstrate an understanding of the rationale for continued professional learning and the implications for improved student learning.

Standard 7: Engage Professionally with Colleagues, Parents/Carers and the Community

7.4.1 – Understand the role of external professionals and community representatives in broadening teachers' professional knowledge and practice.

Upon completion of the experiment, a statement will be provided for you to include as evidence.

ETHICS REVIEW AND COMPLAINTS

This study has been reviewed by the Human Research Ethics Committee (Social Science, Humanities and Behavioural Science) of the University of Wollongong. If you are not happy with the way this research has been conducted, you can contact the Ethics Officer at the University on (02) 4221 4457.

Thank you for your interest in this study. If you have any further questions or concerns, you can email Shirley, Sharon or Gerry (see contact information above).

APPENDIX C

Participant Consent Form (Experiment 1)

University of Wollongong

CONSENT FORM FOR PARTICIPANTS

Research Title: *Investigating the Effectiveness of Product-Oriented and Process-Product Oriented Worked Examples to Support Pre-Service Teachers Understanding of the NSW Quality Teaching Model* (QTM).

Researchers' Names: Dr Shirley Agostinho, Dr Sharon Tindall-Ford and Mr Gerry Sozio

I have read the participation information sheet and have had the opportunity to ask the researchers any further questions I may have had. I understand that my participation in this research is voluntary and I may withdraw at any time from the study without affecting my relationship with the University of Wollongong or the researchers.

I understand that the risks to me are minimal in this study. I have read the participation information sheet that describes the purposes of the study and asked any questions I may have about the risks.

If I have any enquires about the research, I can contact Dr Shirley Agostinho, email: shirleya@uow.edu.au. If I have any concerns or complaints regarding the way the research is or has been conducted, I can contact the Ethics Officer, Human Research Ethics Committee, Office of Research, University of Wollongong on 02 4221 4457. I understand that information from me will be published in a journal article. I understand that my name will not be used in the study to reduce the likelihood of being identified.

By signing below I am consenting to the following:

I understand by signing below that consent to being involved in an experiment that will be conducted at the University of Wollongong. The instructional materials will include a presentation by the research, video recordings of lessons and NSW Quality Teaching Model documentation and resources. The timing of the experiment will be approximately 60 minutes

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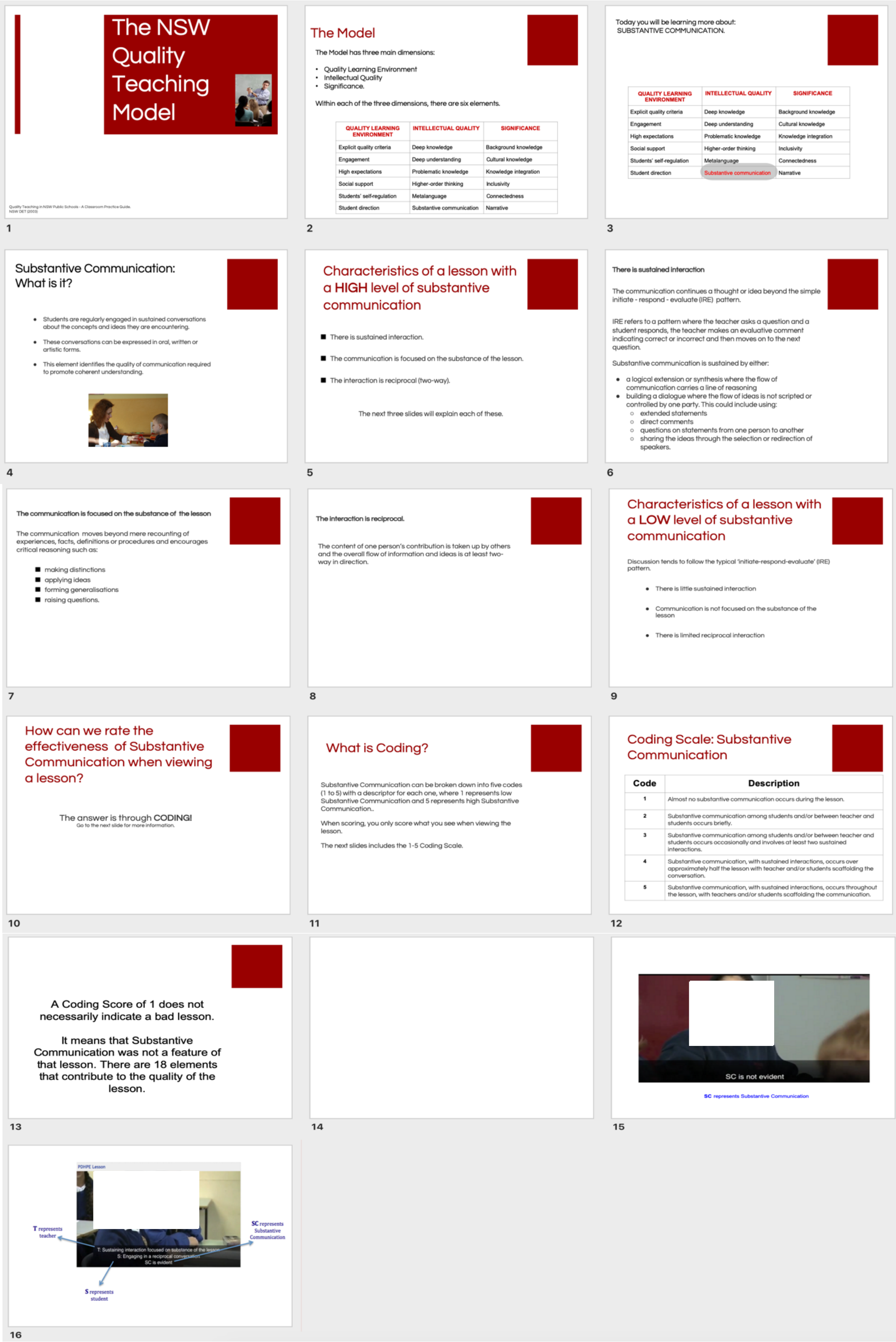
I _________________________________ (please insert name) give permission for my results from the experiment to be used in this research.

Name: ______________________________ Signature:______________________________

Date: _________________

APPENDIX D

Participant PowerPoint Presentation



The complete PowerPoint presentation can be accessed by clicking on the following link:
https://bit.ly/3yApYjB

APPENDIX E

Participant Booklet (Process Condition)

DO NOT OPEN THIS BOOK UNTIL INSTRUCTED TO DO SO

Participant Code: PPX___

The NSW Quality Teaching Model

☐ Male ☐ Female	Age:
Write down everything you know about the NSW Quality Teaching Model.	
Write down everything you know about Substantive Communication.	

Task 1

Watch the video of the PDHPE lesson to understand why the coding score was given.

ELEMENT	Coding Score	Generic Coding Description	The Coding Score was determined by the level of:
Substantive communication	4	Substantive communication, with sustained interactions, occurs over approximately half the lesson with teacher and/or students scaffolding the conversation.	**Sustained Interactions** In the lesson, several sustained interactions were evident. The teacher asked questions like 'anything else?' to encourage students to extend their responses which continued the idea beyond the simple 'initiate-respond-evaluate' (IRE) pattern. The group work showed students effectively building a shared understanding. **Focus on the Substance of the lesson** The communication moved beyond mere recounting of facts and experiences and encouraged the application of ideas. The teacher raised questions like 'what things at parties might concern you?' to enable the students to apply ideas and make distinctions focusing on the substance of the lesson. **Reciprocal Interaction** The lesson wasn't scored a 5 as the introduction of the lesson involved Initiate-Respond-Evaluate communication, where the teacher asked routine questions and students provided short answers. An example of a high level of reciprocal interaction includes the teacher asking the students 'do you agree with me?', to which there was no response. During the group work, reciprocal interactions are high as the flow of information and ideas is at least two way in direction.

Ratings for Task 1

Rate the amount of mental effort you invested to complete Task 1. Circle your rating.

1	2	3	4	5	6	7	8	9
Extremely low mental effort				Neither low nor high mental effort				Extremely high mental effort

Rate how difficult the task was for you.

1	2	3	4	5	6	7	8	9
Extremely easy				Neither easy nor difficult				Extremely difficult

Task 2

Watch the video of the languages lesson to understand why the coding score was given.

ELEMENT	Coding Score	Generic Coding Description	The Coding Score was determined by the level of:
Substantive communication	1	Almost no substantive communication occurs during the lesson.	**Sustained Interactions** The teacher delivered information and asked routine questions and the students giving very short answers. Discussion tended to follow the typical 'initiate-respond-evaluate' (IRE) pattern with low level recall, fact-based questions, short utterances or single word responses, and further simple questions and/or teacher evaluation statements (e.g. yes, good). **Focus on the Substance of the lesson** Through out the lesson, the communication did not move beyond the mere recounting of facts and definitions. **Reciprocal Interaction** The content of one student's contribution was not taken up by others and the overall flow of information and ideas was not two-way in direction.

Ratings for Task 2

Rate the amount of mental effort you invested to complete Task 2.
Circle your rating.

1	2	3	4	5	6	7	8	9
Extremely low mental effort				Neither low nor high mental effort				Extremely high mental effort

Rate how difficult the task was for you.

1	2	3	4	5	6	7	8	9
Extremely easy				Neither easy nor difficult				Extremely difficult

Task 3 (4 minutes to complete)

Read the dialogue between the teacher and students below.

Teacher:	How do you find the area of a rectangle?
Peter:	By multiplying the length by the breadth!
Teacher:	Why do you think that?
Peter:	Because that is the formula.
Teacher:	How can the formula 'length times the breadth' be developed?
Peter:	I am not sure.
Teacher:	Samantha, are you able to explain how the formula is developed?
Samantha:	I remember with Mrs Smith last year, we used grid paper to help us find the area of rectangle.
Teacher:	Please explain what you did.
Samantha:	On the grid paper, we drew a rectangle around the grids and then counted the number of small squares.
Teacher:	Why did you do that?
Samantha:	It helped us find the area of the rectangle.
Teacher:	How did it do that?
Samantha:	Because each small square represented one unit square of area, and in counting the number of unit squares, we could then find out the area of the rectangle.
Teacher:	Can anybody now expand on what Samantha has described? Remember we want to know how the formula that Peter mentioned was developed.
Craig:	I remember doing the activity. We noticed that when we drew the rectangles around the square grids, that the area of the rectangles could be found by multiplying the number of grid columns by the rows.
Teacher:	That's good Craig, and how did that then lead to the formula 'length by breadth'.
Craig:	We noticed that the number of rows was the same as the breadth of the rectangle, and that the number of columns was the same at the length.
Teacher:	How did that then lead to the formula, Sonia?
Sonia:	We noticed that multiplying the number of columns by the number of rows was the same as multiplying the length by the breadth.
Teacher:	Well done!

What characteristic(s) of Substantive Communication are evident in the dialogue?	**Use specific examples from the dialogue to support your choice(s)**

Ratings for Task 3

Rate the amount of mental effort you invested to complete Task 3.
Circle your rating.

1	2	3	4	5	6	7	8	9
Extremely low mental effort				Neither low nor high mental effort				Extremely high mental effort

Rate how difficult the task was for you.

1	2	3	4	5	6	7	8	9
Extremely easy				Neither easy nor difficult				Extremely difficult

Task 4 (2 minutes to complete)

You will watch one short video. After watching the video, answer the questions below.

VIDEO (2 minutes to answer questions related to video)
Is the characteristic of Reciprocal Communication Evident? Yes / No (Circle your answer)
Provide explicit evidence from the video justifying your answer.
How could you enhance the **Sustained Interaction** during the Video?

Ratings for Task 4

Rate the amount of mental effort you invested to complete Task 4.
Circle your rating.

1	2	3	4	5	6	7	8	9
Extremely low mental effort				Neither low nor high mental effort				Extremely high mental effort

Rate how difficult the task was for you.

1	2	3	4	5	6	7	8	9
Extremely easy				Neither easy nor difficult				Extremely difficult

Task 5 (2 minutes to complete)

You will watch a video of a Science lesson.

Suppose you were the teacher, how would you enhance the characteristics of Substantive Communication listed below?

Characteristics	Strategies to enhance Substantive Communication
There is sustained Interaction.	
There is a focus on the substance of the lesson.	

Ratings for Task 5

Rate the amount of mental effort you invested to complete Task 5. Circle your rating.

1	2	3	4	5	6	7	8	9
Extremely low mental effort				Neither low nor high mental effort				Extremely high mental effort

Rate how difficult the task was for you.

1	2	3	4	5	6	7	8	9
Extremely easy				Neither easy nor difficult				Extremely difficult

Task 6 (2 minute to complete)

Complete the following questions by circling your rating and adding comments.

1. I enjoyed learning in this way.

1	2	3	4	5
Strongly Disagree				Strongly Agree

Comment:

2. I found this type of instruction engaging?

1	2	3	4	5
Strongly Disagree				Strongly Agree

Comment:

APPENDIX F

Referencing Tables for the three Instructional Conditions

Coding Information presented to participants for the Process Condition

ELEMENT	Coding Score	Generic Coding Description	The Coding Score was determined by the level of:
Substantive communication	4	Substantive communication , with sustained interactions, occurs over approximately half the lesson with teacher and/or students scaffolding the conversation.	**Sustained Interactions** In the lesson, several sustained interactions were evident. The teacher asked questions like “anything else?” to encourage students to extend their responses which continued the idea beyond the simple ‘initiate-respond-evaluate’ (IRE) pattern. The group work showed students effectively building a shared understanding. **Focus on the Substance of the lesson** The communication moved beyond mere recounting of facts and experiences and encouraged the application of ideas. The teacher raised questions like “what things at parties might concern you?” to enable the students to apply ideas and make distinctions focusing on the substance of the lesson. **Reciprocal Interaction** The lesson wasn’t scored a 5 as the introduction of the lesson involved Initiate-Respond-Evaluate communication, where the teacher asked routine questions and students provided short answers. An example of a high level of reciprocal interaction includes the teacher asking the students “do you agree with me?”, to which there was no response. During the group work, reciprocal interactions are high as the flow of information and ideas is at least two way in direction.

Coding Information presented to participants for the Product condition

ELEMENT	Coding Score	Generic Coding Description	The Coding Score was determined by the level of:
Substantive communication	4	Substantive communication, with sustained interactions, occurs over approximately half the lesson with teacher and/or students scaffolding the conversation.	**Sustained Interactions** Sustained interactions were evident. **Focus on the Substance of the lesson** Focus on the substance of the lesson was high. **Interaction is Reciprocal** Reciprocal interactions were evident.

Coding Information presented to participants for the Control condition

ELEMENT	Coding Score	Generic Coding Description	The Coding Score was determined by the level of:
Substantive communication	4	Substantive communication, with sustained interactions, occurs over approximately half the lesson with teacher and/or students scaffolding the conversation.	**Sustained Interactions** **Focus on the Substance of the lesson** **Interaction is Reciprocal**

APPENDIX G

Researcher Script (Process Condition)

Process -
Handout Scripts to Participants / allocate a participation number to each student (starting at 1)

Hi everyone

Thank you for participating in today's session. My name is Gerry Sozio and I am a research student at the UOW. Today's session is a part of my PHD research, and through participating in the session, you will learn about the NSW Quality teaching model and its application in the classroom. In front of you information about the research, a consent form and the workbook. Please don't open the workbook.

Please read the participation information sheet and complete the consent form. If you don't consent, do not sign, but you will still be required to complete the tasks. Your data will not be used. As well as reading the information sheet and signing the consent form, on the front of your work book, you are asked to answer some questions. Firstly indicate your gender and age in the appropriate sections and then answer the two questions. You have 3 minutes to complete this.

PARTICIPATION AND CONSENT FORM

You are not to open the workbook at this stage. You will be instructed on when to open the workbook and when to turn the pages, also, when going through the workbook, you are not allowed to turn back pages. This is for the purpose of the experiment.

The NSW Quality Teaching Model has 18 elements that are recognised as influential factors in classroom teaching to improve student learning outcomes. The element that we will be focusing on will be Substantive Communication.

During this session, I will deliver a power-point presentation about the NSW Quality Teaching Model, and following this, there will be a series of tasks where you will apply your leanings. You will learn about the characteristics of high levels of Substantive Communication and you will also learn how to rate the quality of the element of Substantive Communication in a lesson, by using a 1-5 Coding Scale that will be provided for you.

The tasks that you will complete will require you to record information in workbooks that will be provided for you. However, you will not be allowed to make any additional notes, especially while watching video recordings of lessons being taught. This may not be what you do normally, but is what is required for the purpose of this research.

You will be guided throughout the session on what to do and when to do it.

Individually you will complete a series of tasks, and after each task you will be asked to complete a Cognitive Load Effort rating, where you will be asked to rate the amount of mental effort you exerted during the activity you had just complete. You will also be asked to rate the perceived level of difficulty of the task. On the screen you will see the two 9-point scales, ranging from very very low to very very high

RATING SCALES - Leave on screen for 20 seconds

If I asked you to solve 2 x 3, what Cognitive Load Effort rating would you score i.e., what mental effort did you exert to answer the question? If I was now to ask rate your perceived level of difficulty of the question, what would you score?

Now, if I asked you to mentally calculate 23 x 45, without a calculator, what would you score in relation to the mental effort exerted in attempting to solve this without writing any notes? If I were to ask you to rate the perceived level of difficulty of the question, what would you now score? The amount of ME exerted may well be high, but you may not consider this a difficult task at all.

Now, if I asked you to use your calculator to calculate 23 x 45, what Cognitive Load Effort Rating would you score in coming up with the answer?

It's important to note that Mental Effort has nothing to do with intelligence or your competency, or a test of your ability. It is a subjective rating of the amount of mental effort you had to exert to solve a problem.

Remember it is what you think, there is no right or wrong answer.

I will now commence with the power-point presentation**.** Please pay attention to each slide. You are not able to make notes during the presentation.

POWERPOINT PRESENTATION

Slide 2 – The Model

The QTM has three Dimensions, the Dimensions are Quality Learning Environment, Intellectual Quality and Significance. Within each of the Dimensions, there are six elements linked to that dimension. For example, elements in QLE include engagement and high expectations, elements in Intellectual Quality include deep knowledge and deep understanding, and elements in Significance include cultural background and cultural knowledge.

Slide 3 – SC

For today's session we will focus on the element of SC, which is included within the Intellectual Quality dimension.

The element SC has been chosen as it is a complex element and also an important element to engage students and improve learning. Also, for the purpose of this experiment, it would be to complex to consider more than one element of the NSW QTM.

Slide 4 – SC What Is It?

On the screen is a definition of SC. Please read this.

Slide 5 – Characteristics

On the screen are the three characteristics of high levels of SC in a classroom. Please read these. The next three slides will explain each of these.

Slide 6 – Sustained Interaction

On the screen is the characteristic of Sustained Interaction unpacked for you. Please read through this.

Questions such as: Why did you think that ..? How did you get that? How is this different from.."
For example: What's the area of a rectangle that is 4m by 3m?
How did you get that?
Why did you do that?
What other dimensions of a rectangle give an areas of 12 m squared?
If the conversation were typical of the Initiate Response Evaluate model, the teacher would just say good when the student responds and then move on.

Slide 7 – Substance of the Lesson

On the screen is the characteristic that the communication is focused on the substance of the lesson.

Please read.

Rather than asking define an acute angle,
Ask if the small hand of a clock is on the 12, what might the time be?
What do you need to consider?

You could also encourage students to generate questions about the topic for discussion and use these as the basis for lesson development.

Slide 8 – The Interaction is Reciprocal

On the screen is the characteristic that the interaction is reciprocal.

Please read.

For example, if I ask what's 3x4, and a student answers 12, rather than say yes only, I could ask, explain how you got that answer, or ask another student whether they agree or disagree, or how the answer was calculated.

Rather than just asking a question, engage in a conversation about a concept.

Slide 9 – LOW SC

Here are characteristics of low levels of Substantive Communication, please read.

In classes where there is little or no substantive communication, teacher-student interaction typically takes the form of the teacher delivering information and asking routine questions and the students giving very short answers.

Discussion tends to follow the typical "initiate–respond–evaluate" (IRE) pattern with low level recall, fact-based questions, short utterances or single word responses, and further simple questions and/or teacher evaluation statements (e.g. "yes", "good").

Teachers are encouraged to Develop opportunities and structures for substantive communication, e.g. in pairs, small group discussion and cooperative learning activities, to allow students to share substantive ideas about the lesson topic.

Slide 10 – Coding Introduction

There is a way in which we can rathe the effectiveness of SC when viewing a lesson, and this is through a process called coding.

Slide 11 – What is Coding

SC can be rated on a 5-point scale. On the scale, 1 represents a lesson low in SC and 5 represents a lesson high in SC. When coding, it is very important that you code only what you see when viewing a lesson.

Slide 12 – The Coding Scale

On the screen you will see the Coding Scale, please read through the description for each code score.

Slide 13 – Coding Sore of 1

It is important to note that a coding score of 1 does not necessarily indicate a bad lesson. It just may not be a feature of that lesson, and the lesson may have scored high in other elements.

At this point all you are required to understand is you will be focusing on the element of Substantive Communication and you can rate the quality of this element by using the 1-5 Coding Scale

Now turn to page 1 of your workbook.

You are going to watch a video of a PDHPE lesson. PDHPE may be a part of your immersion program. You will only watch a snippet of a lesson. Now, in coding using the 1 to 5 scale, you will code this snippet of the lesson as if it was the whole lesson.

During the video that you are about to watch, there will be annotations, which provide information as to whether *Substantive Communication* is evident or not at different points of the lesson. You must read the annotations. At key points, the video will pause for about 10 seconds. While the video pauses, there will be annotations on the screen indicating whether the section of the lesson that was just watched before the pause contained high or low levels of the characteristics of substantive communication. You must read these annotations.

On the screen there is a screenshot of such an annotation, where the T represents teacher and S represents student, and then there is a statement in relation to the level of SC.

SHOW POWERPOINT WHICH HAS A SCREEN SHOT

On page 1, you will see a table that includes the Coding Score for the element of SC for the video that you are about to watch. You will also see a generic description of why the code of 4 was given, and then further information as to how the coding score was determined in relation to the characteristics of SC. You have 45 seconds to read this, and you must read. Please commence reading the information on page 1.

45 SECONDS TO READ

You will now watch the PDHPE lesson.

SHOW PDHPE VIDEO

You now have 45 seconds to reread the information on page 1.

45 SECONDS TO READ

Now, turn to page 2 and complete the rating scales. You have 20 seconds to complete the ratings.

20 seconds

Now, turn to page 3 of your workbook.

You are about to complete a similar task to the previous one. This time you will be watching the recording of a Languages lesson.

On page 3, you will note that the coded score is 1. As per the previous task, read through the information on this page. You have 45 seconds to complete this.

45 SECONDS

Now look at the screen where you will watch the recording of the Languages lesson. As before, there video will be pauses with annotations for your to read.

SHOW LANGUAGES LESSON

You now have 45 seconds to reread the information on page 4.

45 SECONDS

Now, turn to page 4 and complete the rating scales.

20 seconds

Turn to page 5 to commence Task 3. You are required to read the dialogue and complete the questions in the box at the bottom of the page. You have 4 minutes to complete this task.

FOUR MINUTES

Now, turn to page 6 and complete the rating scales.

20 seconds

You are now required to turn to page 7 of your workbook to commence Task 4.

You are going to watch a short video recording of a lesson. You will then be asked to answer the three questions in the table on page 7.

Please watch the video.

SHOW VIDEO

Please answer the questions on page 7.

TWO MINUTES

Now, turn to page 8 and complete the rating scales.

TWENTY SECONDS

Now, turn to page 9 of your workbook to commence Task 5.

During this task, you will watch a video of a Science lesson. At the conclusion of watching the short video, you will be required to respond to the following:

Suppose you were the teacher, how would you enhance the characteristics of Substantive Communication listed below?

SHOW VIDEO

Please commence Task 5 on page 9, you have 3 minutes to complete this.

THREE MINUTES

Now, turn to page 10 and complete the rating scales.

TWENTY SECONDS

Now turn to page 11 of your workbook to complete Task 8. This is the last task. Please complete the questions on page 11. In the Comment section, answer in point form. I really want to hear what you think of this.

TWO MINUTES

Thank you for your participation, I will come round and collect your workbooks. I wish you luck with your continued studies.

APPENDIX H

Experiment 1 Marking Criteria

Marking Criteria

TASK	Recall/ Near / Far Transfer	NATURE OF QUESTION	MARKS	DESCRIPTION / EXAMPLES	SAMPLE RESPONSES
PRE-TEST Question 1		Write down everything you know about the NSW QTM.	**2 Marks**	Extensive knowledge – refers to a framework that teachers can use to reflect on elements of their teaching. Would expect reference to Dimensions and elements. The Dimensions include Quality Learning Environment, Intellectual Quality and Significance. Within each of these Dimensions are identified elements which include: • Explicit quality criteria • Engagement • High expectations • Deep knowledge • Deep understanding • Higher-order thinking • Background knowledge • Cultural knowledge • Inclusivity	"As part of lesson planning it is important to incorporate the 3 teaching areas: Intellectual, Environment and Significance."
			1 Mark	Some knowledge – makes reference to some elements of the NSW Quality Teaching Model. Refers to a set of criteria or the qualities displayed by teachers at a certain level.	"There are three standards and in each statement there are six outcomes."
			0 Marks	No knowledge. Participants reference the AITSL professional teaching standards.	"It outlines the basic skills, provisions and expectations each teacher is expected to learn and master during their practice as teachers."

PRE-TEST Question 2		Write down everything you know about Substantive Communication.	**2 Marks**	Extensive knowledge – is able to refer to any of the characteristics of substantive communication: • Sustained interaction • Focus on the substance • Reciprocal interactions	"Substantive communication is having the teachers approaches to learning be evenly targeting strategies that have the teacher communicate and the learners collaborate with the set learning tasks."
			1 Mark	Some knowledge – makes reference to SC, especially in relation to improving communication in classes to improve learning.	"The ability to convey accurate and detailed information in a comprehensive and succinct manner that is appropriate to the students/listeners."
			0 Marks	No knowledge	"Mode of transmitting messages."
Task 1a	Recall	All three characteristics are evident	**3 Marks**	1 Mark for each characteristic: • Sustained interaction – or 'sustained communication'. • Focus on the substance • Reciprocal interactions – or 'reciprocal'	"Sustained dialogue." "Reciprocating."
				0.5 marks for the following: • Gives a correct reference to IRE (instead of sustained) • Writes 'continuing conversation, moving beyond facts', rather than reciprocal interactions. • Writes 'two-way conversation', rather than reciprocal interactions. • Description aligns to the characteristics, e.g. 'at least 2 way' relates to 'reciprocal interactions'	"Conversation always about subject / topic."

				O marks for the following: • Writes follow of an idea or concept • If just 'interaction ' is written. Sustained is required. • Writes just substance.	"Responsive dialogue." "Substance."
Task 1b	Near Transfer	Required to give specific examples for each characteristi c	**3 Marks**	1 Mark for giving a specific example for each identified characteristic **Examples for Sustained Interaction:** • Teacher asks Peter 'Why do you think that?' • Teacher asks Samantha 'Please explain what you did.' • Teacher asking Samantha 'Why did you do that?' **Examples for Focus on the Substance:** • Teacher asks Peter 'How can the formula 'length times breadth' be develop?' • Mentioning that Samantha continues the ideas that were discussed between Peter and the teacher • Craig explaining how he noticed that the area of the rectangles can be found by multiplying the number of rows and columns **Examples for Reciprocal Interactions:** • The whole dialogue can be identified to represent reciprocal interaction as the teacher in bouncing ideas off students	Samples are included in the 'Description/Examples ' column. Note that each example given is allocated one mark of it correlates to the characteristic that is written.

				• e.g. after speaking with Craig, the teacher asks Sonia: 'How did that lead to the formula, Sonia?' • e.g. the teacher asking: 'Can anybody expand on what Samantha has described?' e.g. Craig and Sonia bounce off Samantha to come up with the solution.	
Task 2a	Near Transfer	Is the characteristi c of Reciprocal Interaction evident?	**1 Mark**	The answer is NO	"No."
Task 2b	Near Transfer	Explicit Evidence	**1 Mark**	Some explicit evidence is provided Examples include: • Content of one person's contribution not taken up by others. • The overall flow of information and ideas was not at least two way in direction. (Reference to IRE)	"Teacher moved on to other students after a student answered a question she had."
			0 Marks	• No explicit evidence provided. • Answered YES for Task 6a	-
Task 2c	Far Transfer	How to enhance Sustained Interaction	**1 Mark**	Provides at least one strategy. e.g. extended statements, direct comments, questions from one person to another, sharing ideas through selection and redirection of speakers	"Open ended questions, asked other students if they agreed and ask why they agreed, or ask if they disagreed."
			0.5 Marks	Provides part of a strategy linked to enhancing the characteristics of sustained interaction, without clear elaboration.	"Asking more higher order questions after lower order."

			0 Marks	Lists no strategies. e.g. if written 'expand understanding of child'	"The teacher needs to acknowledge the responses of all students."
Task 3a	Far Transfer	Enhancing the characteristic – Sustained Interaction	**2 Marks**	1 mark for each strategy (Maximum of 2 marks) • Frames questions which require more depth in response from students than the initiate–respond–evaluate (IRE) format does. • Encourages students to extend their responses to make thinking and understanding explicit. Ask students: *Why do you think that? How did you get to that solution or viewpoint? How is this like or different from ...?*	Further example: "I would try to push the students to develop their answers more, elaborate, go into more details." "Giving students more time to think and respond, not jumping to the next question too quickly.
Task 3b	Far Transfer	Enhancing the characteristic – Focus on substance	**2 Marks**	1 mark for each strategy (Maximum of 2 marks) • Encourage students to generate questions about the topic for research and discussion and use these as the basis for lesson development. • Move the lesson beyond mere recounting of facts and definitions and encourage critical reasoning such as any of the following: - Making distinctions - Applying ideas - Forming generalisations	Further example: "Introduce the intent / learning outcomes of the lesson."

APPENDIX I

Cognitive Load Effort and Task Difficulty Nine-point Scales

Rate the amount of mental effort you invested to complete Task 1. Circle your rating.

1	2	3	4	5	6	7	8	9
Extremely low mental effort				Neither low nor high mental effort				Extremely high mental effort

Rate how difficult the task was for you.

1	2	3	4	5	6	7	8	9
Extremely easy				Neither easy nor difficult				Extremely difficult

APPENDIX J

Participant Evaluations

Participant Evaluations – Experiment 1

Condition	Comment
Process condition	• Repetitiveness helps. It was interactive. More lucrative way to learn. • prefer to work at my own pace. • Video too long. No discussion between peers. • Practical examples helped. Solo silent work felt restrictive. Difficult to stay focused. • Latter activities were engaging. The foundational ones were not. This gave me a new understanding of teaching theory that I would like to pursue further. • I am not so much a visual learner. I didn't like the time restraints. The videos yes, not so much the format. • Room was too quiet. Would enjoy a more interactive approach. • Visuals aided my understanding but I found it difficult to engage. I also would prefer the tutor to explain certain elements clearly as some of the annotated videos made it confusing. • Good use of videos to demonstrate examples but not very engaging. There was no chance for discussion. A similar format with some improvements could be beneficial. • The visual element greatly assisted. The film wee interesting ways to engage me. I would prefer class discussion added to the mix. • The videos were a little long but better than slabs of writing. It was engaging for the subject matter. The topic was interesting, just late in the day. • Gave excellent real world examples. Simplified it greatly. However, if you miss information, no chance to go back and learn it. • Video gave a good example. Could have used more time. Gives practical examples of how to use the teaching model. • Videos were engaging. Discovery learning. Using a visual medium was engaging. • Provided a context so I understand what I was answering. Provides challenge, and I enjoy a good challenge. Sure, why not, staring at slides gets boring. • Individual learning is ok, but I was bored after an hour. At first it is engaging and challenging, but becomes tiresome. Mix it up, I need to engage with others to learn. • I found it productive and engaging, without being an overwhelming amount of information. This is a fascinating way of analysing teaching. • Don't recommend this for an evening tutorial. • Practical examples gives visual understanding. No time to re-establish understanding of concepts. Lack of cross-communication. I'd prefer a discussion based format. • Visual aids are helpful. Concentration of participants depends on the time of the day.Monotone and direct instructions are unengaging. Not my preferred way, however, I can see the benefits when partnered with other activities. • Visual always help. Didn't really understand why we had to do this. • I need to write notes and re-read notes. I felt like it was a test. If I could take notes and discuss, then yes. • Highly interactive and engaging. Some ran a little too long after the point was made. Not advisable to run at 7:30pm. • Sole learning experience. Little to no engagement. Prefer group activities or reading from a resource.

Product condition	• Considering I didn't know the topic I needed a support like the video. Very slow, I couldn't remember much from initial pages. Videos were engaging, topic was not. • Slow moving presentation. • Boring theory. • Way too long. 1 to 2 videos demonstrating what was would be enough. • Not being able to take notes made this task not useful at all. I can't remember anything! • Pauses dragged out the time - lost interest. In a faster format this format would be highly effective. • Whilst I definitely learned it, it was too dull. • There are surely faster and more interactive approaches. • It provided useful visual examples. Was slow, but helpful in learning. • They were all good examples. 'Stop, start' learning bothers me. I feel this was a successful format. • Provides hints to further information. • I wasn't able to write anything down, therefore I forgot some of the information. • Except for the pauses in the video. Large breaks mixed with scurrying for time meant I was jumping between aimless and engagement. • Some videos got boring, didn't get SC concept properly, hated not being able to take notes. I didn't think I got the concept properly but examples if actual practice of SC useful when not long and boring. • Helps with lesson planning and practices. Can only help in professional development. To ensure that QTM is within the lesson plans is most important. • Video was very useful, but without notes was hard. I found it difficult memorising the information without taking notes. Videos were engaging and a great way to exemplify the point. • It's engaging and easy way for a 'brief' introduction to the theory. • First video helped to identify SC in practice. Perhaps short 'evident' pauses
Control condition	• Not sure what the point was with the pauses in the early videos. I obviously forgot some of the definitions so would have been good to see the answers. • Having loads of information thrown at us in the beginning was not helpful - it does not stick. Not very engaging. • Putting this at 7:30 kind sucked but this was engaging, as it presented us with real life lessons that could aid our classroom management skills. • Seeing teaching in action is more easily accessible as a wall of text can't convey key non-verbal comm and interactions. Rating myself confused me. Yes, actually made me look at it - I see the value in it, especially in English. • Definitely needed the visual examples. It was more interesting … I wouldn't say it was necessarily enjoyable. It was a bit too difficult at times. I would rather it be group discussion based. • It was a very restrictive setting, I would enjoy more open discussion learning rather than individual learning. It was too objective, this type of analysis needs more emotion. • Good to see actual real teachers. I liked moving through content in bite sized pieces. This was very practical and this was definitely not a waste of time, very good! • Would be aided by being allowed to take notes the pauses in the first videos were distracting. Seeing real life examples was great.

APPENDIX K

Ethics Approval (Study 2)

Dear Associate Professor Agostinho,

I am pleased to advise that the amendment request submitted on to the application detailed below has been **approved**.

Ethics Number:	2015/360
Amendment Approval Date:	14/08/2018
Expiry Date:	25/07/2019
Project Title:	Investigating the Effectiveness of Product-Oriented and Process-Oriented Worked examples to Support re-service Teachers understanding of the NSW Quality Teaching Model.
Researchers:	Sozio Gerardo; Tindall-Ford Sharon; Agostinho Shirley
Documents Noted:	Letter of Support from the Catholic Education Diocese of Wollongong
Amendments Approved:	Recruitment expanded to include schools within the Catholic Education Diocese of Wollongong:

- St Johns Catholic High School, Nowra.
- Corpus Christi Catholic High School, Oak Flats
- St Josephs Catholic High School, Albion Park
- Magdalene Catholic High School, Narellan
- Mount Carmel Catholic College, Varroville
- St Benedicts Catholic College, Oran Park
- John Therry Catholic High School, Varroville.

The HREC has reviewed the research proposal for compliance with the *National Statement on Ethical Conduct in Human Research* and approval of this project is conditional upon your continuing compliance with this document. Compliance is monitored through progress reports; the HREC may also undertake physical monitoring of research.

Please remember that in addition to submitting proposed changes to the project to the HREC prior to implementing them the HREC requires:

- Immediate report of serious or unexpected adverse effects on participants.
- Immediate report of unforeseen events that might affect the continued acceptability of the project.
- The submission of an annual progress report and a final report on completion of your project.

If you have any queries regarding the HREC review process or your ongoing approval please contact the Ethics Unit on 4221 3386 or email rso-ethics@uow.edu.au.

Yours sincerely,

Emma Barkus

APPENDIX L

Participant Information Sheet (Study 2)

University of Wollongong

PARTICIPATION INFORMATION SHEET

Dear Participant

This is an invitation to participate in a study conducted by Dr Shirley Agostinho, Dr Sharon Tindall-Ford and Mr Gerry Sozio. The research is called *Investigating the Effectiveness of Product-Oriented and Process-Product Oriented Worked Examples to Support Pre-Service Teachers Understanding of the NSW Quality Teaching Model* (QTM). The purpose of this research is to explore the most effective methods for you to learn about the elements of the NSW Quality Teaching Framework to support your pedagogy.

INVESTIGATORS

Dr Shirley Agostinho
Faculty of Education
shirleya@uow.edu.au

Dr Sharon Tindall-Ford
Faculty of Education
sharontf@uow.edu.au

Mr Gerry Sozio
Faculty of Education
gerry.sozio@dow.catholic.edu.au

WHAT WE WOULD LIKE YOU TO DO

If you choose to participate, you will be involved in an experiment of approximately 90 minutes in duration that will be conducted by a researcher with experience in delivering professional learning to teachers.

Prior to the experiment, Mr Gerry Sozio will provide participants with an overview of the experiment. During the experiment, you will learn about the Dimensions and Elements of the NSW Quality Teaching Model. You will engage in activities that will involve applying the characteristics of a targeted QTM element and rating the quality of the identified QTM Element through watching video recordings of lessons being taught. After each task you will complete a series of self-reporting scales linked to the mental effort exerted while completing the tasks and your perceived task difficulty of completing the tasks. You will also participate in an interview related to your experiences of the activities.

If you choose to participate, the experiment will run on the following dates. You will only participate in an experiment on one of these dates. The dates are:

Sometime in Autumn Semester 2018 for Pre-Service Teachers
Sometime in school Term 2 or 3 2018 for Teachers (Dates to be confirmed)

You will be provided with documentation to record information about the identified QTM Element. Your participation in the research will be confidential.

POSSIBLE RISKS, INCONVENIENCES AND DISCOMFORTS

We cannot see any risks for you through participating in this study.

You are free to decide if you want to be involved in this study or not and you can stop participating at any time. If you choose to not participate in the research, you will be provided with information on the NSW Quality Teaching Model. If you decide to stop participating, any information you have given will not be used. This research is based in the Interdisciplinary Educational Research Institute, University of Wollongong and is funded by the University Research Council, University of Wollongong. If you decide to participate in this study, you will make a valuable contribution to research in cognition (thinking processes) and improving students' learning.

By participating in this study, you will demonstrate evidence towards the NESA Professional Standards for Teachers. These include:

Standard 1: Know Students and How They Learn

1.2.1 – Demonstrate knowledge and understanding of research into how students learn and the implications for teaching (Graduate)

1.2.2 - Structure teaching programs using research and collegial advice about how students learn (Proficient)

Standard 6: Engage in Professional Learning

6.4.1 - demonstrate an understanding of the rationale for continued professional learning and the implications for improved student learning (Graduate)

6.4.2 - Undertake professional learning programs designed to address identified student learning needs (Proficient)

Standard 7: Engage Professionally with Colleagues, Parents/Carers and the Community

7.4.1 – Understand the role of external professionals and community representatives in broadening teachers' professional knowledge and practice (Graduate)

7.4.2 - Participate in professional and community networks and forums to broaden knowledge and improve practice (Proficient)

ETHICS REVIEW AND COMPLAINTS

This study has been reviewed by the Human Research Ethics Committee (Social Science, Humanities and Behavioural Science) of the University of Wollongong. If you are not happy with the way this research has been conducted, you can contact the Ethics Officer at the University on (02) 4221 4457.

Thank you for your interest in this study. If you have any further questions or concerns, you can email Shirley, Sharon or Gerry (see contact information above).

APPENDIX M

Participant Consent Sheet (Study 2)

University of Wollongong

CONSENT FORM FOR PARTICIPANTS

Research Title: *Investigating the Effectiveness of Product-Oriented and Process-Product Oriented Worked Examples to Support Pre-Service Teachers Understanding of the NSW Quality Teaching Model* (QTM).

Researchers' Names: Dr Shirley Agostinho, Dr Sharon Tindall-Ford and Mr Gerry Sozio

I have read the participation information sheet and have had the opportunity to ask the researchers any further questions I may have had. I understand that my participation in this research is voluntary and I may withdraw at any time from the study without affecting my relationship with the University of Wollongong or the researchers.

I understand that the risks to me are minimal in this study. I have read the participation information sheet that describes the purposes of the study and asked any questions I may have about the risks.

If I have any enquires about the research, I can contact Dr Shirley Agostinho, email: shirleya@uow.edu.au. If I have any concerns or complaints regarding the way the research is or has been conducted I can contact the Ethics Officer, Human Research Ethics Committee, Office of Research, University of Wollongong on 02 4221 4457. I understand that information from me will be published in a journal article. I understand that my name will not be used in the study to reduce the likelihood of being identified.

By signing below I am consenting to the following:

I understand by signing below that consent to being involved in an experiment that will be conducted at the University of Wollongong. The instructional materials will include a presentation by the research, video recordings of lessons and NSW Quality Teaching Model documentation and resources. The timing of the experiment will be approximately 90 minutes

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I ________________________________ (please insert name) give permission for my results from the experiment to be used in this research.

Name: ____________________________ Signature: ____________________________

Date: ________________

Consent Form V2 – April 2018

APPENDIX N

Referencing Tables including the Coding of the PHDPE lesson

for each instructional condition (Study 2)

Referencing Table for the Process condition:

ELEMENT	Coding Score	Generic Coding Description	The Coding Score was determined by the level of:
Substantive communication	4	Substantive communication, with sustained interactions, occurs over approximately half the lesson with teacher and/or students scaffolding the conversation.	**Sustained Interactions** In the lesson, several sustained interactions were evident. The teacher asked questions like 'anything else?' to encourage students to extend their responses which continued the idea beyond the simple 'initiate-respond-evaluate' (IRE) pattern. The group work showed students effectively building a shared understanding. **Focus on the Substance of the lesson** The communication moved beyond mere recounting of facts and experiences and encouraged the application of ideas. The teacher raised questions like 'what things at parties might concern you?' to enable the students to apply ideas and make distinctions focusing on the substance of the lesson. **Reciprocal Interaction** The lesson wasn't scored a 5 as the introduction of the lesson involved Initiate-Respond-Evaluate communication, where the teacher asked routine questions and students provided short answers. An example of a high level of reciprocal interaction includes the teacher asking the students 'do you agree with me?', to which there was no response. During the group work, reciprocal interactions are high as the flow of information and ideas is at least two way in direction.

Referencing Table for the Product condition:

ELEMENT	Coding Score	Generic Coding Description	The Coding Score was determined by the level of:
Substantive communication	4	Substantive communication, with sustained interactions, occurs over approximately half the lesson with teacher and/or students scaffolding the conversation.	**Sustained Interactions** Sustained interactions were evident. **Focus on the Substance of the lesson** Focus on the substance of the lesson was high. **Interaction is Reciprocal** Reciprocal interactions were evident.

Referencing Table for the Control condition:

ELEMENT	Coding Score	Generic Coding Description	The Coding Score was determined by the level of:
Substantive communication	4	Substantive communication, with sustained interactions, occurs over approximately half the lesson with teacher and/or students scaffolding the conversation.	**Sustained Interactions** **Focus on the Substance of the lesson** **Interaction is Reciprocal**

APPENDIX O

Script for Study 2

SCRIPT FOR STUDY 2:
PRODUCT-PROCESS EXAMPLE

PHASE ONE

WELCOME

TURN ON RECORDER

Hello.
Thank you for participating in today's session. My name is Gerry Sozio and I am a research student at the UOW. Today's session is a part of my PHD research, and through participating in the session, you will learn about the NSW Quality teaching model and its application in the classroom.

Q: What are your names?

We will commence with some introductory questions (START WITH PARTICIPANT NAMES TO BE ABLE TO IDENTIFY):

Q: Tell me about your teaching experience. That is: how many professional experiences have you done? What stages have you taught?

Q: What does the term 'worked example' mean to you?

Q: Have you used worked examples in your teaching? If yes, can you elaborate on a situation when you used a worked example [probe if they created a worked example and if so how, or if they used an existing worked example.

Q: Another aspect is the NSW Quality Teaching Model. Tell me what you know about the QTM.

Q: Have you heard of the concept of Substantive Communication. What do you think it means. It's an element of the QTM and you will be learning about SC today.

TURN OFF RECORDER

Part A. Learning Phase

You are not to open the workbook at this stage. You will be instructed on when to open the workbook and when to turn the pages, also, when going through the workbook, you are not allowed to turn back pages. This is for the purpose of the experiment.

The NSW Quality Teaching Model has 18 elements that are recognised as influential factors in classroom teaching to improve student learning outcomes. The element that we will be focusing on will be Substantive Communication.

During this session, I will deliver a power-point presentation about the NSW Quality Teaching Model, and following this, there will be a series of tasks where you will apply your leanings. You will learn about the characteristics of high levels of Substantive Communication and you will also learn how to rate the quality of the element of Substantive Communication in a lesson, by using a 1-5 Coding Scale that will be provided for you.

The tasks that you will complete will require you to record information in workbooks that will be provided for you. However, you will not be allowed to make any additional notes, especially while watching video recordings of lessons being taught. This may not be what you do normally, but is what is required for the purpose of this research.

You will be guided throughout the session on what to do and when to do it.

Individually you will complete a series of tasks, and after each task you will be asked to complete a Cognitive Load Effort rating, where you will be asked to rate the amount of mental effort you exerted during the activity you had just complete. You will also be asked to rate the perceived level of difficulty of the task. On the screen you will see the two 9-point scales, ranging from very very low to very very high.

RATING SCALES - Leave on screen for 20 seconds

If I asked you to solve 2 x 3, what Cognitive Load Effort rating would you score i.e., what mental effort did you exert to answer the question? If I was now to ask rate your perceived level of difficulty of the question, what would you score?

Now, if I asked you to mentally calculate 23 x 45, without a calculator, what would you score in relation to the mental effort exerted in attempting to solve this without writing any notes? If I were to ask you to rate the perceived level of difficulty of the question, what would you now score? The amount of ME exerted may well be high, but you may not consider this a difficult task at all?

Now, if I asked you to use your calculator to calculate 23 x 45, what Cognitive Load Effort Rating would you score in coming up with the answer?

It's important to note that Mental Effort has nothing to do with intelligence or your competency, or a test of your ability. It is a subjective rating of the amount of mental effort you had to exert to solve a problem.

Remember it is what you think, there is no right or wrong answer.

You will also be asked to respond to ten statements after completing each task, and you will be asked to tick the relevant square where zero means 'not at all' and 10 means 'completely the case'.

These are just a way to find out about your CL and ME, as I can't scan your brain. Just answer honestly.

I will now commence with the power-point presentation**.** Please pay attention to each slide. You are not able to make notes during the presentation.

POWERPOINT PRESENTATION

Slide 2 – The Model

The QTM has three Dimensions, the Dimensions are Quality Learning Environment, Intellectual Quality and Significance. Within each of the Dimensions, there are six elements linked to that dimension. For example, elements in QLE include engagement and high expectations, elements in Intellectual quality include deep knowledge and deep understanding, and elements in Significance include cultural background and cultural knowledge.

Slide 3 – SC

For today's session we will focus on the element of SC, which is included within the Intellectual Quality dimension.

The element SC has been chosen as it is a complex element and also an important element to engage students and improve learning. Also, for the purpose of this experiment, it would be too complex to consider more than one element of the NSW QTM.

Slide 4 – SC What Is It?

On the screen is a definition of SC. Please read this.

Slide 5 – Characteristics

On the screen are the three characteristics of high levels of SC in a classroom. Please read these. T he next three slides will explain each of these.

Slide 6 – Sustained Interaction

On the screen is the characteristic of Sustained Interaction unpacked for you. Please read through this.

Questions such as: Why did you think that ..? How did you get that? How is this different from..”
For example: What’s the area of a rectangle that is 4m by 3m?
How did you get that?
Why did you do that?
What other dimensions of a rectangle give an areas of 12 m squared?
If the conversation were typical of the Initiate Response Evaluate model, the teacher would just say good when the student responds and then move on.

Slide 7 – Substance of the Lesson

On the screen is the characteristic that the communication is focused on the substance of the lesson.

Please read.

Rather than asking define an acute angle,
Ask if the small hand of a clock is on the 12, what might the time be?
What do you need to consider?

You could also encourage students to generate questions about the topic for discussion and use these as the basis for lesson development.

Slide 8 – The Interaction is Reciprocal

On the screen is the characteristic that the interaction is reciprocal.

Please read.

For example if I ask what’s 3x4, and a student answers 12, rather than say yes only, I could ask, explain how you got that answer, or ask another student whether they agree or disagree, or how the answer was calculated.

Rather than just asking a question, engage in a conversation about a concept.

Slide 9 – LOW SC

Here are characteristics of low levels of Substantive Communication, please read.

In classes where there is little or no substantive communication, teacher-student interaction typically takes the form of the teacher delivering information and asking routine questions and the students giving very short answers.

Discussion tends to follow the typical “initiate–respond–evaluate” (IRE) pattern with low level recall, fact-based questions, short utterances or single word responses, and further simple questions and/or teacher evaluation statements (e.g. ”yes”, “good”).

Teachers are encouraged to Develop opportunities and structures for substantive communication, e.g. in pairs, small group discussion and cooperative learning activities, to allow students to share substantive ideas about the lesson topic.

Slide 10 – Coding Introduction

There is a way in which we can rathe the effectiveness of SC when viewing a lesson, and this is through a process called coding.

Slide 11 – What is Coding

SC can be rated on a 5-point scale. On the scale, 1 represents a lesson low in SC and 5 represents a lesson high in SC. When coding, it is very important that you code only what you see when viewing a lesson.

Slide 12 – The Coding Scale

On the screen you will see the Coding Scale, please read through the description for each code score.

Slide 13 – Coding Sore of 1

It is important to note that a coding score of 1 does not necessarily indicate a bad lesson. It just may not be a feature of that lesson, and the lesson may have scored high in other elements.

At this point all you are required to understand is you will be focusing on the element of Substantive Communication and you can rate the quality of this element by using the 1-5 Coding Scale.

Now turn to page 1 of your workbook.

You are going to watch a video of a PDHPE lesson. PDHPE may be a part of your immersion program. You will only watch a snippet of a lesson. Now, in coding using the 1 to 5 scale, you will code this snippet of the lesson as if it was the whole lesson.

During the video that you are about to watch, there will be annotations, which provide information as to whether *Substantive Communication* is evident or not at different points of the lesson. You must read the annotations. At key points, the video will pause for about 10 seconds. While the video pauses, there will be annotations on the screen indicating whether the section of the lesson that was just watched before the pause contained high or low levels of the characteristics of substantive communication. You must read these annotations.

On the screen there is a screenshot of such an annotation, where the T represents teacher and S represents student, and then there is a statement in relation to the level of SC.

SHOW POWERPOINT WHICH HAS A SCREEN SHOT

On page 1, you will see a table that includes the Coding Score for the element of SC for the video that you are about to watch. You will also see a generic description of why the code of 4 was given, and then further information as to how the coding score was determined in relation to the characteristics of SC. You have 45 seconds to read this, and you must read. Please commence reading the information on page1.

45 SECONDS TO READ

You will now watch the PDHPE lesson.

SHOW PDHPE VIDEO

You now have 45 seconds to reread the information on page 1.

45 SECONDS TO READ

Now, turn to page 2 and complete the rating scales. You have 2 minutes to complete this.

TWO MINUTES

Now, turn to page 3 to commence Task 2. You are required to read the dialogue and complete the questions in the box at the bottom of the page. You have 4 minutes to complete this task.

FOUR MINUTES

Now, turn to page 4 and complete the rating scales. You have 2 minutes.

TWO MINUTES

Turn to page 4 to commence Task 3. You will watch a video recording of a History lesson. This time, you are going to determine and justify the code and justify. Please watch the video.

SHOW VIDEO

2.5 MINUTES

Now, turn to page 4 and complete the rating scale. You have 2 minutes.

TWO MINUTES

You are now required to turn to page 7 of your workbook to commence Task 4.

You are going to watch a short video recording of a lesson. You will then be asked to answer the three questions in the table on page 4.

Please watch the video.

SHOW VIDEO.

Please answer the questions on page 7. You have two minutes.

TWO MINUTES

Now, turn to page 8 and complete the rating scales. You have 2 minutes.

TWO MINUTES

Now, turn to page 9 of your workbook to commence Task 5.

During this task, you will watch a video of a Science lesson. At the conclusion of watching the short video, you will be required to respond to the following:

Suppose you were the teacher. How would you enhance the characteristics of Substantive Communication listed below?

SHOW VIDEO

Please commence Task 5 on page 9, you have 3 minutes to complete this.

THREE MINUTES

Now, turn to page 10 and complete the rating scales. You have 2 minutes.

TWO MINUTES

Now turn to page 11 of your workbook to complete Task 6. In the Comment section, answer in point form. I really want to hear what you think of this.

TWO MINUTES

TURN ON RECORDER

PART B – Exploratory Questions

I am now going to ask you some questions.

Q: What did you do when the worked example was presented?

Note: For the conventional problem solving instructional condition, the question was changed to "What did you do when the video lesson was presented?".

Q: How did you use your time during the pauses?

Q: Were the annotations during the pauses useful to you? Why?

Note: The question in relation to annotations was not asked to participants during the conventional problem solving instructional condition.

Q: Did the worked example help you understand the Coding Score that was given? Why?

Note: For the conventional problem solving instructional condition, the question was changed to "Did watching the video recording of the lesson help you understand the Coding Score that was given? Why?".

Q: For the worked example, why did you rate the Mental Effort Rating and the Task Difficulty Rating as you did?

Note: For the conventional problem solving instructional condition, the question was changed to "For the video recording of the PDHPE lesson, why did you rate the Mental Effort Rating and the Task Difficulty Rating as you did?".

Q: How did the worked example help or hinder you in answering the four task?

Note: For the conventional problem solving instructional condition, the question was changed to "How did watching the video recording of the PDHPE lesson help or hinder you in answering the four tasks?".

TURN OFF RECORDER.

<u>PHASE 2</u>

Part A

Script: "I have presented to you a particular form of WE. I am now going to show you another form'.

Then show 1 minute of a video (second condition – including the pauses) as well as the corresponding WE in the workbook (give same timing for participants to read the WE workbook both before and after the video).

TURN ON RECORDER

Q: This is a second type of WE. Did you see any differences between the two WE, if so, what are they?

Q: How did you use your times during the pauses?

Q: Were the annotations during the pauses useful to you? Why? Note: The questions on annotations were asked for the process oriented and product oriented instructional conditions only.

Q: Of the two worked examples, which do you prefer? Why?

TURN OFF RECORDER.

Part B

Script: "I have presented two types of WE, now I am now going to provide a third type.'

Then show 1 minute of a video (second condition – including the pauses) as well as the corresponding WE in the workbook (give same timing for participants to read the WE workbook both before and after the video).

TURN ON RECORDER

Q: This is a third type of WE. Can you see any differences to the other two WE, if so, what are they?

Q: How did you use your times during the pauses?

Q: Were the annotations during the pauses useful to you? Why? Note: The questions on annotations were asked for the process oriented and product oriented instructional conditions only

Show participants screen shots of the three different types of video annotations, as well as the three related WE from the workbooks.

Q: These are screen shots of the three worked examples that have been presented to you. Rate these 1 to 3, from the worked example you prefer the most to the worked example you prefer the least.

Q: Why did you order the worked examples in this way?

Q: Do you have suggestions on how these worked examples may be improved?

PHASE 3

Q: Thank you for participant in this Study. I have one final question for you.
Has this given you any ideas or further ideas on how you could use WEs in your teaching?

TURN OFF RECORDER.

APPENDIX P

Study 2 Exploratory Questions Asked to Participants

Study 2 Exploratory Questions Asked to Participants

PHASE 1

Q: What did you do when the worked example was presented? *Note: For the conventional problem solving instructional condition, the question was changed to "What did you do when the video lesson was presented?".*

Q: How did you use your time during the pauses?

Q: Were the annotations during the pauses useful to you? Why? Note: The question in relation to annotations was not asked to participants during the conventional problem solving instructional condition.

Q: Did the worked example help you understand the Coding Score that was given? Why? Note: For the Control condition, the question was changed to "Did watching the video recording of the lesson help you understand the Coding Score that was given? Why?".

Q: For the worked example, why did you rate the mental effort rating and the task difficulty rating as you did? Note: For the Control condition, the question was changed to "For the video recording of the PDHPE lesson, why did you rate the mental effort rating and the task difficulty rating as you did?".

Q: How did the worked example help or hinder you in answering the four tasks? Note: For the control condition, the question was changed to "How did watching the video recording of the PDHPE lesson help or hinder you in answering the four tasks?".

PHASE 2

Part A

Q: This is a second type of WE. Did you see any differences between the two WE, if so, what are they?

Q: How did you use your times during the pauses?

Q: Were the annotations during the pauses useful to you? Why? Note: The questions on annotations were asked for the process oriented and product oriented instructional conditions only.

Q: Of the two worked examples, which do you prefer? Why?

Part B

Q: This is a third type of WE. Can you see any differences to the other two WE, if so, what are they?

Q: How did you use your times during the pauses?

Q: Were the annotations during the pauses useful to you? Why?

Note: The questions on annotations were asked for the process oriented and product oriented instructional conditions only

Q: These are screen shots of the three worked examples that have been presented to you. Rate these 1 to 3, from the worked example you prefer the most to the worked example you prefer the least.

Q: Why did you order the worked examples in this way?

Q: Do you have suggestions on how these worked examples may be improved?

<u>PHASE 3</u>

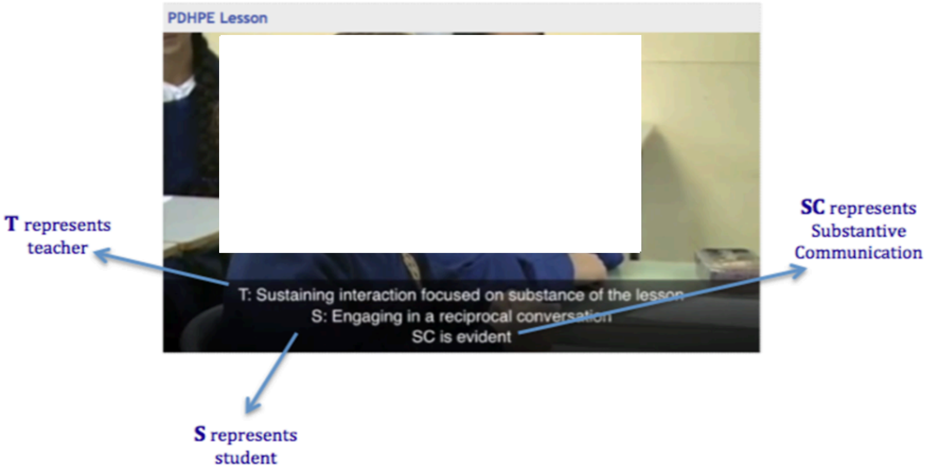
Q: Has this given you any ideas or further ideas on how you could use WEs in your teaching?

APPENDIX Q

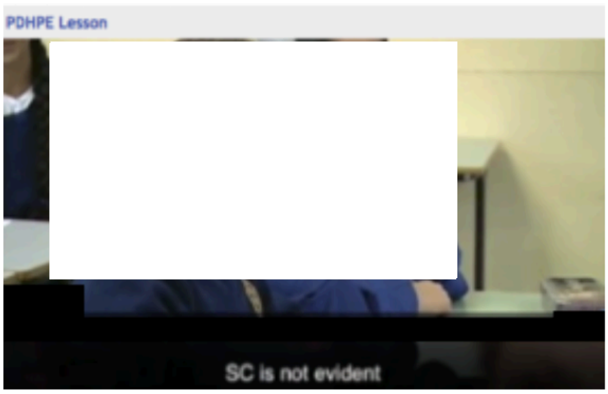
Screen shots of the different types of annotations that occurred during the video recordings of the PDHPE lessons for each instructional condition

(Experiment 1 and Study 2)

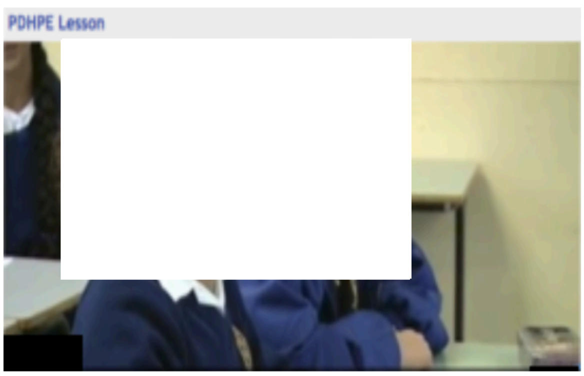
Process Condition



Product Condition



Control Condition (Conventional Problem Solving)



APPENDIX R

Pauses and Annotations included in Video Recordings of Lessons

Video Recordings of the Lessons and Pause Details

The video recordings for each instructional condition during the Learning Phase can be viewed by clicking on the following link: https://bit.ly/3yApYjB

The following displays the annotations that appear during the video recordings of the PDHPE and Japanese Language lessons for the Process condition. The pauses for the Product and Control conditions occur at exactly the same time. However, the annotations for the Product condition include only 'SC evident' or 'SC not evident'. There are no annotations during the pauses of the video recordings for the Control condition.

The Video Recording of the PDHPE Lesson:

Timing of the Pause	**Annotation at the Pause**
27 seconds	T: Asks a routine question S: Provides short response Interaction is not reciprocal – SC not evident
41 seconds	T: Asks 'anything else' and student responds. Sustaining interaction through continuation of an idea – SC evident
1 minute 7 seconds	T: Asks 'what things at parties might concern you' and sustains interaction with the student on substance of the lesson – SC evident
1 minute 30 seconds	S: Provide short answers Interaction is not reciprocal (I-R-E) – SC not eident
1 minute 53 seconds	T: Asks 'Do you agree with me'? S: Students do not respond Interaction is not reciprocal (I-R-E) – SC not evident
2 minutes 12 seconds	T: Asks 'Does everyone remember that one?' S: Students do not respond Interaction is not reciprocal (I-R-E) – SC not evident
2 minutes 40 seconds	T: Encourages students to extend their responses Sustaining interaction through continuation of an idea on the substance of the lesson – SC evident
2 minutes 57 seconds	T: Asks: 'What do you mean by butterflies?' S: Engages in the conversation Sustaining interaction through continuation of an idea – SC evident
3 minutes 25 seconds	T: Encourages students to extend their responses

	Sustaining interaction through continuation of an idea on the substance of the lesson – SC evident
3 minutes 52 seconds	T: Does not give the student the opportunity to answer. Interaction is not reciprocal – SC not evident
4 minutes 40 seconds	T: Encourages students to extend their responses Sustaining interaction through continuation of an idea on the substance of the lesson – SC evident
5 minutes 15 seconds	Build shared understanding through sustained interaction. Reciprocal interactions focusing on the substance of the lesson. SC evident.
5 minutes 45 seconds	Build shared understanding through sustained interaction. Reciprocal interactions focusing on the substance of the lesson. SC evident.
6 minutes 19 seconds	Build shared understanding through sustained interaction. Reciprocal interactions focusing on the substance of the lesson. SC evident.
6 minutes 51 seconds	Build shared understanding through sustained interaction. Reciprocal interactions focusing on the substance of the lesson. SC evident.
7 minutes 30 seconds	Build shared understanding through sustained interaction. Reciprocal interactions focusing on the substance of the lesson. SC evident.

The Video Recording of the Japanese Language Lesson:

Timing of the Pause	Annotation at the Pause
32 seconds	T: Asks factual based questions S: Provide short answers Interaction not sustained as there is no flow of ideas and the conversation is not reciprocal – SC not evident
58 seconds	T: Responds 'That's right, ok'. Interaction is not reciprocal (I-R-E) – SC not evident
1 minute 45 seconds	T: Repeats answer and says 'good' Interaction is not reciprocal (I-R-E) – SC not evident
2 minutes 25 seconds	T: Asks factual based questions S: Provide short answers Communication not moving beyond recounting facts. SC not evident.
3 minutes 7 seconds	T: Asks factual based questions S: Provide short answers Interaction not sustained as there is no flow of ideas and the conversation is not reciprocal – SC not evident
3 minutes 33 seconds	T: Says 'Repeat after me'. This is not a feature of a reciprocal conversation. SC not evident.

4 minutes 6 seconds	T: Asks factual based questions S: Provide short answers and ask a factual based question. Communication is not moving beyond recounting facts – SC not evident

APPENDIX S

An example of how the researcher analysed the transcripts using qualitative coding to develop themes

SECTIONS OF TRANSCRIPT - STUDY 2 PEX PROCESS

A – Engaged with, B – Made meaning

Themes:

Annotations as a guide / scaffold	Misconceptions / disagree	Length of video/amount of Process material	Process information leading to complacency

PART B – Reflection Questions

R: OK, thank you for completing that Matthew and Samuel. I have a few questions that I am going to ask you. So, I'll start with you Matthew. The question is what did you do when the worked example was covered. Now, if you think back, the worked example was made up of the video at the beginning and the table in the work booklet. … what did you do when the worked example was covered?

M: Um, so I used the video and the little annotations on it, and then I referred back to the page, that helped identify where in the lesson the substantive communication actually occurred.

R: OK, what about yourself Samuel, what did you do when the worked example was covered?

S: So, I compared to what I had my understanding of it, to what the book scale was, and then I actually disagreed with the scale used in the book because although they asked for elaborations with substantive communication, like what else do you think, they then dropped back to using IRE with the student responses.

…

R: Great, thank you. I'll now start with you Sam for the next question, so throughout that video you would have noticed annotations during the pauses, were they useful to you and why?

S: They were useful because they gave me a guideline on what sort of things you pay attention to for substantive communication. Also, what other people consider substantive communication to be. They also allow me to think of the substance and, um, prolonged interaction between teacher and student, where as once we jumped to the next section I completely forgot about substance and focused only on sustained interaction. ~~But~~ those pauses and annotations really gave you a clear picture of what sort of things to look for when looking at substantive communication.

…

R: Good, thank you. I might ask Matthew the next question. Did the worked example help you understand why the Coding Score was given and why?

M: Yes, so by looking at coding scale before, and then using the coding scale we could look at why it was ranked 4, so you could annotate it on the lesson where and why they had given that, where as on other ones it was a bit like, ooh, did that happen or did it not?

R: Thank you. What about yourself Samuel?

S: It did help give you clarity to why, but it also helped raise questions as to why. Because everyone perceives things sort of differently, so they perceived the teacher asking the students for more responses as Substantive Communication, but I however don't because it's what they do with those responses where the Substantive Communication takes place. So, I didn't perceive that to be Substantive Communication. So, even though they gave it a four, I would personally have given it a lower score, and so, I guess that sort of altered how I approached the task, in the future ones I still gave the lower score even though they did that back and forth response, like asking for more answers, based on my perception

…

R: So, for the worked example, tell me why you rated the Mental Effort, the Task Difficulty and the Statements as you did.

M: So I rated it quite low, Mental Effort and Task Difficulty, due to the annotations. I found them for me, that helped more than just saying look at this video, where as it helped me go, oh yeh that's there, and I think for me that made it, it didn't take much of a toll for me, I was able to focus on the lesson rather than thinking of what's in that because it was put on the screen and then as it went on, I was able to pick it up easier …

S: I also remember another reason why, because of how long it was. It was a long video so it just, as it went on and on you try and keep more things in your mind, and focus on each new concept. It just got more draining as it went.

R: OK, thank you, and now the last question of this section, and I'll ask Samuel first this time, how did the worked example help or hinder you in answering the next four tasks?

S: Umm, because of the length, it initially hindered me on the tasks where it didn't give a definition of what it was or like the key words

…

R: Thank you. What about you Matthew, how did the worked examples help of hinder you in answering the next four tasks?

M: Um, I think it kind of, the worked example hindered what I could do in the other four tasks due to the fact that I was kind of reliant on the annotations to make some decisions about it

Microsoft Office User
Linked information from the screen to information given in the document (A). Using the Process information as a guide to learning (B).

Microsoft Office User
Disagree (A) with information that has been presented / raising own questions (B) on perceptions / misconceptions – May lead to higher Mental Effort & Task Difficulty during the learning phase. These results were not significant, but results were in the right direction.

Microsoft Office User
Annotations (B) provided a clear picture of what to look for / guideline / clarify / allowing to focus on the lesson as answers are provided / structures and guidelines.

Microsoft Office User
A clear picture of what to look for (B). Does not align with the experiment results. Even though not significant, TD & ME were higher for Process as compared to Product.

Microsoft Office User
As well as providing guidelines – The Process also provided the 'why' – this is seen as a positive (A).

Microsoft Office User
Helped give clarity to the 'why' (A,B)

Microsoft Office User
The Process information also raised questions. (A) This can be linked to misconceptions of the participants. This may linked to the Process Product for both ME and TD – these results are not significant, but are in the right direction.

Microsoft Office User
Possible misconceptions. (A) Adjusted his thinking (B) for other tasks. This may have added to the ME and TD during the test phase i.e. he was working against his own misconceptions. For both ME and TD during the test phase, it was hypothesised the Process < Product. This was not significant and the results indicated the reverse, possibly linked to this idea.

Microsoft Office User
The annotations provided answers to the participant, so that he was able to just focus thinking on the video. (B) This could suggest that TD and ME may have been lowered – however, in the results, the process TD and ME were higher that the product.

Microsoft Office User
The length of the video was referred to as draining. (A) This may have contributed to the higher ME and TD during the Learning Phase.

Microsoft Office User
Refers to the length of the video - he then refers to mental blanks. (A)

Microsoft Office User
Was reliant on being given the answers during the Learning Phase. (A) This may have lead to complacency

Colour-coding was used to assist the analysis of transcripts using a qualitative coding method to develop themes.