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Supporting the Development of Pre-service Teacher Learning Design Capabilities

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Abstract

The learning design processes that groups of pre-service teachers utilise when designing technology-enhanced lessons and the development of pre-service teacher learning design capabilities during these processes are under-researched areas. This study explored how teacher educators could enhance the learning design capabilities of pre-service teachers by investigating the focuses of pre-service teacher design conversations, their design approaches, the factors supporting and/or hindering their collaborative design processes, the relationships between pre-service teachers' learning design practices and learning design artefacts, and the impact of pedagogical strategies of teacher educators upon pre-service teacher learning design practices. These issues were addressed by examining six groups of three pre-service teachers as they completed a collaborative design assignment and two bigger cohorts of pre-service teachers in two iterations in a design-based research mixed-method study. Data analysed included recordings of pre-service teachers' in-class group design conversations, online resources and discussions, Technology Pedagogy and Content Knowledge (TPACK) self-assessments, and interview responses. Thematic analysis and Linear Mixed Model analysis were the two main approaches to analysing qualitative and quantitative data respectively.

Findings, viewed through the lenses of the TPACK framework and Activity Theory, showed that pre-service teachers discussed design related issues, TPACK elements, context, and learners' characteristics in their design conversations with dominant references to design-related issues, substantial occurrences of single TPACK elements, and lower frequencies of integrated TPACK elements and context. Four design approaches were observed: content-based, top-down, learner-centred, and context-oriented. In addition, five factors were identified as enablers to pre-service teachers' learning design practices: technological capabilities, group dynamics, tutor support, pre-service teachers' past educational experience, and the teacher education program's resources and activities. The frequency of technology and context related discussions were positively and significantly correlated with the technological and contextual quality of their final learning design artefacts. As well, while changes to teacher educators' pedagogical strategies between iterations did not have a comprehensive impact on pre-service teachers' learning design processes and products, the approaches adopted by teacher educators did have a significant impact on pre-service teachers' improvement across all TPACK areas across the cohort and for each iteration. Quantitative data also revealed that practicum experience influenced pre-service teachers' development in particular areas of TPACK. Based on the findings of the study, a Design-TPACK framework together with many practical and research-related recommendations are proposed.

Statement of Originality

This thesis has not been submitted for consideration for any other degree from any educational institution. It represents my original work, performed under the guidance and supervision of supervisors at Macquarie University. All instances where the work of others has informed the study and/or creation of this thesis have been referenced appropriately.

Approval to undertake the study informing this thesis has been provided by Faculty of Arts under reference number 5201600079M (for further details, see Appendix 8).

Giang Ngoc Huong Nguyen 07 March 2020

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Chapter 1. Introduction

This chapter introduces background to the study by providing a general overview of teacher technology-enhanced learning design and the specific contextual foundation from which the study arose. The specific context is discussed in relation to practical problems identified from a pilot study involving a particular undergraduate educational technology unit for pre-service teachers. From the recommendations that were suggested to solve these practical problems, the objectives of the current study are established. Finally, the focus and structure of the remaining chapters are outlined to explain how research aims and questions are addressed and reported in this thesis.

1.1. Broad Context

The rapid development of technology in recent years has changed people's lives in many ways. A busy person can verbally "order" their mobile phone to play their favourite songs while driving to work. Researchers are able to access all kinds of relevant resources online. Cinemagoers are fascinated by seats moving, leaves falling within arms' reach, and drops of water splashing onto faces while watching 5D movies in the theatres. The list can go on, not to mention that more and more new technologies are released monthly.

This proliferation of the technological tools and the excitement they bring has also had an impact on education, particularly on the way many teachers teach. For teachers who are surrounded by advanced tools, the process of creating lesson plans, delivering lessons, designing technology-enhanced tasks, implementing assessments, grading papers, and so on are all assisted and facilitated through the use of technology. Making interactive presentations is easier than ever with apps which allow teachers to use special effects and create animations. Traditional blackboard, chalk and posters have been replaced with interactive smart whiteboards connected to computers and which can often be remotely controlled from compact smart mobile devices. Again, the list can go on.

This shift from society having digitally technology-poor to technology-rich learning and teaching environments has created additional pressure on decision-making processes. At a higher level, policy-makers have been pressed to update educational policies to adjust to the new technological milieu, which corresponds with increasing national and international importance being placed on teachers' ability to design learning tasks and appropriately integrate Information Communication and Technology (ICT) into teaching. Governments and professional bodies have underscored the need for teachers to be equipped with technological capabilities so that they can be integrated into school curricula in order to create more authentic and personalised learning experiences for learners (AITSL, 2014; ISTE, 2017; UNESCO, 2018). To this extent, pre-service teacher education programs would ideally prepare future teachers with requisite ICT knowledge and learning design capabilities. However, there remain concerns about whether pre-service teachers are able to effectively integrate ICT into their lesson designs, as well as suggestions that successful integration of ICT can only occur through associated development of pre-service teacher thinking processes and teaching knowledge (Tondeur et al., 2020).

As well, this shift from basic to more advanced technology has exposed teachers to challenges. *First*, some teachers are not confident about using technologies. A wide variety of tools with novel functionalities may excite and at the same time worry teachers, even the technology avid ones (Nguyen & Bower, 2018; Teo, 2009). To address this, there is an evident need for an empirical understanding of how different design considerations and decisions may influence the ultimate learning outcomes. *Second*, some teachers may mistakenly assume that using the latest technologies will automatically create interesting and meaningful lessons. It would be a concern if pre-service teachers, who potentially have less experience not only in teaching content and using pedagogy, but also in teaching with technology, left their programs with this misconception. This concern entails the requirements of developing and implementing teacher education programs which can potentially address the above issues.

In light of our understanding that solely providing technology is not guaranteed to enhance learning, research and policy now places emphasis on teacher as a designer for learning (Laurillard, 2013). Not designing their own lessons could possibly deviate teachers from learning more about what pedagogical approaches actually underpin certain technologies, from catering to their potential learners' needs, and from anticipating potential issues the tools can bring which could only be identified with a real and careful approach to designing. In addition,

> through the metaphor of design… teachers are positioned as architects of classroom experiences, balancing the development of multiple literacies and designing a learning environment where appropriate computer-based cognitive tools are applied imaginatively to collaborative, student-focused, reflective, problem- based approaches to learning. (Kimber & Wyatt-Smith, 2006, p. 28)

These struggles for teachers to know how to effectively integrate their available repertoires of knowledge were originally characterised by Shulman (1986) as teachers' lack of awareness of pedagogy content knowledge (PCK); prompting the need to examine different forms of knowledge that teachers owned. When technology started to permeate classrooms, attention was given to investigating how the technology dimension interacted with PCK to constitute teachers' technology pedagogy and content knowledge (TPACK). While the TPACK framework is reviewed and discussed in detail in Chapter 2, it can be briefly summarised that there has been considerable work undertaken investigating TPACK within the context of teacher education programs in order to prepare teachers with technology integration and to improve their technology integration capabilities (Bower, 2012; Janssen & Lazonder, 2016; Kramarski & Michalsky, 2010a; Tondeur et al., 2012, 2017, 2020; Valtonen et al., 2019; Joke Voogt & McKenney, 2017). However, questions have been raised to whether a purely TPACK focus is sufficient for supporting practice, with limitations including the exclusive focus on knowledge rather than skills in context, and the lack of guidance about which approaches are more effective for enhancing learning (Bower, 2017).

The responsibilities for searching for successful context-based designing approaches and sharing 'best practice', in the last two decades, have been assumed by educational researchers and practitioners in the field of Learning Design. The field of Learning Design can be defined as "research and development dedicated to the quest of equipping teachers with tools and strategies to aid their design of high-quality learning environments" (Agostinho et al., 2013, p. 97). Many learning design studies aim to provide educators with better teaching strategies and tools for improving students' learning outcomes (Asensio-Pérez et al., 2017; Bennett et al., 2015; Conole et al., 2004). Some studies have provided a pedagogical basis for the construction of tools for effective learning designs (Bennett et al., 2015; Bower, 2012; Laurillard, 2013). Other studies enquired about teaching practices and proposed designs that could improve the ways teachers plan, share resources and deliver teaching tasks or lesson plans (Boud & Prosser, 2002; Conole & Wills, 2013; Kearney, 2011). Despite the various orientations of these learning design studies, they all point to several factors that influence teachers' decision making in the processes while creating technology-enhanced learning designs. These factors confluence around pedagogies, learning curricula and outcomes, students' and teachers' teaching and learning styles and capabilities, and the context of teaching and learning.

Among the learning design studies that investigated teachers' learning design practices, there has been limited analysis of teachers' actual learning design processes. As well, most of the analysis focusing on learning design practices relates to teachers in the field (Koh & Chai, 2016) with relatively little research of pre-service teachers. Previous literature exploring expert teachers' design processes called for further studies to investigate whether novice or less experienced teachers follow different thinking processes and take different approaches from experts when designing (Bennett et al., 2016a, 2016b). Pre-service teachers are a critical cohort because the skills and mindsets that they develop at an early stage potentially last a lifetime and have a large impact on their learning design activities once they become in-service teachers. With a huge number of students enrolling in, completing, and graduating from pre-service teacher education courses in Australia and internationally, teacher educators in universities are confronted with the challenge of how to support pre-service teachers, who typically have less developed knowledge than their in-service teacher counterparts, to create outstanding learning designs using technology.

So how can teacher educators effectively help pre-service teachers to develop their technology-enhanced learning design capabilities? Many pre-service teacher development programs create activities and assessments that traditionally require pre-service teachers to design units of work, assessment tasks, or teaching resources (arguably the three common examples). So the issue is not pre-service teachers being engaged in learning design, but teacher educators having a robust and evidence-based understanding of how to improve it. Underpinning teacher education and pre-service teacher education is an assumption that the knowledge that (pre-service) teachers have or develop will influence their learning design processes and products, and that learning design processes will influence the quality of learning designs.

Consequently, this study investigated different knowledge elements pre-service teachers enacted while collaboratively designing their technology-enhanced lessons as well as the relationship between their learning design processes and the learning design products they created. The ultimate purpose of this investigation was to provide research evidence that could be used to improve pre-service teachers' learning design capabilities.

1.2. Background Context

"EDUC261 – Information Communication Technologies (ICT) and Education" is a second-year unit designed for education students, or pre-service teachers, at Macquarie University. The unit forms part of the broader push from the last 20 years or so of having a mandatory ICT component in teacher education programs in Australia (Pearson, 2003). This unit considers ways in which ICT is changing education and is particularly concerned with issues related to the use of technology in the classroom, such as:

- how to successfully select and apply educational technologies to achieve intended learning outcomes;
- the new literacies that educational technologies create; and
- appropriate pedagogies for the contemporary global classroom.

Practical application of these understandings is developed through a series of skills-based tutorials that focus on how to effectively design learning tasks using the contemporary technological approaches being discussed.

While the unit had been iteratively developed and refined over the last decade, it had never undergone a systematic or empirically-driven process of rigorous redesign. In the context of the lack of knowledge in the field generally about pre-service teacher design processes, a pilot study was conducted by the candidate as part of an MRes thesis, to find out (1) what pre-service teachers focused upon while creating their collaborative ICT-based modules and (2) what supported and/or inhibited their learning design processes. This pilot study subtended many implications and recommendations that could be used to guide EDUC261 teacher educators (and teachers more broadly) on what and how to do to improve pre-service teacher learning design capabilities (for full results, see Nguyen, 2016). The 1-year pilot study also constituted Iteration 1 of a 4-year project investigating how to effectively improve pre-service teacher learning design practices. Results from this study were published in the British Journal of Educational Technology (Nguyen & Bower, 2018). The main findings, implications and recommendations of the pilot study will be briefly presented below, followed by the further directions that were proposed for the next 3-year project (this PhD program).

To answer the above two questions concerning design focuses and supporting/inhibiting factors, various sets of data were collected, including recordings of in-class team design conversations, online resources and discussions, evolving learning designs, and follow-up interview responses. The findings showed different factors that the pre-service teachers would (not) focus upon while they were designing in groups, from which three main approaches to designing adopted by pre-service teachers were identified: top-down, content-focused and learner-focused approaches. Technology was another focus of the design conversations though not equally discussed by the three groups of pre-service teachers. Surprisingly, the pre-service teachers did not focus on pedagogy and the learning context in either face-to-face in-class or online design discussions. In addition, group dynamics, teacher-student interaction and the pre-service teachers' technological capabilities emerged as both enablers and barriers to learning design, depending on how they manifested within the design processes.

Based on these findings, implications and recommendations regarding supporting pre-service teachers' learning design processes and executing pre-service teacher learning design projects were proposed. First, findings from the pilot suggested that there should be thought-provoking activities within the group work or within the tutorial time which require ***pre-service teachers to articulate what they understand about learning and teaching***. This would provide pre-service teachers with an opportunity to align and develop their pedagogical thinking as well as provide a better team understanding relating to their design of the module.

Another recommendation from the pilot study was that ***more time should be spent on developing technology skills*** – for example Moodle built-in tools and external technologies like Web 2.0 tools. Moreover, pre-service teachers should be encouraged to use tools with a pedagogical purpose in mind. In addition, a showcase of different students' pedagogical uses of technology each week (either from current or previous student work) could help pre-service teachers learn from each other's practice and therefore improve their capacities to articulate different pedagogical theories to a wide range of tools in varying scenarios.

Furthermore, the findings suggested that ***tutors could play a more active part in helping groups to coordinate and execute group work processes***. For instance, in the first week when pre-service teachers start designing in teams, tutors could lead an initial discussion on group collaboration, the benefits of assigning roles, and approaches to delegating responsibilities. It was also suggested that tasks be equally shared among the group, that the contributions of each group member be clearly delineated, but the work of each individual be marked separately so that those who work harder receive better marks without being affected by those who perform less actively. Taking these actions could raise a sense of mutual accountability among the group members as well as individual self-awareness of connecting with other members and strengthening team collaboration by fulfilling one's roles and duties in group work.

Additionally, it was proposed that ***taking learners' characteristics into consideration in the design process*** should be emphasised throughout tutorial classes. As well as through encouragement by tutors, reflection on the students' perspectives could also be cultivated through activities where pre-service teachers complete and provide feedback on peer modules. This proposed feedback is not only a way for them to broaden their understanding of potential learners' perspectives but also a way to learn from the modules created by peers and obtain feedback from someone else about how they found or evaluated their module as a learner. Taking on the role of a student, evaluating the student-focused design strategies of peers, and receiving feedback from peers about the appropriateness of their modules could all contribute to deeper consideration of prospective students.

As well, there was an identified need to ***prescribe a general design context for pre-service teachers*** considering how important context is in learning design and how little the participants discussed potential institutional context in terms of, for example, technological facilities (software, hardware, internet availability) that are essential in both designing and implementing technology-based lessons in real classes. The anticipation of context enables pre-service teachers not only to create meaningful and motivating lessons, but also to develop very important authentic design skills for when they begin teaching.

Given the important roles of social networking in facilitating the participant groups in designing the Moodle modules, the last recommendation is that the ***appropriate application of social networking be encouraged*** to help pre-service teachers collaborate more effectively and at the same time enhance the efficient use of social constructivist learning approaches. For example, Google Docs' collaborative features can be utilised so that an online document facilitates synchronous collaborative authoring and peer review of work, as opposed to just being used for group shared notes and resources. In other words, tutors should consider how they can actively help pre-service teachers improve their design skills from a social constructivist perspective using technology.

Although the case study enquired into activities of a specific group of student participants in a particular course at a particular university and, therefore, the findings could not necessarily be directly generalised to other students in similar courses, to this extent, the pilot study was able to establish ***possible phenomena and foundations for further research***. For example, one proposed further research inquiry was to investigate whether there is a relationship between the characteristics of the final design products and the focus of pre-service teacher conversations. Another possibility was to examine the way in which specific scaffolding or intervention could support more effective social construction of knowledge, which happens when peers learn from a more capable peer or tutor via small group work interaction. Furthermore, future investigations could apply discourse analysis of pre-service teacher design conversations as a means of examining the impact of applying some or all of the recommendations above. The researcher also recommended using TPACK surveys to gauge the development of teacher understanding as a result of collaborative design.

The aforementioned recommendations regarding the design and execution of a pre-service teacher ICT education program became treatments implemented as part of a design-based research project aimed at understanding how to effectively enhance pre-service teacher technology-enhanced learning design knowledge, practices, and outcomes. This implementation of the treatments forms the research aims and questions of the current study presented in the following section.

1.3. Research Aims and Questions

The overall objectives of this study were to gain insight into pre-service teacher learning design practices and to understand how educators could positively impact upon pre-service teacher learning design capabilities while they undertook an extended group learning design project. There were several areas that this study aimed to explore, including:

- the collaborative processes by which pre-service teachers design technology-based learning experiences for their potential learners
- the knowledge elements that pre-service teachers focus upon when they collaboratively design and create their technology-based design products
- the design approaches adopted by pre-service teachers during their group design process
- the factors that affect their design experiences
- whether there are discernible relationships between technology-enhanced modules that pre-service teachers create and their focuses during design processes

- whether there are improvements in the pre-service teacher learning design practices and their TPACK competence as a result of the university course work
- whether teacher educators' pedagogical strategies have an impact on pre-service teachers' knowledge, learning design processes and artefacts.

In order to explore these areas and address the overarching research aims, this thesis has answered the following main research question:

> **How can the learning design capabilities of pre-service teachers be effectively developed?**

This has been investigated through four more specific questions:

1. What elements do pre-service teachers focus upon when collaboratively designing technology-enhanced lessons?
2. What factors support and/or hinder the collaborative design of pre-service teacher technology-enhanced lessons?
3. Are there any relationships between pre-service teacher learning design practice and the characteristics of their final online artefacts?
4. What are the impacts (if any) of the pedagogical strategies of teacher educators upon pre-service teachers'
    4.1. knowledge development,
    4.2. learning design processes, and
    4.3. learning design artefacts?

Research Question 1 investigated different focuses and knowledge elements in pre-service teacher design conversations. Since in the pilot study it was found that groups of pre-service teacher designers hardly discussed pedagogical perspectives and context in their in-class discussions and Messenger group chats, it was expected that they would articulate more of their understanding of pedagogy and context during their design processes thanks to different interventions implemented by teacher educators.

Similarly, these interventions were expected to minimise some hindrances to pre-service teacher collaborative learning design practices identified in **I1**. The problems included group dynamics, tutor support and technological capabilities, which were also found as enablers to the group design process. Results of supporting factors maximised and inhibiting factors reduced (or even eradicated) were expected once Research Question 2 was examined.

Research Question 3 related the results of Research Question 1 that investigated pre-service teachers' learning design processes to their learning design products. That is, the correlation between pre-service teachers' design focuses and the characteristics of their final online artefacts was explored. The expectation was that the more pre-service teachers focused upon discussing certain aspects, the higher scores they received for the respective aspects. It was anticipated the results would indicate whether teacher educators succeeded in changing the unit's pedagogical strategies.

Like Research Question 3, Research Question 4 traced the sign of improvements in the pre-service teachers learning design capabilities. The improvements should be reflected in the pre-service teachers' changes in their TPACK competencies, design focuses, and design products either across the cohort or over the iterations. In brief, all four specific questions contributed to unpacking how the learning design capabilities of pre-service teachers can be effectively developed.

1.4. Overview of Thesis

This thesis describes the development, analysis, and results of the research, and is set out as follows. In Chapter 2, literature relevant to technology-enhanced teaching and learning in relation to Learning Design and TPACK is described in order to situate this current research study within the field and draw upon appropriate frameworks for analysing the data. After identifying Engeström's adaptation of Activity Theory (1987) based upon a socio-constructivist view of learning as an appropriate framework to frame the analysis, a synthesis of literature relating to the use of TPACK in Learning Design is provided. From this, an analysis of the gaps in the literature is conducted in order to position the study and provide a rationale for research topics and methodology.

Chapter 3 outlines the research methodology adopted in this study. A justification for using a mixed methods approach is presented and the particular approaches adopted to analysing data are described. First, the design-based research methodology is discussed and justified in relation to the research aims. Approaches to (re)designing the learning environment in the three iterations (sessions) are explained, which can be summarised as follows:

- **Iteration 1** (Session 1 of 2016): The pilot study was conducted to identify practical problems related to the pre-service teacher learning design processes.
- **Iteration 2** (Session 1 of 2017): Interventions in terms of course designs and pedagogical strategies were applied to solve the problems discovered in Iteration 1.
- **Iteration 3** (Session 1 of 2018): Further interventions were implemented to find solutions to more problems discovered in Iteration 2.

Chapter 3 then presents a detailed description of and justifications for a thematic analysis approach to analysing qualitative data. A major part of the chapter is also devoted to explaining what the Linear Mixed Model is and how it was applied in this study to analyse TPACK pre- and post-course surveys.

Chapter 4 presents the results in the order of research questions. Findings from Iteration 2 and Iteration 3 were jointly reported due to the similarities between the data nature and what arose from the data.

Chapter 5 provides a detail discussion on the findings to the four research questions. Evidence-based implications and interpretations drawn from the major findings are highlighted and discussed in relation to each other or to the relevant literature.

Chapter 6 builds on the key findings from the study and summarises the implications and significance of this study for teacher education and learning design. The chapter also critically explores how the study informs possible future directions in policy, practice, and research. Concluding remarks about learning design research and pre-service teacher education are also provided.

Chapter 2. Literature Review

The chapter details theory and background research relevant to the current study. Initially, Activity Theory is presented and justified as a suitable theoretical framework for the investigation. Next, major relevant studies on Learning Design and Technological Pedagogical Content Knowledge (TPACK) are reviewed to provide elaborations on major concepts, insights and the relationship between them. The chapter concludes by summarising the gaps in research and discussing the applications of the literature review for the present study.

2.1. Activity Theory as the Theoretical Framework

2.1.1. Overview of Activity Theory

Activity Theory is a theoretical framework originating from the sociocultural tradition in Russian psychology, grounded in the work of the Russian psychologist Vygotsky (1978) and his students, particularly Leont've (1978). Vygotsky (1978) introduced the concept of mediation claiming that activities are mediated by culturally situated tools. Engeström (1987) proposed an updated version of Activity Theory based on both Vygostky and Leont'v's work, adding his perspective that an activity is not only mediated by human beings and related interactions, but also adjusted in response to the changes in the whole bounding context (Chung et al., 2019).

Activity Theory was developed to analyse human practices and allows for "the putting forward of necessary elements in understanding and forming complex learning environment" (Ozdamar-Keskin & Ozturk, 2015, p. 46). Important to the framework is the concept of *activity*, which is depicted as "a holistic, high-level, usually collaborative, construct" (Hasan & Kazlauskas, 2014, p. 10). The sorts of collaboration being considered are those that are interconnected, stable, long-term, natural, and with definable objectives (Ozdamar-Keskin & Ozturk, 2015).

The original model of Activity Theory was composed of the *subject* (the person(s) undertaking the activity), the *tools* used (internal and external resources) and the *object* (the thing being done) of the activity (Vygotsky, 1978). Engeström (1987) popularised Vygostky's model adding the components of *rules*, *division of labour* and *community* in order to present the concept of a '*collective activity system*' and to facilitate his work on the collaboration of people in groups, as depicted in Figure 2.1.

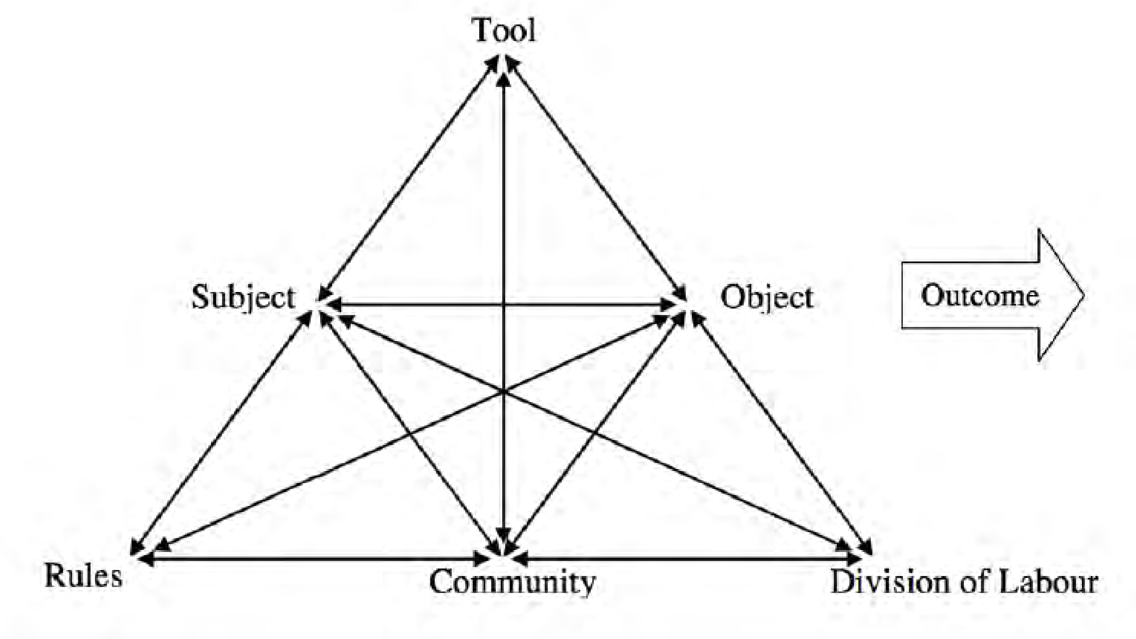

Figure 2.1: Engeström (1987) collective activity system

The diagram suggests that different agents, or constituents, in the activity system have distinctive roles and interact with each other within a context or a community governed by rules mediated by tools in order to build an object and gain an outcome. Now that the basic components of Activity Theory have been briefly explained, the reasons for using it in learning design studies in general and in this study in particular will be unpacked in the next section.

2.1.2. Why Activity Theory?

Conole (2015) explains that Learning Design is mainly socio-culturally situated drawing on work by Vygotsky (1978) and others. Among the sociocultural perspectives, Activity Theory serves to contextualises the learning design process (Conole, 2015). Design processes viewed from an Activity Theory perspective are those that occur within a community and a context, are controlled by rules, and involve individuals working together to achieve a common goal. Thus, Activity Theory is highly relevant for making sense of collaborative learning design processes in general, as well as those carried out by the pre-service teachers in the current study.

Activity Theory has been listed among popular theories borrowed and used in the field of Learning Design (Bower, 2019; Conole, 2015; Conole et al., 2004). In fact, it has been the base for numerous studies on learning design in order to help teachers create pedagogically sound and technically executable teaching plans (Miao et al., 2009); to complement the contributions and limitations of various concepts of teacher community (Levine, 2010); to investigate the insights and trends of mobile learning (Chung et al., 2019); to analyse needs, tasks, and outcomes for designing constructivist learning environments (Jonassen & Rohrer-Murphy, 1999); to analyse the interactions between collaborative-, content-, and technology-related discourses (Bower & Hedberg, 2010); and to design a mobile computer-supported collaborative learning system (Zurita & Nussbaum, 2007), to name just a few.

Activity Theory provides an effective theoretical framework for understanding and describing the learning design experience for pre-service teachers when they collaboratively design technology-enhanced lessons for their potential learners for the following reasons. *First,* it adopts a holistic approach to explaining activity and has the capacity to be integrated with other contemporary learning theories (Bower, 2008), which is an advantage in investigating pre-service teacher learning design practices. *Second,* it provides a lens for analysing learning design processes and outcomes that "capture more of the complexity and integration with the context and community that surround and support it" (Liaw, Hatala, & Huang, 2010, p. 453). *Third*, taking Activity Theory as the theoretical framework provides important insights into the ICT integration process among participants (Lim & Hang, 2003). More specifically, as conceived by Engeström (1987) and as shown in Figure 2.1, the framework highlights mutual relationships between different constituents of purposeful behaviour. For example, it can help to emphasise that the relationship between subject and object is mediated by tools.

The *fourth* reason is Activity Theory provides a language for describing and understanding the changes, difficulties and some of the iterations of the development not just of the pre-service teacher learning design capabilities alone but also of the surrounding practices of teachers on the course (Isssroff & Scanlon, 2002). The *fifth* reason is that an activity is best understood and analysed in the context of its cultural and historical environment where it occurs, which is highlighted by Activity Theory (Jonassen & Rohrer-Murphy, 1999; Kaptelinin & Nardi, 1997).

The sixth reason is viewing an activity through the Activity Theory lens enables researchers to make sense of who is doing what for what incentive (Vygotsky, 1978), especially in team work. Since Activity Theory "provides a rich holistic understanding of how people collaborate" (Hasan & Kazlauskas, 2014, p. 12), this study used Activity Theory to conceptualise the elements of how pre-service teacher teams collaborate and design. Activity Theory can help to describe and explain any changes to pre-service teacher learning design capabilities that may partly be due to the way participants collaborate. This is because each individual is a constituent and indispensable part of the collective community whose actions can contribute to changing it (Roth, 2004).

In summary, Activity Theory is arguably relevant to make sense of phenomena in this current study because the theory attaches importance not only to collaborative design, but also to the design process as a whole with different factors other than "small groups" involved and interacting. The interpretation of each component in use when activity occurs is explained in more detailed in the next section.

2.1.3. How different concepts in the Activity Theory have been operationalised in learning design studies

In addition to *Activity*, which is "what people do" (Engeström, 1987), there are seven entities, or concepts, engaged in the process of doing: Subject, Object, Tools, Rules, Community, Division of labour, and Outcomes. Some of these concepts, surprisingly, are interpreted differently in different Learning Design studies, as outlined below.

The *subject* of any activity simply refers to an individual or individuals engaged in the activity (Bower & Hedberg, 2010). The subject directly carries out the activity. In a learning design setting, subject may be a single designer or a group of teachers/students designing for learning.

An *object* is directly acted on by the subject. This concept, along with *outcome*, seems to be the most confusingly interpreted by learning design researchers. Some scholars understand object as a tangible product like an artefact (Miao et al., 2009) or as an intellectual output like a curriculum-based task (Bower & Hedberg, 2010) or a collection of teaching materials (Miao et al., 2009). Some understand object as objectives or goals of the activity (Chung et al., 2019; Zurita & Nussbaum, 2007). In the latter case, *object* seemed to be used interchangeably with *outcome* which is a desired ultimate goal achieved by the engagement of the whole "activity system". In fact, in order to avoid this confusion, some researchers combine object and outcome in one category (Miao et al., 2009), ignore clarifying whether it is the object or outcome discussed in their examples (Conole, 2015), or choose to remove outcome out of the whole system and name object as objective instead (Chung et al., 2019).

In the current study, *object* and *outcome* are considered different in order to understand the learning design process holistically. An object is a complete technology-based module together with its supplementary resources. It is constructed by subjects with an intention in mind. On the other hand, the outcomes are the underlying intentions of the activity, such as an effective learning experience for students, a better learning environment for students, or an improvement in learning design capabilities for pre-service teachers. Whereas both are supposed to be achievable, the object is more concrete and specific, while the outcomes are more general and overarching.

Tools can be any resources, artefacts, technologies, devices, etc. that mediate the activity process. Tools are external, visible and concrete, for example a technological tool can be an ICT service (Miao et al., 2009) or a computer-based application like a web-conferencing system (Bower & Hedberg, 2010). In contrast, tools can also be internal, invisible and cognitive like knowledge, skills, and reflection (Chung et al., 2019). In short, answers to the question, 'By what means are the subjects performing this activity?', assist to clarify the definition of tools (Zurita & Nussbaum, 2007).

Rules are any controlling factors intentionally influencing the performance of the activity, restricting the activity to a set of disciplines or strategies (such as how many people in each team), and with the purpose of supporting rather than hindering processes. Examples of rules are institutional constraints and professional requirements or conditions (Conole, 2015; Miao et al., 2009), individual or group norms, responsibilities, and disciplines (Chung et al., 2019; Zurita & Nussbaum, 2007), and the whole system's customs (Bower & Hedberg, 2010).

Community, where the activity is conducted, ranges from the whole society with its distinctive historical and sociocultural context, to a line of research inquiry or a specific discipline (Chung et al., 2019; Levine, 2010), and a learning environment (Bower & Hedberg, 2010; Jonassen & Rohrer-Murphy, 1999). Community also includes a collection of the interdependent groups that share a set of social meanings or common general objectives (Ozdamar-Keskin & Ozturk, 2015).

Divisions of labour is a straightforward concept, denoting the task allocation among actors carrying out the activity. This task delegation is an important part of a collaborative activity because it can influence the efficiency and effectiveness of collaboration.

This brief review on how different concepts in the Activity Theory have been operationalised in Learning Design research has informed how they are conceptualised in this study. More information on how the components of Activity Theory are operationalised in this study will be provided in the following section.

2.1.4. How Activity Theory is operationalised in this study

Informed by the preceding sections on Activity Theory, this section will detail how Activity Theory is used in the current study. In this study, the *Activity* is designing a technology-enhanced learning module. Further details about the learning module are provided in the Methodology. Other constituents are operationalised as follows.

The *Subjects* are education students (pre-service teachers) engaging in a learning design process. These students interact with each other in groups to create an *object*, a final learning design product, which is a shared Moodle-based technology-enhanced module along with individually written rationales for it. These students' collaborative design process (performance of the activity) is mediated and supported by *tools* which are technological tools (e.g. Moodle, web tools 2.0, apps, etc.), conceptual tools (e.g. a learning design guide), skills, and other resources provided by teacher educators as well as the knowledge employed by students themselves. This learning design process is also controlled and supported by *rules* including pedagogical strategies (interventions) applied by teacher educators. The learning design process occurs collaboratively within a *community* which is situated either in the physical classroom or online chat space, which also involves a group of interdependent people sharing the same ultimate goal that is to create effective learning experiences for school children. These people include peers within a group, peers as a whole class and teachers/tutors who support the pre-service teacher design process in class. *Division of labour* refers to the task distribution among the group members. This process and all the interactions above are expected to lead to an *outcome*, which is the improvement in pre-service teachers' learning design capabilities. The whole above activity of designing is presented in Figure 2.2 and briefly summarised in Table 2.1 below.

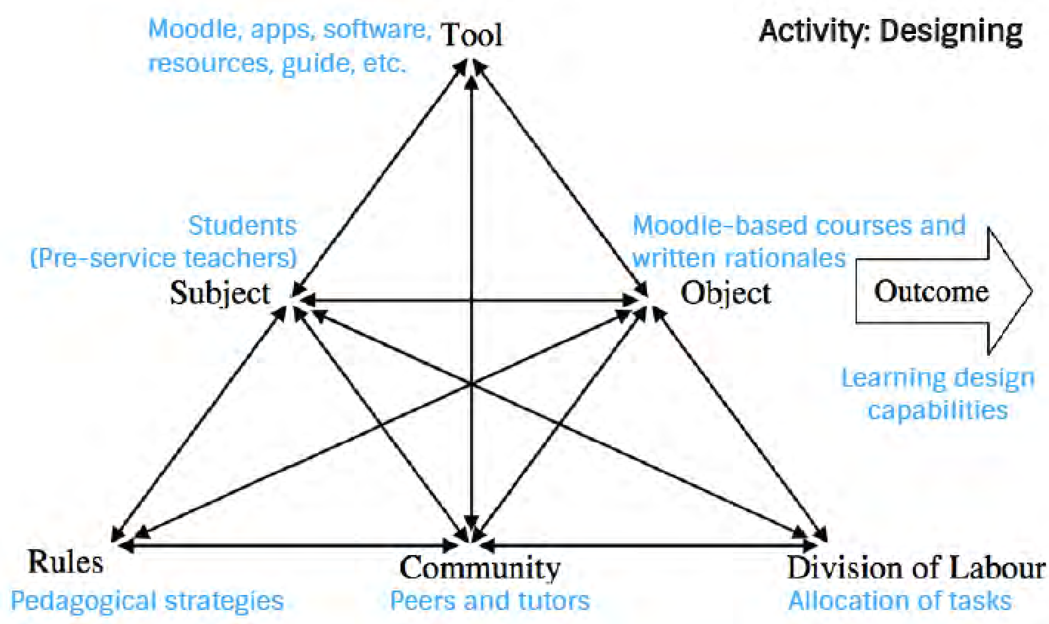

Figure 2.2: Different constituents of Activity Theory in the current study

Table 2.1: Activity Theory constituents operationalised in this study

Activity: Designing a technology-enhanced module			
	Activity Theory Components	**Applicability in study context**	**Explanation/Examples**
1	Subjects	Students	Pre-service teachers
2	Object	Learning design products	Moodle-based courses designed by students and their written rationales for Moodle designs
3	Tools	Technological tools; Conceptual tools; Skills and other resources	Moodle, web tools 2.0, apps, etc. Learning Design Guide; Readings, lectures
4	Rules	Pedagogical strategies applied by teacher educators	Interventions such as more concentrated reading for students, activities to ensure more articulation of student design thinking
5	Community	Interdependent people engaging in the activity	Peers within group, peers as a whole class, and tutor
6	Division of labour	Allocation of tasks among community members	Tasks allocated to peers and to tutor
7	Outcome	Improvement in pre-service teacher learning design capabilities	Reflected through the whole learning design process and final products

In conclusion, this current study adopts the Activity Theory perspective with the aim of developing pre-service teachers' technology-enhanced learning design capabilities through a collaborative learning design process supported with tools and influenced by rules. Engeström's (1987) model of Activity Theory emphasis on social environment and interrelations between entities is especially useful to the researcher's analysis of the pre-service teachers' collaborative design of their technology-based modules as it allows the researcher to think through different ways in which their learning design is actively created as a shared product. To this end, the Activity Theory's conceptualisation of the processes by which knowledge is constructed via collaboration is of value for informing us how to understand the roles of community (peers, teachers), tools (technologies, unit's resources, pre-service teacher knowledge), and rules (including teacher educator interventions) throughout the learning design process. Activity Theory also serves to help understand the relationship between different components of the activity system, for example, between the design process and the final product.

How Activity Theory is used as a lens for interrogating different research questions will be explained at the end of the literature review.

2.2. Supporting Learning Design Practices

2.2.1. Overview of Learning Design

According to Agostinho et al. (2013), Learning Design originates from two lines of inquiry: (1) how to represent learning experiences constructed and delivered online from a technical perspective and (2) how to represent learning experiences in a way that teachers can think about their design process and share new ideas about e-learning pedagogy. The underlying assumption of learning design is the conception that if 'good' learning and teaching practice can be standardised and systematically represented, then 'good' practice could be reused and further perfected, ultimately leading to an improvement in the quality of teaching and learning (Oliver, 2001; Price & Kirkwood, 2014). If the Learning Design field achieves its goal of determining, describing and sharing 'good' patterns of learning design process and products, this can also serve to increase the learning design capabilities of teachers within the profession (Dalziel et al., 2015).

Fundamental to the Learning Design research field is the concept of teacher as a designer of technology-enhanced learning (Laurillard, 2013), where teachers are expected to consider such factors as learning outcomes, learner-related issues, context, and provided resources as well as the interaction between them (Persico et al., 2018). This is in line with Bower (2017), who characterises learning for design as understanding and catering to learners, basing it on intended learning objectives, attending to the alignment within designs, and promoting accessibility, social and physical. Likewise, Laurillard (2013) emphasises the importance of aligning learning outcomes to learning tasks and pedagogy.

The field of Learning Design aims to make the design of teaching and learning more pedagogically informed and thus promotes better quality designs (Persico & Pozzi, 2015). In addition to recommending tools and strategies to support learning design (Bennett et al., 2015; Bower, 2012; Laurillard, 2013), other important goals of Learning Design include providing standards and specifications of technology (Berlanga et al., 2012). The learning design approach encourages a "participatory culture of design" (Persico & Pozzi, 2015, p. 233) with the support of tools and technologies to encourage a more effective learning design process. More about how learning design research has supported teacher learning design practices is explained in the following sub-sections.

2.2.2. Definitions of learning design

Since its early development, Learning Design has suffered from challenges in its categorisation and definition. Dobozy (2013) reviewed the empirical research carried out by multidisciplinary and international academics from Learning Activity Management System (LAMS) and Learning Design Conference Proceedings over six years. The review revealed that numerous authors did not define the term 'learning design' clearly and explicitly and concluded that there was a crucial struggle to define the term, "illustrating powerfully the immaturity of the field" (Dobozy, 2013, p. 70).

In response to the need for a definition of learning design, Dalziel et al. (2015) devoted a major part of their paper entitled 'The Larnaca Declaration on Learning Design" to clarifying the learning design definition problems. These scholars suggested capitalising the term (Learning Design) when referring to it as the field of study as a whole with the aim to create good learning environments for students, as explained in the first paragraph of this section. In this sense, Learning Design's ultimate goals sound very much similar to the goals implied in Dalziel's (2015) reference to learning design as a 'framework' to discover what underlies an online 'sequence of educational activities' conceptually and practically in order to provide a guide to constructing a better sequence; and to Conole's study (2013) description of learning design as:

> a methodology for enabling teachers/designers to make more informed decisions on how they go about designing learning activities and interventions, which is pedagogically informed and makes effective use of appropriate resources and technologies. This includes the design of resources and individual learning activities right up to curriculum-level design. A key principle is to help make the design process more explicit and shareable. (p. 312)

Be it a framework or methodology, Learning Design encompasses "research and development dedicated to the quest of equipping teachers with tools and strategies to aid their design of high-quality learning environments" (Agostinho et al., 2013, p. 97).

Dalziel et al. (2015) also identified that numerous educators tend to use 'learning design' as 'designing for learning'. In this sense of 'design for learning', learning design is an act or a practice, 'a verb' which should be used as an uncountable noun in a non-capitalised format. Dalziel and colleagues (2015) also proposed using the term as a countable noun, 'a learning design' or 'a design' for future use. They referred to it as 'a sequence' or 'an instance' of what is designed.

To that end, learning design has actually been viewed as a process, a verb, as well as a product, a noun (Conole & Wills, 2013). As a process, it can be defined as "an application of a pedagogical model for a specific learning objective, target group and a specific context or knowledge domain" (Conole & Fill, 2005, p. 5). Alternatively, learning design can be described as "the process of planning, structuring and sequencing learning activities" (Cross & Conole, 2009, p. 1). As a product, it is a plan or a design "created either during the design phase or later" (Cross & Conole, 2009, p. 1), represented in some form of documentation which guides development, implementation and evaluation of the learning experience. The term 'pedagogical plans' was also used by several researchers (for example, Persico & Pozzi, 2015) to refer to the products of the learning design activity in order to avoid the frequent ambiguity between learning design to mean the activity of designing and learning design to mean the product of the same activity.

Advised by the above definitions from various studies, this thesis continues the convention of using capitalised Learning Design to refer to a field of study. Learning design in this study is a process of planning and structuring technology-enhanced learning activities informed by an understanding of pedagogy, technology potential, content, and other contextual factors. A learning design is a product, which can be either a plan or an artefact or both, created from such a process. In this study, learning design and a learning design is also referred to as design and a design respectively.

2.2.3. Is learning design a smooth process?

Learning design is a complex process with myriad factors identified as either supporting or inhibiting, from which solutions to the problems can be recommended to make it a smoother process, hence facilitating the development of teacher learning design capabilities. With respect to hindrances, the first and most cited reason is the inadequate access to technologies and facilities such as hardware, software, Internet, and tools (Ertmer, 1999; Ertmer et al., 2012; Kopcha, 2012). This inadequacy does not seem the case anymore with the increasing availability of technologies. However, there has arisen another concern among pre-service teachers caused by the overwhelming number of tools, which have demotivated pre-service teachers, especially those lacking technology skills, to improve their technological capabilities or to apply technology to creating teaching materials (Nguyen & Bower, 2018; Teo, 2009). Seminal work by Ertmer et al (2012) also identified teacher beliefs as a possible hinderance to learning design practices. The lack of administrative, professional, tutor, and peer support can be another inhibiting factor (Ertmer et al., 2012; Nguyen & Bower, 2018). Upon synthesising previous studies, Kopcha (2012) observed that a teacher development program could be a barrier when it was executed in isolation from authentic classroom practice or when it solely trained participants how to use technology. In sum, barriers to learning design practices can relate to objects (technologies), human beings (tutors and peers), policies (administration and professional development), and/or training programs. These issues raise the question of what should be done to minimise these problems.

Furthermore, some facilitating factors can also become hindrances to pre-service teachers' learning design, if poorly implemented. For instance, while access to a variety of technology and resources was viewed by pre-service teachers as advantageous to learning design practices, the issue of technological complexity was identified as among the difficulties that confused pre-service teachers, especially those inexperienced technology users, from applying technology to developing curricula and lesson plans (Teo, 2009). Likewise, Nguyen and Bower (2018) also found technological capabilities, tutor support, and group dynamics as both enabling and obstructive factors, depending on their instantiation.

Therefore, there is a need to further investigate whether there are hidden hindrances behind enablers, particularly in collaborative design processes where, according to Boschman, McKenney, and Voogt (2015), teachers are found to express their practical concerns pertaining to technological barriers or other constraints. It is also useful to examine hindrances in a longitudinal study, where problems can be identified and iteratively addressed with the intention of ultimately improving learning design capabilities. More about research on supporting learning design practices will be presented in the next section.

2.2.4. Strategies and tools for supporting learning design practices

Several previous studies have proposed strategies and tools to support teachers' learning design practices. In terms of strategies, Svihla et al. (2015) developed a *fingerprint pattern* that conceptualises ways for teachers to develop their identities as designers. The recommended supporting patterns include modelling practice, supporting dialogue, scaffolding design process, design for real-world use, deep understanding of pedagogy, and professional identity.

McKenney et al. (2015) proposed an ecological framework that considers different interactions of elements important to design and emphasises different aspects of knowledge bases that teachers need to tap into while designing. These aspects include know-what, know-why, know-how, know-when, know-who, and know-where. The framework also attaches importance to scholarship that McKenney and her colleagues believed would help teachers tackle challenges during design and facilitate their design considerations.

With respects to designing for whom (target audiences) and in what situations (context), McKenney et al.'s viewpoint (2015) is similar to that of Bennett and her research team (2011), which is to understand deeply the context or students and teachers' needs before recommending learning design tools. This thorough consideration of context is labelled as a conceptual tool that helps activate design thinking processes teachers are familiar with by Dagnino et al. (2018). Dagnino et al. (2018), in a systematic review of literature about teachers' needs in connection with learning design tools, offered a list of support tools including: support for reuse and adaptation of designs, support for co-operation amongst teachers, support for reflection, ease of use, time saving, textual vs graphical representation in addition to the conceptual tool above.

Part of Dagnino et al.'s aforementioned list (2018) is composed of some conceptual tools (e.g. support for co-operation amongst teachers and support for reflection, teacher educators) that are in line with strategies provided by many teacher educators for teacher education courses. These strategies consist of aligning theory and practice, expert modelling, reflection tasks, learning technology by design, collaborative design, scaffolding authentic technology experiences, providing continuous feedback, access to resources and technology, and providing comprehension metacognitive prompts (Chai et al., 2019; Kramarski & Michalsky, 2010b; Mouza et al., 2014; Polly et al., 2010; Tondeur et al., 2012).

Before Dagnino et al. (2018), many teacher educators made empirical efforts in recommending what tools were suitable and necessary for teachers to create their technology-enhanced resources. Examples of the tools under investigation were Web 2.0 tools (Bower, 2012), Moodle (Berggren et al., 2005; Bower & Wittmann, 2011), Learning Designer (Bower et al., 2011), and other tools (Katsamani et al., 2012). However, there was a lack of studies on the influence of tools in the effectiveness of a teacher development program. To fill in the gap, Asensio-Pérez et al. (2017) conducted a mixed study exploring what characterised the interactions between Learning Designer tooling and the Teacher Professional Development approach. Results showed Learning Designer tooling had capacities of facilitating a complete design process and was greatly appreciated by participating teachers and students.

As well, in the line of learning design supporting inquiry, there has been a shift to research that has sought to improve teachers' abilities to combine technology, pedagogy, and content in designing their technology-based lessons, with this improvement regarded as a positive change in learning design competencies (e.g. Papanikolaou et al., 2017). Earlier research found that a training program implemented without a specific context to consider and with a focus on how to use the tools only was among the hindrances to a smooth learning design process (Kopcha, 2012). These findings entail an inquiry that teacher educators consider facilitating pre-service teachers' development of technical skills, subject matter knowledge, and pedagogical practices, as well as how these three concepts were intertwined with one another in order to prepare pre-service teachers to design effectively for learning and teaching (Koehler & Mishra, 2009).

This integrative knowledge was referred to and introduced by Koehler and Mishra (2009) as Technological Pedagogical Content Knowledge (TPACK), which has been the core foundation of numerous pre-service and in-service teacher education programs (Alemdag et al., 2019; e.g. Graham et al., 2012; Janssen & Lazonder, 2016; Koh et al., 2013, 2017; Koh & Chai, 2016; Mouza et al., 2014; Tondeur et al., 2020; Tseng et al., 2019; Zhang et al., 2019). When the TPACK framework is introduced to teacher training workshops, it arguably helps teacher educators avoid teaching trainees how to use technologies without relating to content and pedagogy, assisting them to make informed decisions regarding how to teach what content with what technologies to a specific group of learners. Thus, TPACK may be a strong enabler to effective technology integration. In other words, teachers' TPACK competencies would appear to be strongly related to teachers' learning design capabilities.

More about the connection between Learning Design and TPACK in relation to supporting teacher design capacity will be detailed in the next section.

2.3. Learning Design and TPACK

Teacher knowledge has been conceptualised in many ways. With regards to the origin of knowledge (where it is from), teacher knowledge is categorised as knowledge *for* practice and knowledge *in* practice in many studies on teachers' knowledge and their practice (Cochran-Smith & Lytle, 1999; Fenstermacher, 1994; Loughran, 2019). The former is referred to as the type of knowledge primarily known and produced by researchers while the latter principally known and produced by teachers. Fenstermacher (1994) also referred to knowledge *for* practice as teacher formal knowledge and knowledge *in* practice as teacher practical knowledge. He defined this practical knowledge as the knowledge teachers themselves generated as a result of their experience as teachers and their reflections on these experiences. In essence, both major types are classified based on the question, "Who possesses and produces teacher knowledge: the teacher or the researcher?"

If knowledge is to be analysed by researchers but also based upon and relevant to the practice of teachers, it needs to encompass knowledge *for* practice as well as knowledge *in* practice. Only in this way, will the research authentically encapsulate the reality of what occurs in classrooms, and the findings be usefully applicable to teachers. Fortunately the field of technology-enhanced learning design has a well-established framework of conceptualising teacher knowledge that is based upon teacher practice and validated by the research field, known as the TPACK framework.

2.3.1. Technological Pedagogical Content Knowledge (TPACK) Framework

Extended from the pedagogical content knowledge framework established by Shulman (1986) and theorised by Mishra and Koehler (2006), TPACK stands for Technological Pedagogical and Content Knowledge and includes seven components: Technology Knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK) and Technological Pedagogical Content Knowledge (TPACK) (see Figure 2.3 for the TPACK framework's knowledge components).

TPACK is described as "the type of integrative and transformative knowledge teachers need for effective use of ICT in classroom" (Chai et al., 2013, p. 31) and, therefore, has been the foundation for the design of pre-service and in-service teacher education programs (Boschman, McKenney, & Voogt, 2015; Koh, Woo, & Lim, 2013; Pamuk, 2012).

At the core of the framework is the concept of TPACK where there is a complex interplay of the three primary elements of knowledge: TK, CK and PK. Effective integration of technology in teaching goes beyond considering each element individually (Koehler & Mishra, 2009). Effective technology-enhanced teaching and learning require comprehensive understanding of what teaching strategies to use with what content and what technologies in certain contexts (Koehler & Mishra, 2009).

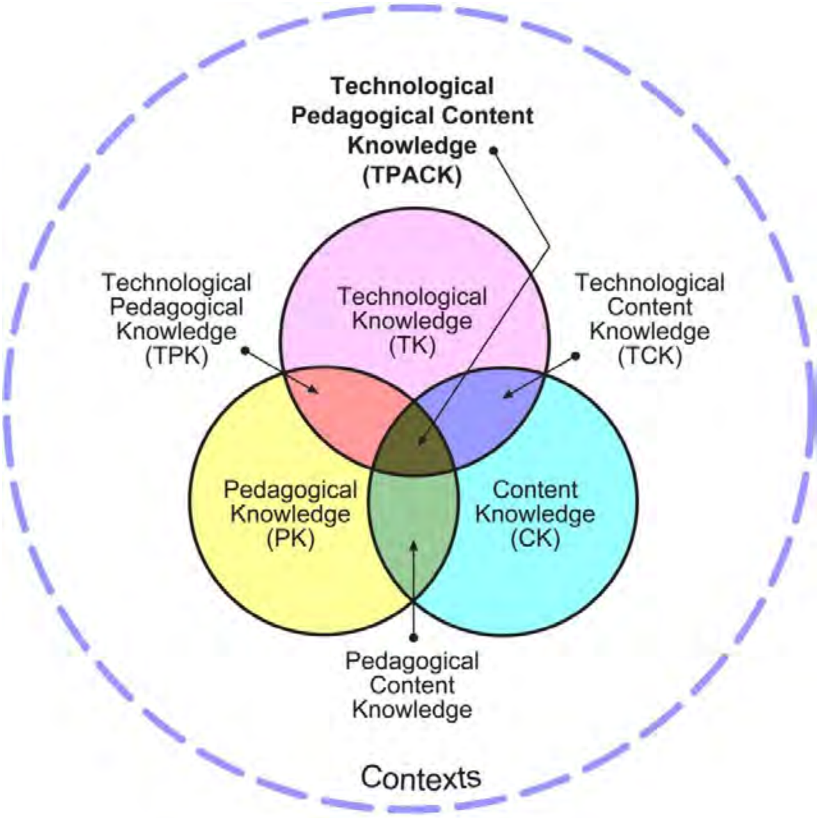

Figure 2.3: The TPACK framework and its knowledge components (source: http://www.tpack.org/)

Apparently, the type of knowledge teachers possess as viewed through the lens of the TPACK model is not characterised by the question of where knowledge is from. Its nature is more like based on the question of knowledge in what area teachers should employ in order to have successful technology integration: content, technology, pedagogy or the interplay between these areas. In other words, the framework stresses importance on teachers' full understanding of the subject matter, technology, and pedagogy as well as how these areas are intertwined in order to design sound pedagogically informed technology-enhanced lessons irrespective of where their understanding is from and formed.

2.3.2. TPACK in pre-service teacher education programs

The TPACK framework has been used for numerous studies on teacher ICT integration, particularly pre-service teacher ICT integration. *First*, the framework has been used to provide an analytical lens to understand pre-service teacher technology integration decisions. Graham et al. (2012) used TPACK to create pre- and post-course assessments for 133 teacher candidates in an educational technology course. In both assessments, these teacher candidates were required to provide rationales for their selection of certain digital technology for the instructional design assigned to them to teach a particular future core curriculum using technology. The findings indicated that there was an increase in the teacher candidates' rationales that were oriented to content-specific knowledge and general pedagogical knowledge.

Second, the TPACK framework has been utilised as an instrument to explore pre-service teacher ICT course experiences to ultimately evaluate the course and inform teacher educators about the design of digital technologies courses. For instance, Koh et al.'s (2013) study on a cohort of 869 Singaporean pre-service teachers revealed that the practical examples and hands-on ICT integration assignments were most influential to teacher candidates' construction of TPACK. The significance of these and similar assignments appears to imply that their knowledge develops best via design practices. Because the study investigated the pre-service teachers' perceived TPACK, it is important to examine whether the real hands-on practice with developing ICT-based lessons can improve pre-service teacher TPACK competencies.

Third, the principles of TPACK have been used as an evaluative framework to examine pre-service achievement barriers to technology integration (Pamuk, 2012). Pamuk (2012) found that inexperience in pedagogical strategies hindered pre-service teachers from taking appropriate approaches to integrating technology when constructing ICT-based lessons. And therefore, he suggested that improving pre-service teacher content knowledge and pedagogical capabilities should be made a priority before enhancing their technological competency and should be supported with actual teaching experience.

Fourth, TPACK has been used as a measurement of teachers' technology integration and learning design capacities. Teacher educators often witness an improvement in pre-service teachers' learning design competencies after certain pedagogical strategies have been applied. For instance, Mouza et al. (2014) found that TPACK capacity was able to be improved across all areas when an approach to integrating instructional design opportunities, authentic in-field experiences, explicit reflection tasks, a theory into practice focus, and the use of role models was adopted. Also, TPACK-based rubrics and instruments were helpful to support trainees and practising teachers' evolving technology-enhanced learning design practices (Bower, 2012; Chai et al., 2019; Koh et al., 2017). Furthermore, an experimental design study on 54 pre-service biology teachers found that those who received integrated support attended more to the integration of pedagogy with content in their justifications for their technology-based lesson plans than those who received separate support (Janssen & Lazonder, 2016).

In preparing pre-service teachers with TPACK, Tondeur et al. (2020) conducted a survey on 688 pre-service teachers using a reliable instrument developed by Tondeur et al. (2016) based on six key strategies identified by Tondeur and his co-researchers (2012). These six strategies included 1) using teacher educators as role models, 2) reflecting on the role of technology in education, 3) learning how to use technology by design, 4) collaboration with peers, 5) scaffolding authentic technology experiences, and 6) providing continuous feedback. Tondeur and his colleagues (2020) found that there were positive and significant correlations between these six strategies and pre-service teachers' TPACK, indicating the critical role of teacher education programs as well as teacher educators' strategies.

2.3.3. TPACK and collaborative learning design

Several studies have examined how collaborative design tasks can be used to develop technology-enhanced learning design capabilities (e.g. Boschman et al., 2015; Kali, McKenney, & Sagy, 2015; Papanikolaou, Makri, & Roussos, 2017). Voogt et al. (2011) define collaborative design as when "teachers create new or adapt existing curricular materials in teams to comply with the intention of the curriculum designers and with the realities of their context" (p. 260). A collaborative design approach can be advantageous because it enables educators to exchange relevant knowledge and perspectives over an extended time period in a certain context, either applied or authentic (Voogt et al., 2011). Formal learning that involves collaborative design opportunities for teachers can help clarify the rationale for technology-enhanced learning, increase awareness of the potential of e-learning technologies, promote competence in technology-enhanced learning design, enable learning through collaboration, and in some cases, improve confidence (Nihuka & Voogt, 2012). Importantly, when collaboratively designing, teachers are provided with agency, which promotes in-depth engagement with concepts they are learning (Voogt et al., 2011; Voogt et al., 2015). This type of design matches real-world practice since in New South Wales (NSW), the NSW Education Standards Authority (NESA) encourages collaborative planning as the best approach to developing units of work, assessment tasks, and resources, especially for a mixed-ability class (NESA, 2019).

As mentioned at the start of Section 2.3.2, TPACK has been used as one lens to conceptualise and analyse the development of technology-enhanced learning design capabilities. Since the framework's inception, Mishra and Koehler (2006) have proposed that teachers' knowledge of technology, pedagogy, and content, and the interplay between these elements underlies what teachers need to know about technology-enhanced learning design. This proposal has led to some researchers using the TPACK model to examine collaborative technology-enhanced learning design (Boschman et al., 2015; Koh & Chai, 2016; Papanikolaou et al., 2017; Zhang, Liu, & Cai, 2019).

Papanikolaou et al. (2017) adopted a collaborative design approach to enhancing pre-service teachers' learning design capabilities (TPACK competencies) via two cycles. TPACK was measured through Schmidt et al.'s (2009) survey instrument and an improvement in all TPACK elements was observed over cycles. A very detailed description of pre-service teachers was provided including numerous times when they discussed their shared artefacts in groups either in class or online (via forum posts). However, the study did not explore the actual design thinking that transpired in order to produce those design products, nor did it investigate the relationship between TPACK and the groups' final products. Papanikolaou et al. (2017) acknowledged that challenges for other researchers were to correlate pre-service teachers' TPACK with the groups' final products for more objectivity and to examine the distributions of pre-service teachers' TPACK via their group discussions.

To some extent addressing those gaps, Boschman et al. (2015), Koh and Chai (2016), and Zhang et al. (2019) examined the nature of collaborative design conversations using the TPACK framework to find out factors influencing teachers' design decisions. Interestingly, all the three teams of researchers found that experienced teachers predominantly discussed issues related to PCK and TPACK in their design talks. More interestingly, other non-TPACK matters were also discovered such as design-related issues (Koh & Chai, 2016) that the scholars labelled as Design Knowledge (DK). This discovery opens up a hypothesis that TPACK elements are not the only matters discussed in a design for learning talk as well as a potential for more factors to be discovered.

This accords with previously raised concerns about whether exclusively using the TPACK model as a means of analysing technology-design captures all aspects of design performance (Bower, 2017). In light of the identified potential of the TPACK model for analysing technology-enhanced learning design talks, but also the possibility that other aspects of learning may be important, other research literature relating to examination of technology-enhanced learning design process was also reviewed below to determine *a priori* learning design focuses and influences, as further presented in Section 2.4 below.

2.4. Design Focuses and their Influences

Teacher decision making has been an important topic in the research area of teachers as designers of their technology-enhanced lessons. From an understanding of teacher learning design decision making, more has been revealed about what they took into account and based their decisions upon during their learning design processes (Bennett et al., 2016a, 2016b; Nguyen & Bower, 2018). As well, different aspects of teacher knowledge have been discovered and refined, leading to better design processes and products (Tondeur et al., 2020).

In the pilot study exploring elements that pre-service teachers focused upon while discussing their technology-enhanced modules in groups, five *a priori* areas identified from the limited studies within the literature were found to influence teacher learning design decisions, namely content, pedagogy, technology, learner characteristics, and context (Nguyen, 2016). In the same study, there was empirical evidence that in addition to the above five areas, pre-service teachers also discussed issues with regards to scheduling, allocating tasks, structuring a lesson, and establishing a common ground awareness. These were categorised as “Other”. A more updated review of the relevant literature reveals that there are more than these six areas that teachers focused upon during their design process, especially in the studies on how different TPACK elements were reflected in design conversations. The sub-sections below briefly explain the areas that teachers have focused upon in design conversations and provide examples of relevant findings from the research literature. The associated findings from the pilot study are also explained (Nguyen, 2016), as background to the current study.

2.4.1. Knowledge elements and design focuses

2.4.1.1. Technology

One factor that may inform teachers’ decisions for technology integration is their understanding of, and ability with, technology. Churchill (2006) found that some teachers were aware of the limitations and advantages of technology for learning and thus designed their lessons in a way that technology can be best utilised. One of the participants saw “the benefits of technology as being the delivery of multimedia-based content, which enabled students to move through the content at their own pace” (Churchill, 2006, p. 569). This study also found that in the process of lesson designing and re-designing, teachers reflected on their experiences of using technology in the classroom and their understanding of the way in which online learning differed from face-to-face learning that does not utilise digital technology.

Approximately 10% of future teachers in a study conducted by Graham et al. (2012) identified technological ability as an influential factor in their design decisions when asked to provide rationales for the technology they would select for their future designs. However, the findings also revealed that many pre-service teachers placed more value on the technical aspects of the tools themselves than the capacity of the technology to facilitate classroom learning (Graham et al., 2012) .

Regardless of the important role of technology in ICT integration and designing technology-enhanced learning, technology has not featured as a focus area in teachers’ design group discussions. Kindergarten teachers in Boschman et al.’s study (2015) hardly discussed technology in their design talks (7 out of 65 counts of the units coded). In line with this finding, discussions related to technology accounted for only 3.25% of the units coded in the primary teachers' design talks in Koh and Chai's study (2016). Zhang et al. (2019) also found that technological knowledge owned by primary teacher participants had the lowest distribution frequency (2.3% of the units coded) on forum posts.

This low attention to technology was also observed among pre-service teachers. Janssen and Lazonder (2016) found few technology-related units coded in 54 pre-service teachers' justifications for their lesson plans. Similarly, discussions related to technology constituted only 7 out of 59 counts of the discourse episodes coded in Tseng et al.'s study (2019).

On the other hand, technology was among the main focuses of design conversations among pre-service teachers in the pilot study (Nguyen & Bower, 2018). However, Nguyen and Bower (2018) raised a concern that introduction to excessive technology and too much time spent on technological aspects of their designs may have distracted the participants from explicitly considering other elements such as pedagogy; hence the current study to examine the way teacher educators' pedagogical strategies influenced pre-service teachers' changes in different TPACK elements including technology. Other scholars have also attempted to improve pre-service teachers' technological capacities and recognised significant changes in their technological knowledge over time (Papanikolaou et al., 2017; Valtonen et al., 2019). In the former study, TK had the biggest change of all TPACK areas while in the latter, the smallest change. These findings, together with little attention to technology in pre-teachers' design discussion, suggest a need for further examination into pre-service teachers' understanding and uses of technology in technology-enhanced lesson designing.

2.4.1.2. Pedagogy

Teachers' teaching experience and knowledge is also a basis for design practices (Bennett et al., 2015; Churchill, 2006; Graham et al., 2012; Postareff & Lindblom-Ylänne, 2008; Tseng et al., 2019; Zhang et al., 2019). In a study of 133 pre-service teachers, Graham et al. (2012) found that teachers mainly referred to general pedagogical strategies in their post assessment rationales as to why they wanted to design their technology-based lesson in a certain way (83% of respondents). These general pedagogies included collaboration, active learning, and class management. This finding is also supported in the study conducted by Churchill (2006) where the teachers tended to base their designs on the teaching and learning strategies that they thought were useful for their students.

Furthermore, teacher participants in studies by Churchill (2006) and Bennett et al. (2015) reflected on what approaches worked better in designing technology-based lessons for their students. Some paid attention to selecting appropriate topics before developing plans of technology-based learning (Churchill, 2006) while others were interested in the teaching strategies from the literature that they read or the training that they experienced (Bennett et al., 2015). In line with Churchill (2006) and Bennett et al. (2015), Postareff and Lindblom-Ylänne (2008) found that their university teacher participants considered pedagogies in relation to learners. Those who attended more to learners were aware of their pedagogical development and skills during their lesson planning while those who attended more to content were not. Thus, the researchers thought that teachers' pedagogical knowledge deserved to be further investigated for its importance and relationship to learners and content.

In collaborative design activities, educational participants were found to pay attention to pedagogy in designing their lesson plans and teaching materials. Primary teachers in Zhang et al.'s study (2019) discussed pedagogy 87 times, accounting for 15.5% of the units coded. Having lower frequencies, pedagogy related discussions had 5 out of 59 counts among pre-service teachers' discourse episodes in Tseng et al.'s study (2019). Strategies have been carried out to improve pre-service teachers' pedagogical knowledge to facilitate their technology integration and learning design activities. Pre-service teachers in several multi-cycle studies saw a significant increase in their pedagogical knowledge (Papanikolaou et al., 2017; Valtonen et al., 2019).

Regardless of the important guiding role of pedagogy in designing, pedagogy was rarely mentioned by teachers during their design conversations in some studies, including the pilot study (Boschman et al., 2015; Nguyen & Bower, 2018). However, while the pre-service teachers in Nguyen and Bower (2018) reported a backwards approach where they designed their technology-enhanced online courses first and then thought about what pedagogical approaches underpinned the designed learning activities at a later stage when they needed to write up justifications for their designs, more experienced teachers (with 30 years teaching experience on average) in Boschman et al.'s study (2015) discussed pedagogy in relation to content or content and technology though they did not discuss pedagogy separately. The gap between years of teaching experience could be an explanation for the difference in why pedagogy was considered to be largely absent in each study. Another underlying reason might be that Nguyen and Bower (2018) did not explore teachers' design talks using the TPACK framework whereas Boschman et al (2015) did. This indicates the need for design talks among pre-service teachers to be examined and coded against the TPACK knowledge elements.

2.4.1.3. Content

One factor emerging from the relevant literature affecting teacher design decisions is content which can be considered the subject matter or the learning outcomes. Churchill (2006) – in his exploration of teachers' own viewpoints that influenced their technology-enhanced lesson design – did not find content knowledge to be "a homogenous area that mediated the design of technology-based learning" (p. 570), and therefore suggested "further studies might focus on exploring the manner in which knowledge of content mediates design of technology-based learning" (p. 570).

Since Churchill (2006) there have been many attempts to investigate the impact of content on teachers' learning design practices. To capture primary school teachers' design thinking when they were developing comprehensive teaching programs, Bennett (2013) discovered that learning outcomes were the primary influence on these teachers' design decisions. Similarly Graham et al. (2012) and McKenney, Boschman, Pieters, and Voogt (2016) found that content formed a significant area of focus in their participants' design of technology-enhanced lessons. According to Bennet (2013), learning outcomes are, as a factor in design decision, closely connected with learning content. Content in McKenney et al.'s analysis (2016) is composed of goals, objectives, and themes in early literacies whereas content knowledge in Graham et al.'s study (2012) is the knowledge of learners' prior knowledge, the misconceptions as well as the problems with certain content. Harris and Hofer (2011), investigating a group of teachers' lesson plans and follow-up interviews, discovered that the teachers first focused on the content and then organised lessons using activities that supported learners' understanding of the content. This suggests a content-focused design approach which was also adopted by university teachers and pre-service teachers in Bennett et al. (2016b) and Nguyen and Bower (2018) respectively.

Content also characterised many teachers' collaborative design conversations. Discussions related to it had a low distribution frequency compared to other knowledge elements, 3.8%, 6.3%, and 7.7% of the units coded in the respective studies conducted by Koh and Chai (2016), Zhang et al. (2019), and Boschman et al. (2015). Tseng et al. (2019) discovered a higher frequency of content knowledge among pre-service teachers who discussed their learning designs in groups (roughly 17% of the units coded). Quantitative studies also provided more insights about pre-service teachers' self-assessment of their content knowledge. All 1,185, 207, and 365 pre-service teachers in the respective studies carried out by Koh et al. (2010), Papanikolaou et al. (2017), and Valtonen et al. (2019) studies reported their CK changes as the lowest or second to lowest though significant.

2.4.1.4. Pedagogical Content Knowledge (PCK)

Teachers also discussed issues related to pedagogy and content together while designing their technology-based lesson plans. PCK occurs when teachers discuss the use of content in relation to pedagogy; i.e. what pedagogical approaches work best with what kind of content. In recent studies, teachers were found to refer predominantly to PCK when they discussed or provided rationales for their technology-enhanced lessons (Boschman et al., 2015; Janssen & Lazonder, 2016; Koh & Chai, 2016; Tseng et al., 2019; Zhang et al., 2019). For example, the issues related to PCK dominated the teacher participants' design discussions, over 37% and 55% of the units coded in Koh and Chai's study (2016) and Zhang et al.'s study (2019) respectively. These high frequencies were due to primary teachers often depending on teaching methods to teach stories and songs while rarely considering the use of technology (Zhang et al., 2019), and the training program mainly promoting the integration of content and pedagogy (Janssen & Lazonder, 2016). In addition, in a longitudinal study on the development and changes in pre-service teacher TPACK assessments over the first three years in teacher education (Valtonen et al., 2019), pre-service teachers' self-reported confidence in PCK was the most considerably improved.

2.4.1.5. Technological Pedagogical Knowledge (TPK)

Teachers' design conversations are also characterised by their discussions on the use of technology together with pedagogy (i.e. on TPK). Graham et al. (2012) found that teacher candidates' choices of what technology to use in designing their lessons were rooted in their selections of what teaching strategies to use. For example, PhotoStory was chosen because one participant thought it would give students an opportunity to work together in collaborative groups. Another teacher candidate opted for a particular tool since it would help maintain class management (Graham et al., 2012). These teacher candidates were drawing from their pedagogical understanding of collaborative learning and classroom management to justify their choices of technology.

When TPK-related issues occurred in the design conversations in Koh and Chai's study (2016), the teacher participants discussed technological resources and how to use these technologies pedagogically with references to the researchers' advice. Discussions related to TPK in the same study was marginal as indicated by their low distribution, just under 1% of the units coded.

Several researchers have found there to be no focus on TPK in pre-service teachers' design discussions (Tseng et al., 2019). This research team explained that the absence of TPK was due to the platform (Adobe Connect) the participants were using to design technology-based lessons in that it constrained teachers' integration of more technologies, especially when they designed technology-enhanced teaching material on Power-Point. This finding leads to a confirmation by the researchers that all the knowledge elements conceptually coined by Mishra and Koehler (2006) are not necessarily enacted during the design conversations owing to the uniqueness and complication of context.

2.4.1.6. Technological Content Knowledge (TCK)

Teachers were also found to discuss technology in relation to content (TCK) in their design conversations. Like TPK, TCK in Koh and Chai's study (2016) received hardly any attention during teachers' design conversations, 0.66% of the units coded. In a study on 81 primary teachers' TPACK via collaborative learning design practices, Zhang et al. (2019) also identified discussion on TCK as having the lowest distribution (2.3%). The justification the researchers provided for this was that lower year teachers barely used technology to teach content and mostly used pedagogy with content instead. Similarly, Tseng et al. (2019) identified TCK as least counted (4 of 59 counts) in both early and later stages of the study. TCK may be less discussed because in K-12 settings, content knowledge may still be conceptualised as knowledge to put into the mind rather than knowledge to be created through inquiry which necessitate the use of TCK both as a tool and as knowledge resources represented in subject-based knowledge repository (e.g. language corpora).

2.4.1.7. Technological Pedagogical Content Knowledge (TPACK)

The ability to combine all the TPACK elements in (discussing the) designing of technology-enhanced lessons has been considered the most highly desirable TPACK competency among teachers. Teachers have been found to take into account such elements as technology, pedagogy, and content all together in their designing of technology-based lessons. In a study on 133 elementary and early childhood pre-service teachers, Graham et al. (2012) found that among the written justifications that the pre-service teacher participants provided for their technology-based lesson design tasks, 42% of the justifications were related to TPACK. TPACK in Graham et al.'s study (2012) includes knowledge of integrating technology with teaching strategies in alignment with particular content, content that potential learners can understand, and content the presentation of which can be transformed using technology. Furthermore, the same study identified not only a dramatic change in the quantity of the justifications regarding TPACK between pre- and post-assessment, but also changes in the quality of the rationales; that is, more detailed and longer responses were provided in the post-assessment by the participants.

In other studies, TPACK was found to be one of the areas of focus of teacher learning design conversations (Koh & Chai, 2016; Tseng et al., 2019; Zhang et al., 2019). It constituted nearly 20% of the units coded in Koh and Chai's study (2016) and over 15% of the units coded in Zhang et al.'s study (2019). Although not directly investigating the decisions teachers made via the TPACK framework, Boschman et al. (2014) found that their kindergarten teacher participants reported to refer to pedagogy while addressing technology through a pedagogical and early literacy frame of reference. This reference implicitly adopts a succinct definition of TPACK as "discussions related to the use of ICT to support particular pedagogies for particular subject content" (Koh & Chai, 2016, p. 248).

On the contrary, both TPACK distribution in pre-service teachers' rationales for their lesson plans and the TPACK quality of the lesson plans were found to be low (Janssen & Lazonder, 2016). The researchers, also teacher educators, speculated that the low quality might be due to the fact that they only provided students with the content and pedagogy to apply to lesson planning and when to apply them in the absence of how and why to integrate technology, pedagogy and content. This suggests TPACK improvement is influenced by various contextual factors including teacher educators' teaching strategies, hence the need for further research on this area.

2.4.1.8. Design Knowledge (DK)

Design knowledge has been interpreted differently in the Learning Design literature. Koehler and Mishra (2009) considered TPACK itself a sort of design knowledge advisably utilised by teachers in order to design solutions to 'wicked problems' arising from technology integration. The researchers also viewed teachers as 'creative designers of curriculum' because they view teaching as a flexible navigation surrounding the 'TPACK landscape' (Koehler & Mishra, 2009, p. 10). Likewise, Laurillard (2013) considers all the knowledge that teachers employ to be design knowledge, which is based on the proposal that teachers are designers of their own teaching materials and technology-enhanced lessons. In both studies, the authors honoured teachers' ownership of their knowledge in teaching and designing. Both approaches to conceptualising design knowledge seemed to agree that the knowledge that teachers own are all types of knowledge *necessary for designing*.

In addition, there has been empirical evidence of more than seven TPACK areas plus context taken into account while pre-service teachers were discussing their online modules collaboratively. Koh and Chai (2016) coded this emergent dimension as design knowledge (DK), constituting well above 34% of the unit coded, where the issues discussed by their participants pertained to the design strategies like choosing design goals, arranging where to save their design drafts, and delegating tasks among themselves. Similar design-related themes scheduling, task distribution, online lesson structuring, and common ground awareness establishment were also found in Nguyen and Bower's study (2018). These elements were found to be related to other factors. For example, pre-service teachers discussed their design aesthetics in relation to their learners' age and preferences. Koh and Chai (2016) emphasised the pivotal role of DK in TPACK creation as well as in the design process and recommended it as "an area warranting further consideration" (p. 255).

This current study takes a simple view of design knowledge. Informed by Koh and Chai (2016) and Nguyen and Bower (2018), design knowledge in this study is conceptualised as extending beyond TPACK knowledge elements identified from design conversations between teachers involved in a collaborative design process. This label (design knowledge) distinguishes elements such as the artifacts' aesthetics and management of design processes from the TPACK elements usually instantly associated with (CK, PK, TK, PCK, PTK, TCK, TPACK, Context). What is included in design knowledge and how design knowledge is further conceptualised is presented in Section 4.1.1.1 of the Findings chapter, Section 5.1.1.1 of the Discussion chapter, and 6.2.1 of the Conclusion chapter.

Note that the researcher of the current study is aware that teaching and designing are highly complex activities that draws on many kinds of knowledge viewed through different lenses in various fields of studies. The current study exclusively focuses upon the sorts of knowledge related to educational technology and learning design characterised by the TPACK framework.

2.4.1.9. Context

The teaching and learning context for which teachers design is expounded to be among the influential factors that impact teacher learning design processes, which is indispensable and inseparable from the learning design (Boyle & Ravenscroft, 2012). In their study of primary school teachers, Bennett et al. (2015) and Harris and Hofer (2011) identified context as a strong influence upon teachers' learning design. The contextual factors in their study ranged from requirements of the relevant industry to a range of restrictions with regards to teaching and learning environment like class size, timetabling, material costs and workload.

Likewise, Bennett et al. (2011) established a broader sense of the context in which teachers conducted their work, with factors including the set curriculum, teaching the same units every year, frequency of new unit design, frequency of unit design, team and individual planning, and institutional features and requirements.

The learning context also emerged from the data as one of the indicators of teacher decisions in technology-based learning in Churchill's study (2006). Context in this study seemed to go beyond an institutional level that had to do with the institute's administrators and colleagues. He described aspects of context as "changes in society and their implications in education" and "ways in which such changes impact teachers and students" (p. 570).

Regardless of the fact that context has been considered a central element in the TPACK framework by its developers (Mishra & Koehler, 2006; Koehler & Mishra, 2009), there is evidence in prior literature that context was frequently missing when researchers described, explained, or operationalised TPACK (Rosenberg & Koehler, 2014), or when teachers discussed their technology-enhanced designs. It was also found that the meaning of context varied widely from micro factors like classroom, meso factors like school, teacher, and student to macro factors like leadership and society (Rosenberg & Koehler, 2015). In the pilot study of this project (Nguyen, 2016), context was not among the design discussion focuses of pre-service teachers. Hence, it is worth considering context as one of the themes for coding in the current study because of its importance in creating high quality learning designs.

2.4.1.10. Learners' characteristics

Student characteristics have been found to play a major role in teacher design decisions. Bennett et al. (2015) conducted interviews with 30 academics in Australia to find out what shapes university teacher design decisions. She identified student characteristics as a consistent theme among these academics. *Firstly*, designing teaching materials that met the needs of students and responded to students' characteristics was deliberately emphasised as the most important factor to consider. *Second*, modifying a particular part of teaching based on student feedback was another consideration. Academics accumulated their knowledge and understanding of their students over time and they seemed to draw on the information from this reservoir of knowledge to design their lessons and adapt their designs (Bennett et al., 2015).

These findings are in line with those of Churchill's study (2006). However, the participating teachers in Churchill's study also seemed to build up an evolving profile of their students over a six-month period. The teacher participants took into account how their learners learn, their limitations and their ability to use technologies, which in turn determined the teacher participants' design of technology-based learning. One of the four teachers' design approach was found to shift from direct instruction to student-centred learning (Churchill, 2006).

Both Churchill's and Bennett et al.'s findings are further confirmed by Graham et al. (2012) and Tseng et al. (2019). Graham et al. (2012) studied 133 teacher candidates' rationales for designing a particular technology-based core curriculum. Using the TPACK framework as an analytical lens to understand pre-service teacher technology integration decisions, the researchers found that most of the studied teacher candidates (53%) said they would design their technology integrated lessons taking into consideration their future students' age, abilities, motivation, and learning style/preferences (Graham et al., 2012). Likewise, pre-service teachers in Tseng et al.'s study (2019) also considered their learners' prior knowledge and short attention span in designing web-conferencing teaching materials.

In brief, the factor of learner characteristics is included in context by some researchers (Rosenberg & Koehler, 2014; Tseng et al., 2019), as a separate factor influencing teacher design decisions independent of context in other studies (Bennett et al., 2015; Churchill, 2006), and as a pedagogical factor when considered together with technology in another study (Graham et al., 2012). Irrespective of how the aspect of learner characteristics was labelled, one commonality was that learner characteristics in all these studies played an important role in shaping teacher design decisions. In this study, learner characteristics were treated as a factor characterising teacher design decisions.

2.4.1.11. Summary of design focuses

In summary, the research literature regarding learning design focuses on the development of support tools and strategies for teachers based on the premise that supporting teachers with tools and strategies in designing will lead to better quality teaching and student learning outcomes. However, little is known about what pre-service teachers take into account during their extended design processes with their practices being examined in depth via 'live' design conversations. Furthermore, much more needs to be known and established about the link between TPACK and design talks (Boschman et al., 2015). Also, richer and more complete accounts of design work need to be further developed (Bennett et al., 2015).

2.4.2. Design approaches

A small number of studies have revealed different approaches to design adopted by educators. One of the approaches was *learner-centered* where student needs and prior knowledge were taken into account as the foundation for designing when academics were creating their technology-based lessons (Postareff & Lindblom-Ylänne, 2008). The products from this process were claimed to be able to be modified and adapted. Postareff and Lindblom-Ylänne (2008) also found a contrasting teacher/content-focused approach, where teachers' interests were the basis of the constructed designs that were barely adaptable.

Bennett et al. (2016b) in their empirical study of a large group of university teachers' learning design processes found a similar focus on learning *content*.

The approach was also learning outcome-based and dependent on context. The outcomes chosen by some participants in their study were what the teacher participants wanted their students to be able to do by the end of the designed unit.

In addition, Bennett et al. (2016b) identified that the design process involved decisions that shifted from a broad perspective to a specific one (a *top-down* approach). For instance, from the broader perspective, the process started from the understanding of the unit's overarching framework such as learning outcomes, content, assessment and structure of learning activities. After the general framework was established, the focus was shifted to creating and collecting learning resources as well as detailing the assessments and tasks. They also found that the design occurred before, during, and after a unit was implemented.

In a study aiming to discover how TPACK informed in-service teacher technology-based lesson planning, Harris and Hofer (2011) discovered a content-first design approach where a variety of learning activities were considered first followed by how to engage learners with the content. This discovery may be because the training program primarily focused upon content-based learning activities rather than technology. Teacher learning designs were conceptualised around content goals and therefore the finding was probably biased by the researchers.

In the same study, a student-centred design approach was also identified. This student-focused approach has much to do with the choices of technologies in the way that the teacher participants paid attention to how their learners were motivated using certain technology (Harris & Hofer, 2011).

The three above design approaches – top-down, content-based, and learner-centred – were determined based on interviews of individual participants in the respective studies. The same three approaches were also identified among groups of pre-service teachers who co-designed their technology-enhanced modules (Nguyen & Bower, 2018).

In summary, among these above studies examining teachers' design approaches, only one investigated the actual design process and that of the pre-service teacher (Nguyen & Bower, 2018) via exploring 'live' design conversations. This indicates a need for further explorations of design approaches based on primary evidence, including those adopted by pre-service teachers.

2.5. How Studies on Teacher Learning Design and TPACK have been Approached

The purpose of this study was to improve pre-service teachers' learning design capabilities by examining their knowledge capacities, learning design processes, and learning design products, in part through the TPACK lens applied to design conversations. Therefore, it was important to systematically examine previous studies to determine gaps in the literature and identify the research basis for the current study. This relevant literature was sourced from learning design literature using Google Scholar and other database systems and libraries such as ERIC and Wiley Online Library. Mostly, articles from well-established and international peer-reviewed journals were selected. Occasionally, a new article was added to the list due to Google Scholar's automatic suggestions based on previous searches. To this extent, the review was an ongoing process with the list of the selected journal articles frequently added, revised, and re-visited throughout the study.

There were over 50 journal articles identified in early searches. Almost all of them were reviewed together with the literature reviewed in the pilot study for the purposes of constructing this broader literature review chapter. However, only 16 of them have been listed in Table 2.2 below for their direct methodological and comparative relevance to the current study being undertaken. The articles included in the table are those researched and written in English, drawing upon empirical research, and focusing on decision making and design focuses in TPACK studies. Most of the detailed conclusions that follow at the end of this chapter were drawn based an analysis of these most relevant 16 articles.

A Review of Studies on Teacher Learning Design and TPACK

Table 2.2: A review of 16 studies on teacher Learning Design and TPACK

	Authors and date	Title	Research questions/aims	Research methods used	Participants	Theories used	Key findings/Conclusions/Recommendations
1	(Churchill, 2006)	Teachers' private theories and their design of technology-based learning	1. What areas of private theories mediate teachers' learning design? 2. How do teacher private theories change through reflection during design process?	QUAL multicase study Content analysis: Interviews, filed notes, written reflections, final products No ICR; Not actual process	4 university teachers Training	None	1. 6 areas of private theories identified: Students, Learning, Teacher, Technology, Design, Educational changes 2. Areas dominating a participant's design decision: Technology, Students, Teacher
2	(Postareff & Lindblom-Ylänne, 2008)	Variation in teachers' descriptions of teaching: Broadening the understanding of teaching in HE	1. To capture variation in teacher descriptions of their teaching 2. To create categories of description	QUAL Semi-structured interviews: Content analysis ICR	69 university teachers Individual	None	1. Learner-focused vs content focused approach Former: Pedagogical awareness emphasised; products reusable Latter: Teacher interests put first; teachers not aware of pedagogical skills; products not flexible and not sharable
3	(Harris & Hofer, 2011)	Technological Pedagogical Content Knowledge (TPACK) in	To discover nature and development of teacher TPACK as it is applied in lesson planning	QUAL Pre and post interviews; lesson plans,	7 experienced secondary teachers Training	None, with reference to TPACK	1. In both pre and post interviews, participants took into account content first: activities to implement; then: what to engage learners to content 2. Context awareness – contextual constraints

		action	and technology integration	reflections Independent and collaborative coding; Not ICR; Not actual process	Individual		(time, resources) 3. Student-centred: presence of technology choices seems to have made lesson planning even more student-centred
4	(Graham et al., 2012)	Using TPACK as a framework to understand teacher candidates' technology integration decisions	1. What are teacher candidates' general and content-specific rationales for using ICT as part of a design task? 2. How do rationales change following a training course?	MIXED Pre and post: Coding rationales for how and why they teach an outcome Eliciting responses ICR	133 elementary and early childhood pre-service teachers Training Individual	None, with reference to TPACK	1. TPK-oriented rationales most commonly given (part of which has to do with use of tech in relation to general strategies (active learning, class management, etc.) or learner characteristics (learning style/preferences, or age appropriate, motivation, etc.) 2. TPACK: 42% - More content-specific than TPK CK = K of L prior knowledge, a K of misconception, difficulties with specific content. TK: 7% 3. Pre to post: dramatic increase for TPK and TPACK 53% PST rationales: L characteristics, 48%: content
5	(Boschman et al., 2014)	Understanding decision making in teachers' curriculum design approaches	To understand whether and how teachers' existing orientations, external priorities and/or practical concerns influenced their conversations and	QUAL Multiple case study Interviews Design talk: episodes as unit of analysis	3 teams of Dutch kindergarten and early literacy teachers (9) Brief training of PictoPal before design	None	1. Technology is addressed through a pedagogical and early literacy frame of reference (P and C – Kindergarten team: TPK, Early literacy experts: TPACK) 2. Teachers expressed knowledge and beliefs about teaching and learning in kindergarten: motivational strategies, socio-emotional development, and how kindergarteners learn. Motivation achieved via authentic tasks,

			decision making	ICR Actual process?	learning activity, not a long process Collaborative		appealing to small kids.
6	(Boschman et al., 2015)	Exploring teachers' use of TPACK in design talk: The collaborative design of technology-rich early literacy activities	1. What TPACK domains are represented in design talk? 2. How is TPACK linked to explicated design reasoning in design talk?	QUAL; case study Design talk coded using TPACK frwk; Design talk = design team 3 meetings – not actual process; unit of analysis: topic exchange ICR	7 kindergarten teachers (average 60 yrs, 30 yrs teaching experience, zero to little ICT experience; Training Collaborative	None, with reference to TPACK	1. Teachers discussed more PCK, not TPACK while scarcely mentioning TK, PK, CK separately 2. Further research is needed to establish and understand how TPACK is linked to design talk. 3. Method of discourse and conversation: shed light on TPACK development – Future studies extend this approach to studying interactions of teacher in different contexts
7	(Bennett et al., 2015)	Technology tools to support learning design: Implications derived from an investigation of uni teachers' design practices	To understand what influences university teachers when designing units they teach with a view to determining how support tools might improve their design decisions	QUAL Interviews via phone mainly	30 university teachers No training Individual	Activity Theory and case-based reasoning but very vague, if not no, explanation	1. Key influences shaping teacher design decisions: Learner characteristics, teacher beliefs and expertise, and context 2. Further research to develop richer and more complete accounts of design work 3. Further work also needed to develop theoretical basis for learning design 4. Much more needs to be known about challenges of uptake of design tools
8	(Koh & Chai, 2016)	Seven design frames that teachers use when considering	1. What aspects of TPACK did teachers consider? 2. What design	MIXED QUAL: Content analysis of design talks while working	27 primary teachers (1 to 30 years of teaching experience)	None, with reference to TPACK	1. 3 most discussed: PCK, DK, TPACK 2. TK (3.25), CK, TPK, TPK, TCK 3. Firs time presence of DK was reported in a TPACK study while need to consider DK as

		TPACK	frames used? 3. What design frames adopted when considering aspects of TPACK?	on designs (actual process); sentences level ICR	divided into 5 DTs No training Collaborative		part of teacher ICT integration expertise – 4. Investigation of design talks by PST might lead to different results esp. in PCK, because of in-service and PST differences in pedagogical capabilities.
9	(McKenney et al., 2016)	Collaborative design of technology-enhanced learning: What can we learn from teacher talk	To examine how teachers' own content knowledge is manifested in design conversations, as well as the kinds of expert contributions that yield the most influence on design decision-making	QUAL Content analysis: design talk, interview	21 kindergarten teachers over 3 years No training Collaborative No ICR	None, with reference to TPACK	1. Significant role of content 2. Absence of PK discussed in isolation 3. Pedagogical beliefs, about teaching and learning in kindergarten, are a dominant lens through which technology was viewed. Most teachers draw most on their own personal experiences to feed the design of technology-enhanced learning material.
10	(Janssen & Lazonder, 2016)	Supporting pre-service teachers in designing technology-infused lesson plans	1. Will number of TPACK-related justifications differ between integrated and separate support? 2. How will 2 types of support contribute to the quality of TPACK in lesson plans?	Experimental design MIXED method QUAL: coding justifications ICR	54 PST Training Individual	None, with reference to TPACK	1. Half justifications refer to PCK (integrated support focused on pedagogy and content only) – not associated with quality of PCK in lesson plans. 2. Number of TPACK justifications were low expected. Explained: integrated support did not promote PST integration of pedagogy, content *and* tech. 3. Few tech-related statements. Reason: separate presentation of tech info.
11	(Papanikolaou et al., 2017)	LD as a vehicle for developing TPACK in blended teacher training on	1. Effect of synthesis design activities on single and synthetic types of	QUAN Used Schmidt et al.'s survey (2009) Design-based	PST Training Collaborative talks (on forum	TPACK and CoI models	1. Significant increase in TK and PK, TCK, TPK, TPACK 2. Future research: compare PST perceptions (TPACK?) with evaluation of group product; Trace development of knowledge through

		TEL	knowledge?	research?	and in class)		contributions to forum using also QUAL
12	(Nguyen & Bower, 2018)	Novice teacher technology-enhanced LD practices: The case of the silent pedagogy	1. How do PSTs approach the collaborative design? 2. What factors support or hinder PST as they design?	QUAL Design talk Interview Thematic analysis (group of sentences)	3 groups of PSTs Training Collaborative	None, with reference to	1. No mention of pedagogy 2. Three design approaches: Top down, content-based, learner-centred 3. Hindrances + Supporting factors: group dynamics, tutor support, technological capabilities
13	(Zhang et al., 2019)	Exploring primary school teachers' TPACK in online collaborative discourse: An epistemic network analysis	1. What are the categories, frequency distribution and time series characteristics of teachers' knowledge domains in online discourse?	QUAL or MIXED? Content discourse analysis: not clear if sentence level Comments collected from forum posts (not actual process)	81 primary teachers Collaborative	None, with reference to TPACK	1. PCK most frequent (53.5%) followed by PK (15.5%) 2. Lowest: TK (2.3%) and TCK (2.3%) Reason: lower year teachers barely used technology to teach content; only use pedagogy with content
14	(Valtonen et al., 2019)	Examining pre-service teachers' TPACK as evolving knowledge domains: A longitudinal approach	To outline the development of and changes in PST TPACK assessments during the first 3 years in teacher education	Longitudinal: over 3 years QUAN: Survey (Schmidt et al., 2009):	365 PST from 3 cohorts of PST from 3 Finnish universities Training Individual	None, with reference to TPACK	1. Number of longitudinal studies focusing on development of TPACK is minimal 2. Changes between the years were all positive.
15	(Tseng et al., 2019)	How pre-service teachers enact	1. How did pre-service teachers enact TPACK in the	QUAL: Content analysis of design talk:	6 PST teaching distant courses	None, with reference	1. PCK predominantly (23 counts): web-conferencing limited teachers' integration of more technologies, especially when they design

		TPACK in the context of web-conferencing teaching: A design thinking approach	context of web-conferencing teaching? 2. What were the contextual factors that might influence teachers' TPACK enactment?	discourse episodes Actual process of design TEL materials	Collaborative	to TPACK	TE teaching material on Power-Point. 2. CK (11), TPACK (9), TK (7), PK (5), TCK (4) 3. TPK (0): confirms that every TPACK subdomain conceptually defined by Mishra and Koehler (2006) may not necessarily appear in practice due to the uniqueness and complexity of context
16	(Tondeur et al., 2020)	Enhancing pre-service teachers' TPACK: A mixed-method study	1. To explore PSTs' perceptions of how well teacher education programs prepare them for effective technology integration in their future classrooms 2. To explain how organizational factors and individual factors work together to influence their TPACK	Mixed method: surveys and interviews; Survey (Schmidt et al., 2009)	688 PSTs from 20 TTIs in Belgium, 25 years on average Interviews: 22 beginning teachers Individual Not actual process	None, with reference to TPACK	1. Interviews revealed teachers' perceptions about the connections between TPACK and support provided by their TTIs, including role models, reflection opportunities, instructional design, collaboration, authentic experiences, and feedback. 2. Quantitative data collection showed a positive and significant relationship between pre-service teachers' TPACK and their perceptions of the SQD-strategies implemented in their TTIs, even after controlling for pre-service teachers' general ICT attitudes.
	QUAL: A qualitative approach was adopted in the reviewed study. QUAN: A quantitative approach was adopted in the reviewed study. PST: Pre-service teachers; ICR: Inter-coder reliability						

The 16 articles presented in Table 2.2 were mainly on enhancing teacher learning design capabilities via examining teacher decision making and design focuses using the TPACK framework. Some of them did not explicitly use the TPACK framework, but they discovered different technology, pedagogy, and content related issues that their teacher participants took into account in the technology-enhanced learning design process. Because there was such a small pool of studies, each article was thoroughly examined.

Table 2.2 details the information concerning authors, focuses, aims, research methods, participants, theory, and key findings/implications of the studies. Such detailed information provides useful snapshots of how teacher learning design seen though the TPACK lens has been and has not been approached. The following sub-sections point out several general observations and gaps surrounding theory and methodology, which inform the current study theoretically and methodologically.

2.6.1. General observations

The *first* general observation is that design thinking in a design process has been approached in three different ways. First, design thinking is in the form of teachers' design intentions in certain scenarios where teachers provide rationales for their design decisions (Graham et al., 2012). In this case, participants did not engage in a real design process. Second, most studies elicited participants' retrospective learning design process via interviews (e.g. Bennett et al., 2015) or reflective reports/forum posts (Zhang et al., 2019). Third, although participants worked together and were involved in a design process in the Zhang study, they only planned a technology-based lesson, rather than actually taking part in creating an actual module or product (Zhang et al., 2019). There is therefore a lack of investigations that focus on teacher design thinking and decision making while engaging in the real-time and actual process of designing an online TEL artefact.

The *second* general observation is that a wide range of methods and instruments have been used in attempting to understand teachers' decision making, including: surveys (e.g. Papanikolaou et al., 2017), reflection report analysis (Baran & Uygun, 2016), lesson plan analysis (Harris & Hofer, 2011), interviews (e.g. Bennett et al., 2015), forum posts (Zhang et al., 2019), and eliciting responses about technology use based on a simplified design task (Graham et al., 2012). Each of these methods provides a different insight into teacher decision-making process but ultimately fails to reach a full understanding of the actual learning design processes, which cannot be achieved without examining the actual process when the design is 'live'— that is, when the design conversation is happening—either in a physical class or online (e.g. in a Facebook Messenger group chat). In Table 2.2 above, there were only three such studies (Koh & Chai, 2016; Nguyen & Bower, 2018; Tseng et al., 2019) using teachers' 'live' design talks as methods of collecting data and gaining insights into their learning design practices.

The *third* general observation is that in some projects, teachers' design thinking was elicited individually; in others, collaboratively. Design thinking of individual teachers was often collected using forum posts, interviews, reflections, lesson plans, or survey with collaborative data usually collected in the form of interviews or recordings. Some studies claimed to adopt and examine a collaborative design process, but the whole process was not fully collaborative; that is, participants discussed online together as a cohort via forum posts, but each teacher came up with an individual TEL lesson plan as a product (Zhang et al., 2019). A fully collaborative approach to learning design in this current study means members of each group worked together from the beginning (planning) until the final stage when they came up with a complete Moodle-based online course.

The *fourth* general observation is that following teachers' design process being unpacked through examining teachers' design talks, teachers' final products were also examined. However, none of the 16 studies sought to explore the relationship between the characteristics of teachers' design process and the online artefacts.

The *fifth* general observation is that most studies were conducted on experienced in-service teachers, with researchers often underscoring the need for further research on pre-service novice teachers for a better insight or comparison. Koh and Chai (2016) emphasised there should be more investigation into pre-service design frames so that comparisons between the design frames of pre-service teachers and in-service teachers could be carried out, from which teacher educators were able to "distinguish the pedagogical approaches for supporting design work in pre-service and in-service ICT courses" (p. 255). Similarly, examining design talks by pre-service teachers might lead to different results especially in PCK because of in-service and pre-service teacher differences in pedagogical capabilities (Koh et al., 2014).

2.6.2. The theoretical gap

As can be seen from Table 2.2, most studies did not explicitly indicate theories used, except for two studies (Bennett et al., 2015; Papanikolaou et al., 2017). The latter study was thorough in justifying the synergy of the TPACK framework and the Community of Inquiry model. On the other hand, the former study led by Bennett only cited the names of the theories (Activity Theory and Case reasoning) without further explaining why the theories were used and how they were important in framing and discussing the findings. This observation shows absence of broad engagement with theories, making it appear as though the field of design learning in general and design thinking in particular is almost an atheoretical field. More theoretical engagement in the field is urgently needed so that the field is further completed by gaining more respect and credibility. Some researchers themselves also called for future work into developing theoretical basis for learning design (Bennett et al., 2015). This call is in line with what is discussed in Bower's analysis (2019).

2.6.3. The methodological approach and gap

As briefly mentioned above, there is generally a wide range of research designs (design-based research, experimental design, case study), methodologies (qualitative, quantitative, mixed), and instruments used (interviews, surveys, reports, lesson plans, reflective post forums, etc.). However, there are still the following gaps.

First, only two studies investigated learning design practices via a design-based research (DBR) approach or over an extended period of time (Papanikolaou et al., 2017; Valtonen et al., 2019) regardless of findings from some empirical research that learning design is an iterative process (Boschman et al., 2015) and characterised as reframing problems and solution focused (Bower, 2017), which requires a longitudinal investigation for opportunities to allow different cycles of reflections and (re)designing. In addition, the number of longitudinal studies on the development of TPACK via design conversations is minimal (Valtonen et al., 2019). These above two points suggest more adoption of a DBR approach to exploring teacher learning design practices via tracing the presence of TPACK in design conversations.

Second, solely qualitative (QUAL) studies obviously dominate (10 out of 16). Only two studies are quantitative (QUAN) studies (Papanikolaou et al., 2017; Valtonen et al., 2019) and four, mixed methodology (Graham et al., 2012; Janssen & Lazonder, 2016; Koh & Chai, 2016; Tondeur et al., 2020). The dominance of solely qualitative analyses suggests a methodological limitation, which is the lack of studying attaching importance to the relationship among key variables. This could weaken the explanatory nature of the field. This limitation implies the need for more use of quantitative or mixed methods in learning design research.

Third, all the qualitative studies in Table 2.2 use *either* Thematic, Content, or Discourse analysis to explore nature of design talks or interviews either at sentence level, groups of sentence level or topic exchanges. Especially, the method of analysing discourses/sentences happening during design conversations contributed to a clearer understanding of TPACK development and was suggested for further studies on the interactive design among teachers at different levels and contexts (Boschman et al., 2015). These analyses are often complicated and thorough, requiring at least two coders to guarantee the inter-coder reliability. However, only 5 out of 11 qualitative analyses conducted inter-coder reliability check.

Fourth, it can be observed that out of the three TPACK studies (Papanikolaou et al., 2017; Tondeur et al., 2020; Valtonen et al., 2019) using surveys to measure pre-service teachers' TPACK improvement over time, all three of them adopted Schmidt et al.'s self-reported instrument (2009). This instrument has been found to be "the most universally used survey, and encompasses most of the aspects of TPACK associated with pre-service teacher education" (Young et al., 2013, p. 154). Thus it would appear that using Schmidt et al.'s TPACK instrument would be a sensible tool to use in mixed methods research investigating learning design processes.

2.6.4. Summary of previous studies examining learning design using TPACK

In summary, a synthesis of all the 16 reviewed studies on decision making and TPACK reveals several gaps in the existing literature. On the whole, learning design and TPACK studies are *theoretically vague* (no theories clearly mentioned or explained), *methodologically limited* (DBR minimally used, dominantly qualitative, lacking inter-coder reliability), and *do not often investigate pre-service teachers' actual collaborative learning design processes relating to the development of actual artefacts*. There were no papers that investigated the relationship between learning design processes and the products yielded from it. To close these gaps, this current study aims at using a theoretical framework, Activity Theory (see Section 2.1), adopting a DBR and mixed-methods approach (see Sections 3.1 and 3.2), analysing design talks using thematic analysis approach using inter-coder reliability check (see Section 3.7.2), and exploring pre-service teachers' actual process of collaborative learning designing and their relationship with learning design products and outcomes, including TPACK improvement among pre-service teachers.

2.6. Summary of the Literature Review

The chapter of Literature Review has discussed in detail the Activity Theory theoretical framework, how it has been used in the field of Learning Design and how it is used in the current study. In the current study, Activity Theory is used as the overarching theoretical framework for identifying the elements being considered and for reporting on influences on pre-service teacher learning design practices. More specifically, the data have been analysed and the findings reported in terms of how rules, community, division of labour, cognitive and social tools influenced outcomes.

Additionally, the TPACK conceptual framework was identified and explained as a means of analysing teacher knowledge and design focuses (along with other elements). To this extent, TPACK and its relationship with learning design processes was also discussed. Previous research investigating learning design through the lens of TPACK has been systematically reviewed from a theoretical and methodological perspective to identify gaps in the research and provide a rationale for the current study.

Chapter 3. Methodology

This chapter explains how a design-based research methodology incorporating both conventional case study approaches as well as a thematic analysis was applied to conduct a mixed method analysis of pre-service teacher collaborative learning design practices. First, the design-based research methodology is described. Then, the mixed methods approach – including related participants, instruments, types of data, and data collection procedures – are explained. Thereafter, the chapter describes data analysis procedures for each research question, the focuses of which are a presentation of thematic analysis approach to analysing qualitative data (design conversations and post-course interviews) and an account of how the Linear Mixed Model was applied to analyse quantitative data (TPACK surveys). The chapter concludes with a summary mapping each research question to its corresponding participants, instruments, methods, and procedures.

3.1. Design-Based Research

3.1.1. About Design-Based Research

As a contemporary methodology, Design-Based Research (DBR) allows educational researchers to design and develop instructional interventions in authentic settings in a systematic way (Sari & Lim, 2011; Shattuck & Anderson, 2013; Wang et al., 2014). In the setting of educational research, it has been also referred to with other names such as Educational Design Research, design research, development research, and formative research (McKenney & Reeves, 2018). Since learning is supposed to vary within the environment in which it takes place, the purpose of DBR is to support construction of appropriate designs of the learning environment and to develop theoretical understandings which support learning in the designated interventions through iterative cycles of design, deployment, and redesign (Hung, 2011).

Although educational empirical research often utilises interventions, the use of the term *intervention* varies from study to study. In some instances, *intervention* is considered to be an educational program that introduces a systematic change in the teaching-learning environment (Jen, Moon & Samarapungavan, 2015).

However, more commonly, an intervention has broader connotations and encompasses simultaneous changes in complex and interrelated systematic elements of educational programs and settings such as curricular content, duration, pedagogies, physical/material resources, and new technical tools (Kim et al., 2015; Sari & Lim, 2011; Schmitz et al., 2015; Wang et al., 2014; Wong et al., 2011). In the majority of situations, DBR researchers design and examine more than one intervention, or study complex interventions with multiple layers of context. Interventions in this study are teacher educators' pedagogical strategies applied in attempts to improve pre-service teachers' learning design capabilities (further details provided in Section 3.1.2).

Based upon reviews of the top most cited DBR articles, Anderson and Shattuck (2012) and Jen, Moon, and Samarapungavan (2015) characterised DBR as: (1) being situated in a real educational context; (2) focusing on the design and testing of a significant intervention; (3) adopting mixed methods to provide better guidance for educational refinement; (4) involving multiple iterations to reach the best design of intervention; (5) promoting collaboration between researchers and practitioners; and (6) the use of theory in conducting real work. Regarding the last feature, it is argued that theories are not only used in DBR to provide rationale for the intervention or to interpret findings, but are also often developed, in terms of both the process of learning and the means that support learning (Jen et al., 2015). This argument is further reinforced by McKenney and Reeves (2013) who argue that DBR should be able to generate a theoretical understanding that can broaden others' understandings of how humans think, know, act, and learn.

There are several advantages to using DBR in educational research. First, DBR helps educators and researchers better understand how to optimise the design of innovative learning experiences in everyday educational contexts (Kim et al., 2015; Reeves, 2006; Shattuck & Anderson, 2013; Wang et al., 2014). In addition, Reeves (2006) argues that DBR is an effective way to derive new design principles. Another benefit is that this exploratory research approach is "appropriate in addressing the issues of making… learning more approachable, interesting, enjoyable, and contextual while determining the efficacy of the pedagogy, resources, and conditions needed for the continuous curriculum enhancement process" (Kim et al., 2015, p. 598). It is suggested that DBR should not be limited to long-term projects, but also applied to short-term ones such as a PhD thesis, provided that relevant cycles are thoroughly conducted to guarantee effective and meaningful learning design principles (Pool & Laubscher, 2016).

Despite the advantages provided above, DBR researchers can face challenges such as maintaining collaborative partnerships with participants and generalising findings (Jen et al., 2015). Researchers may also face logistical issues; the whole process of DBR can be time- and money-intensive though its results are often considered worth the effort (Hung, 2011).

3.1.2. Applying Design-Based Research to this study

This study mainly investigated six cases (six groups of three students) seeking answers to the main research question (How can the learning design capabilities of pre-service teachers be effectively developed?). Because such a "how" question deals with "operational links needing to be traced over time, rather than mere frequencies or incidence" (Yin, 2013, p. 10), a case study method in a DBR approach which entails a detailed investigation over a period of time and requires an extensive and thorough explanation and/or description of certain contemporary circumstances was appropriate to be utilised to inform the methodological design of this PhD study considering the nature and aims of the study.

Reeves' (2006) four-phase DBR model was used (see Figure 3.1). As can be seen in Figure 3.1, the model has four distinct stages, showing that the intervention process is iterative and conducted following a cycle of design, implementation, and feedback from implementation, all of which flow into subsequent cycles of (re)design, (re)implementation, and refinement.

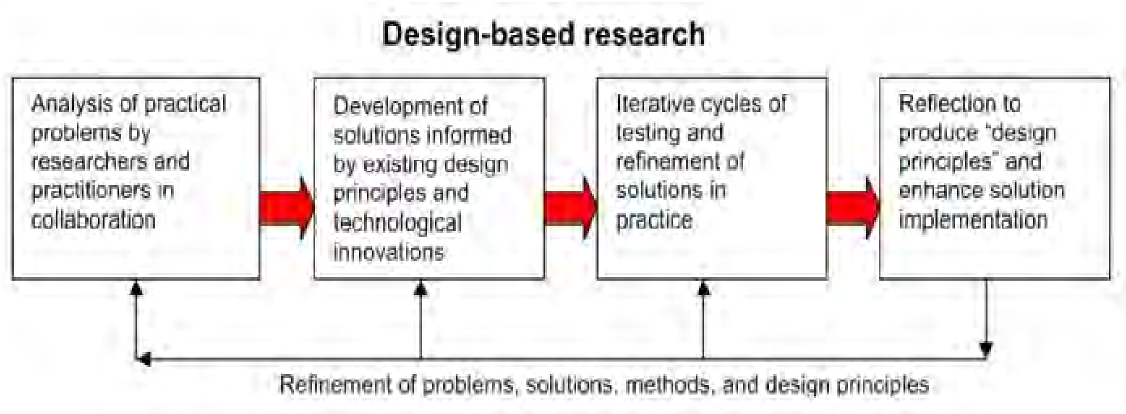

Figure 3.1: Design-based research cycle (Reeves, 2006)

Reeve's 2006 model shown in Figure 3.1 arguably improves on his earlier version (2000) because it provides guidelines to developing solutions in Phase 2 and allows minor changes in developing solutions in Phase 3 without having to commence on the next phase – which Reeve's earlier version did not do – making it easier to adopt the model in a real world problem solving project (Cotton et al., 2009).

The MRes study and this PhD project constituted three such design cycles, each of which is referred to as an iteration. Iteration 1 (**I1**) was the MRes pilot study, separated from this current PhD study, that provided baseline observations of the phenomenon being investigated. Iteration 2 (**I2**) and Iteration 3 (**I3**) were subsequent design cycles aimed at improving pre-service teachers learning design capabilities. Because **I1** was closely connected with the later design cycles, and for a continuous narrative purpose, it will be briefly summarised below (noting that further details about **I1** were provided in the Introduction chapter). **I1** will also be referenced in the next chapters for comparison and discussion purposes. Brief summaries of **I2** and **I3** are also provided below to explain the substantive nature of interventions that occurred as part of this PhD project.

Iteration 1 (Pilot study – 2016)

I1 began with the researcher identifying practical learning design problems that pre-service teachers were experiencing in the unit by examining pre-service teacher design conversations, the online resources the participants referred to, their Moodle learning design artefacts, and their follow-up interview responses. The problems identified have been discussed in Chapter 1 (e.g. student participants not providing rationales for their choices of technology, not articulating their use of pedagogy, not devoting sufficient time to exploring tools, and not considering context). These observations formed the basis of the recommendations that were made and solutions developed for a revised design of the unit EDUC261, the educational course where the data of the current study were collected (see Chapter 1 and Section 3.3 for more information about EDUC261). Thus, **I1** enabled the researcher to gather the baseline data for the study, using the existing EDUC261 design. More information about the whole MRes pilot iteration is available in Nguyen's MRes thesis (2016) and Nguyen and Bower's corresponding British Journal of Educational Technology publication (2018).

Iteration 2 (2017)

More investigations were conducted using more in-depth research processes on student participants who learned to create technology-enhanced lessons with the new EDUC261 design developed based on the **I1** recommendations and implications mentioned in Chapter 1. In particular, EDUC261's new design features included:

1. Greater emphasis on students' understanding the research relating to technology-enhanced learning design. Students were expected to do more focused and relevant readings compared to **I1** when students did more disparate and unrelated readings. Students were required to complete a Peerwise quiz activity every fortnight to encourage their engagement with the readings and research. This quiz activity asked students to compose multiple choice questions relating to the course content and respond to the questions of others.
2. Considerable emphasis on developing pre-requisite technical skills in tutorials. For example, before students commenced their Moodle group work, they had numerous opportunities to practise using technologies. Each of them was provided with their own Moodle site so that they could better their skills in using all the Moodle authoring tools, either built-in or

external, which prepared them for their Moodle group work assignment that followed. This preparation was to prevent them from focusing too much on learning technological skills during group work, which could be one of the causes of less discussion on pedagogy, context, and other elements.

3. Wiki entries and the individual Learning Activity Management System (LAMS) design task (a task where students designed their technology-based lessons on LAMS) were removed in order for students to be able to concentrate more on understanding research and develop prerequisite technical skills, as well as focus on their collaborative learning designs. This aligned with the new assessment policy, which encouraged convenors to reduce the number of assessments so that students could learn more deeply.
4. More learning activities were created to encourage pre-service teachers to articulate their design thinking explicitly. For instance, pre-service teachers were exposed at a higher frequency to a conceptual tool called Learning Design Guide with more conversations required of them though this tool was not a new one (see Appendix 1).
5. A general context was prescribed for the pre-service teachers to base their collaborative design processes upon. It was stated in the Moodle task specification that the groups could define their own context; however, as a default, they could assume a mixed ability cohort of potential learners from various socio-economic backgrounds within a coeducational school that provides good technological facilities.

The implementation of these interventions was to see whether the identified problems from **I1** could be addressed. Thematic analysis of the design conversations among the student participants and interviews with them showed that most of the problems identified in **I1** were addressed (this is examined in-depth in the Findings chapter, Chapter 4). The main area that apparently received the least attention among the pre-service teachers was Context (more detail is presented in Section 4.1.1). Therefore, further redesign of EDUC261 took place at the end of **I2** to pave the foundation for **I3**.

Iteration 3 (2018)

Informed by the findings and problems identified in **I2**, the following interventions were implemented:

1. Two real-life schools (one primary, one secondary) were provided in addition to the default context requirements. They were added on the assumption that pre-service teachers would more deeply consider context if they were provided with specific schools for which they needed to target their learning designs. Pre-service teachers needed to explore the school websites and search for more contextual information from these real-life schools and therefore increased their consideration of context during their design conversations. An expectation was that the information learnt from considering the context would focus the groups' attention to envisioning and building their own distinct cohorts to design for and upon.
2. A Learning Design Studio model (Mor & Mogilevsky, 2013) was attempted to give students an opportunity to design as a class (within a community) and thus encouraging more interactions among peers, among groups, and between students and tutor. A Learning Design Studio approach involves learning designers working reflectively and extensively on their design projects in groups, receiving feedback from peers and trainers, and providing feedback about other peers/groups' design work (Kali & Ronen-Fuhrmann, 2011). This concept is in line with the view of teachers as designers, and teaching as a design space (Laurillard, 2013). In a pre-service teacher education setting, the place where the Learning Design Studio takes place is the tutorial classroom, in which tutors guide students through the whole collaborative process while students work in their teams and work with other teams to provide joint feedback and improve their work based on other team members' or other teams' feedback. This open-ended approach involving constant reflection-in-action and reflection-on-action that was compared to the architects' design studio (Hoadley & Cox, 2009) was built upon work by Schön (1983). The Learning Design Studio has been used as a pedagogical manifestation by some researchers and shown to be effective in the

development of students' theoretical knowledge and practical skills (Mor & Mogilevsky, 2013).

3. More time was devoted to the Moodle group task in-class design conversations (25 minutes on average each in **I2** vs 40 minutes on average each in **I3**). Additionally, 6 weeks were allocated to the Moodle task assignment in **I3,** compared to 5 weeks in **I2**. As a result of more time dedicated to the Moodle task related discussions, the higher frequencies of design focuses, and knowledge elements were expected.

I3 used similar data and methods to **I2** so as to provide a standardised means of comparison. Whether or not these problems were solved by the end of **I2** and what the findings were are presented in Chapter 4, the Findings chapter.

As discussed in the Design-Based Research section, mixed methods are often used in DBR projects. The next section presents how qualitative and quantitative methods were combined to address the research problem of the study.

3.2. Mixed Methods

3.2.1. Definitions and usages of the mixed-methods approach

3.2.1.1. Definitions and usages in general

Mixed methods approaches involve a process of systematically collecting, analysing, and integrating both quantitative and qualitative approaches in a single study or a series of studies to investigate complex phenomena (Creswell, 2015; Tashakkori & Creswell, 2007a; Tashakkori & Newman, 2010). If research problems and questions are complex and require more than one methods to be understood and resolved, rather than qualitative and quantitative research occurring in separation, then a mixed methods research design is an ideal option (Lund, 2012). In other words, "mixed methods researchers combine the characteristics of quantitative and qualitative traditions that yield answers to questions that neither method alone can answer" (Tashakkori & Newman, 2010, p. 514). This type of research design works best with research questions beginning with "what and how" or "what and why" that show "interconnected qualitative and quantitative components or aspects" (Tashakkori & Creswell, 2007b, p. 207).

This integrated approach is increasingly popular among scholars due to its distinctive characteristics and strengths. One key characteristic is that it conveys the notion of triangulation which can be understood as the combination of varying sources of data (Lund, 2012) or the interconnection between three points: two sources of data (qualitative and quantitative) and the phenomenon under investigation (Creswell, 2015). A major strength that follows is that the integrated approach gives researchers the power to choose the most suitable techniques to address an overarching research problem (Tashakkori & Newman, 2010). Choices of techniques are facilitated by a wide variety of methods, both quantitatively and qualitatively, which lead to one more characteristic where a specific technique can be complementary and compensating to the other and vice versa. For example, words and narratives may elaborate on numbers while numbers may shed light on words and narratives (Johnson & Christensen, 2012). The complementarity is reflected in the way the findings of the two approaches can inform each other or inform different aspects examined of the research (Cheek et al., 2004; Lund, 2012), in the way the strengths of one approach offset the weaknesses of the other (Tashakkori & Newman, 2010). Both usages aim at providing a panoramic understanding of the whole research problem.

By adopting a mixed-methods approach, researchers have an opportunity to explore various types of empirical evidence from diverse sources of data and perspectives. This diversity can lead to findings that are either confirmative, complementary, divergent, or contradictory, which open up opportunities for further exploration of the research problems, more reflections on different dimensions of the research, and revisiting hypotheses (Lund, 2012; Tashakkori & Newman, 2010). This diversity, together with convergence and triangulation, also adds more validity to inferences and the conclusions (Johnson & Christensen, 2012; Lund, 2012).

How and why the mix-methods research was used in this study are explained in the following sub-section.

3.2.1.2. Usages in this study

In this study, quantitative and qualitative data were collected and analysed through multiple iterations to answer the overarching research question, "How can the learning design capabilities of pre-service teachers be effectively developed?" The four specific questions were addressed via either quantitative or qualitative analysis alone, or the mixture of both types of analysis, as shown in Table 3.1 below.

Table 3.1: Types of data to answer each research question

Research Questions	Types of data used to answer RQs
1. What elements do pre-service teachers focus upon when collaboratively designing technology-enhanced lessons?	Qualitative (text – transcriptions of design conversations)
2. What factors support and/or hinder the collaborative design of pre-service teacher technology-enhanced lessons?	Qualitative (text – transcription of design conversations and follow-up interviews)
3. Are there any relationships between pre-service teacher learning design practice and the characteristics of their final online artefacts?	Quantitative (numerical + quantified data)
4. What are the impacts (if any) of the pedagogical strategies of teacher educators upon pre-service teacher knowledge, learning design processes and artefacts?	Quantitative (numerical + quantified data)

The mixed methods approach applied in this project was beneficial in three ways. *Firstly*, it provided rich datasets and thus assisted to strengthen findings' reliability and credibility through the triangulation of different empirical evidence (Cheek et al., 2004; Chow et al., 2010; Creswell, 2015; Johnson & Christensen, 2012). For instance, in this study, evidence from the follow-up interviews helped inform and confirm the observations of the design conversations. *Secondly*, the approach increased the comprehensiveness of overall findings by showing how qualitative explanations and descriptions could be confirmed and verified by statistical data (Johnson & Christensen, 2012;

Tashakkori & Newman, 2010). This was where different types of data were related. For example, in the current study, the shifts in pre-service teacher design talk focuses could be confirmed by TPACK surveys results. Another example is both the shifts in pre-service teachers' frequencies of knowledge element discussions and the changes in their TPACK scores over time could reflect changes in their learning design capabilities. *Thirdly*, it increased the methodological rigour as findings in both approaches could be checked for consistency. When there was consistency in the results, conclusions could be drawn regarding the whole cohort of participants or concerning the overarching research problem.

More details and insights pertaining to the mixed-methods research approach in general as well as in the current study are presented in the sections below. These sections further discuss the mixed method design and the mixed data collection procedures.

3.2.2. Mixed-methods research design in this study

There are different ways of implementing both qualitative and quantitative methods and utilising both sources of data in a mixed method study. In his recent book, Creswell (2015) discussed six mixed methods designs including the parallel design, the explanatory sequential design, the exploratory sequential design, the embedded design, the transformative design, and the multiphase design. This study adopted a multiphase mixed methods research design which involves the examination of a research problem or topic via different phases or studies (Creswell, 2015). Multiphase mixed methods research fits well with the design-based research approach of the present study. In fact, design-based research can be considered a type of multiphase mixed methods research, where successive iterations attempt to resolve practical problems experienced in the previous iterations, and the multiphase mixed methods design providing the framework to collect and analyse mixed data types in order to answer the research questions over time.

As well, a synergistic approach was adopted, that attached equal weighting to qualitative and quantitative methods (Hall & Howard, 2008), suggesting a balance in subjective and objective viewpoints. From this position, "neither approach inherently overrides the other because researchers value the contributing epistemologies, theories, and methodologies equally all the time despite necessary fluctuations in the use of either quantitative or qualitative methods throughout the research process" (Hall & Howard, 2008, p. 252).

The multiphase mixed methods research design of this study is illustrated in Figure 3.2. As can be seen, Phase 1 and Phase 2 of multiphase mixed methods research design took place during DBR's Iteration 2 and Iteration 3 respectively (Iteration 1 was the pilot study of the current PhD project and therefore was not included in this diagram). Both quantitative (QUAN) and qualitative (QUAL) are capitalised to indicate that quantitative and qualitative data in each phase were of equal value in both phases. The diagram also shows that findings in Phase 1/Iteration 2 informed possible changes in methods as well as in teacher educators' pedagogical strategies applied for Phase 2/Iteration 3. Findings from Phase 1/Iteration 2 and Phase 2/Iteration 3 were compared and related so as to facilitate a comprehensive interpretation of data. This enabled the research to reach final conclusions, address research problems, and achieve the goals of the study. More information about the procedures by which the mixed data were collected and analysed in each phase and for each research question is presented in Section 3.5 and 3.6.

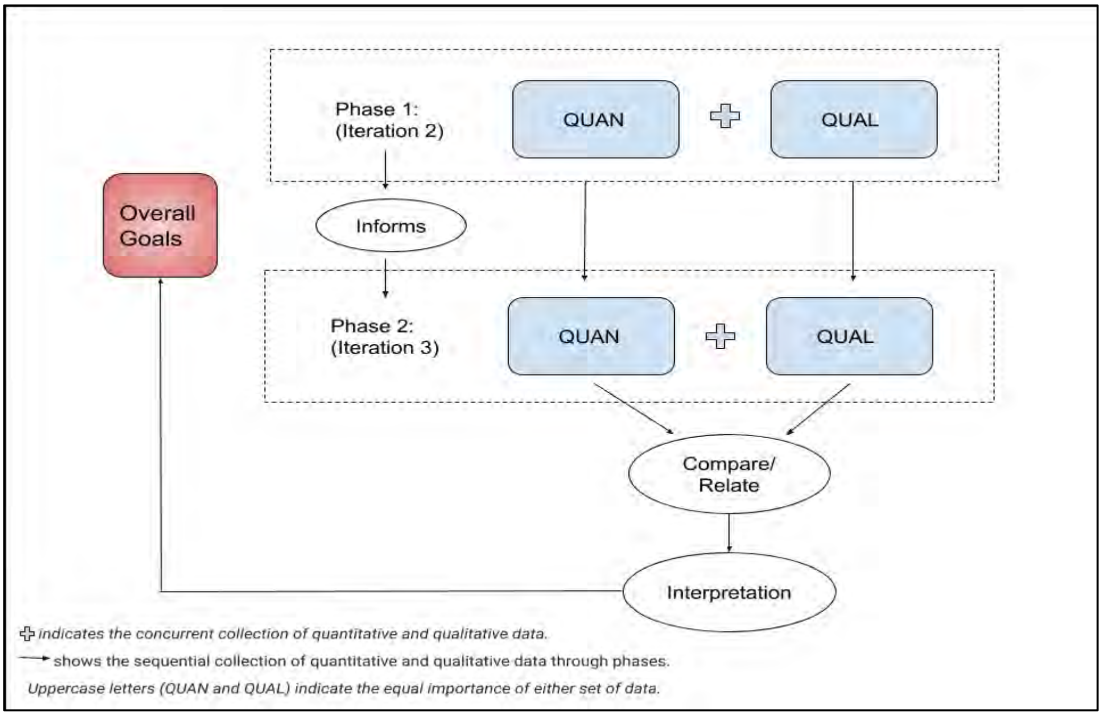

Figure 3.2: Multiphase mix-methods research design of the study

3.3. Study Setting and Participants

3.3.1. Study settings

As discussed in the Introduction chapter, the current research was undertaken at Macquarie University, Australia. Data were collected from EDUC261, a teacher education unit entitled Information and Communication Technologies (ICT) and Education that adopts a blended-learning approach, which comprises learning activities taking place both face-to-face and online. Weekly tutorials are held in the physical classroom (C5A204) supported by the unit's online content, and learning activities are located on iLearn (http://ilearn.mq.edu.au), Macquarie University learning management system. Students – the majority of whom are pre-service teachers undertaking formal training – develop their individual and group online courses on the University EducMoodle server (http://educmoodle.ltc.mq.edu.au). Moodle is a popular open-source Learning Management System chosen and utilised by Macquarie University to facilitate teaching and learning activities. For more information about Moodle see http://Moodle.org.

EDUC261 is a full semester course that contains ten face-to-face weeks including a 1-hour lecture and a 2-hour tutorial each week. The aim of the course is to equip student teachers with skills and knowledge to develop ICT-based learning designs that are based on appropriate selection and use of contemporary educational technologies. Students are encouraged to critically evaluate and justify technology selection and design decisions with reference to current research and theory in pedagogy regarding ICT in educational contexts. The prerequisite for enrolment in the course is that students have taken at least one first-year education subject or received a minimum of 12 credit points.

In **I1** (2016), students had to complete three assignment tasks:

(1) a Wiki task requiring them to provide a pedagogical critique of a learning technology (Tutorial 1-2),
(2) a design task where they individually created a lesson using LAMS (Tutorial 3-5), and

(3) a Moodle task where they created a Moodle-based course in groups (Tutorial 6-10).

By the time students began their Moodle weeks, they had been introduced to key issues in ICT in education like effective technology integration and the TPACK Model and had learnt how to critically analyse the technology affordances and use Web 2.0 tools to design for learning (see Appendix 2 for a detailed weekly syllabus in **I1**). Qualitative data were collected during the Moodle weeks and after the final results of the assignment tasks were released.

Due to the treatments applied in **I2** (2017), EDUC261 had a new design with more focus on students' understanding the research relating to technology-enhanced learning design, more development of pre-requisite technical skills in tutorials, a refocusing of assessment tasks to place greater emphasis on understanding of learning design concepts, and more learning activities that assisted student teachers to articulate their design thinking explicitly (for the detailed changes, refer to Section 3.1.2). Accordingly, the **I2** assignment tasks were modified as follows, consisting of:

(1) a quiz task that required each student to create five multiple choice questions and answer 25 questions composed by other classmates based on the content of EDUC261 lectures, readings, and tutorials (throughout the session); and
(2) a Moodle task where they designed a Moodle-based technology-enhanced course in groups (Tutorial 6 to 10)

The quiz tasks were intended to encourage students to constantly refer back and forth to the research evidence, knowledge, and practical skills learned from lectures, readings, and tutorials. Moreover, the intent was to require them to focus on the relevant content, produce meaningful content, and learn from peers throughout the course. In this way, their understanding of the contemporary learning design issues was expected to support their Moodle-based collaborative learning design practices and to be solid toward the end of the program.

Like the Moodle-based collaborative design task in **I1**, students in **I2** were to design and develop a module of work for a Moodle-based course in groups of three. The designed module was to be based upon an Australian syllabus or New South Wales Education Standards Authority (NESA) syllabus. The module needed to relate to one or more outcomes stipulated in the NESA curriculum for any learning area with a duration of two 50-minute lessons per person in the group. In addition, each student had to submit an 800-word written justification of the design they had created. The justification needed to be supported by educational theories and describe how the module had been designed to help students achieve the pre-identified syllabus outcomes, and any strategies used to promote inclusive education. Furthermore, students were required to provide a 200-word critical evaluation of designing learning modules in groups, including the advantages and difficulties experienced and how these could be overcome. During Tutorial 6, 7, 8, 9, and 10 (i.e. Moodle Week 1, 2, 3, 4, and 5 respectively), the groups were given 25 minutes on average to work on their Moodle designs in groups. The only difference in this task compared to the task in **I1** was that the groups of student learning designers in **I2** were prescribed with a general context of the school they were designing for with the expectation that they would consider this context in their group discussions.

According to the **I2** schedule, before students began working on their Moodle design in Tutorial 6, they had been equipped with knowledge and skills pertaining to such conceptual tools as TPACK, pedagogies of technology-enhanced learning, technology affordances, the representation and sharing of content, and design thinking and learning design in Tutorial 1, 2, 3, 4 and 5 respectively (see Appendix 3 for a detailed weekly tutorial content in **I2**). Another important change compared to **I1** was that by the time students started their Moodle assignments in groups, each of them had been set up with their own individual Moodle sandbox to familiarise themselves with different built-in authoring tools as well as external tools compatible with Moodle such as learning objects and Web 2.0 tools.

The assignment's structure in **I3** was very similar to that in **I2**. There were some changes in design directly related to the Moodle group assignment task. As mentioned in Section 3.1.2, two websites of the two real schools were added as a reference and foundation for students to developing their learning designs upon. Another change was that extra time was dedicated to in-class group design conversations (on average from 25 minutes each in **I2** to 40 minutes each in **I3**) and more time allotted to the Moodle collaborative task (6 Moodle weeks in **I3** instead of 5 Moodle weeks in **I2**). This increased time as part of the Learning Design Studio model provided pre-service teachers with a more sustained opportunity for discussion and reflection. The Design Studio also provided greater opportunity for interaction with tutors, explicit activities requiring students to peer evaluate each other's designs, incorporation of whole-class conversations about evolving group designs, and more purposeful tutor prompts aimed at promoting the development of learning design capabilities.

3.3.2. Participants

Participants were two different cohorts of students who enrolled in EDUC261 in Session 1 of the 2017 and 2018 academic years separately. In this study, Session 1 of 2017 constituted **I2**; and Session 1 of 2018 related to **I3**. These participants were divided into two categories depending the types of data mainly collected from them. As stated in the Mixed Methods section, the current study collected two types of data: quantitative and qualitative. The major source of quantitative data consisting of TPACK pre- and post- course surveys was collected from the whole cohort of consenting pre-service teachers from each respective iteration. The qualitative data – including design conversations, Moodle artefacts, and interviews – were collected from six groups of three pre-service teachers, with three groups in each iteration. The former was referred to as *TPACK surveys participants* while the latter was labelled *Case study participants*. Note that many of the case study participants also completed the TPACK survey. The section below details how the participants were recruited and their backgrounds.

3.3.2.1. TPACK survey participants

The recruitment of the participants in TPACK surveys occurred in the following sequences. At the commencement of, as well as at the end of, EDUC261's 2017 and 2018 Session 1 offerings, students were invited to complete a pre-course and a post-course TPACK survey, at the end of which was an option for students to allow their responses to be used for study purposes. Inclusion and exclusion process included the following steps:

1. First, those who said No to the research option were excluded.
2. After that, those who responded to both pre- and post- course TPACK surveys were included.
3. Next, those who responded carelessly (e.g. selecting one option Strongly Agree throughout the entire questionnaire) were excluded.

Note that EDUC261 was an elective unit, so there were also students from other departments and faculties other than the Department of Educational Studies and Faculty of Human Sciences. These students are referred to as Planet students, who undertook the unit without the intention to pursue teacher training. Although these Planet students were not endeavouring to become pre-service teachers, they were included in the final TPACK survey cohort based on the argument that they met the perquisite criteria to enter the course, experienced the same learning design experience and conducted the same learning design practices as the other Education students — or pre-service teachers — during the course. Furthermore, pre-service teachers versus non pre-service teachers was deemed to be an interesting variable to explore in the data analysis — therefore including them in the data allowed for this analysis and enabled the holistic contribution of the Education program to be gauged (i.e. the other units beyond EDUC261).

In total, there were 90 and 110 valid responses in **I2** and **I3** respectively, making it 200 respondents for both iterations. Table 3.2 summarises background information about this TPACK survey cohort. More than two-thirds of the participants were female, were taught by more experienced tutors (as determined by the class to which they had been allocated), and had some previous practicum experience. Approximately 85% of respondents were aged 20 years and younger and studying to be pre-service teachers. The number of Planet Units (Non Education) participants accounted for just above 15% of the sample. The number of primary and secondary pre-service teachers was more or less the same (86 and 80), constituting 43% and 40% of the whole population respectively.

Table 3.2: Background of 200 TPACK survey participants

Background information		Number (out of 200)	Percentage (100%)
Gender	Female	135	67.5
	Male	65	32.5
Age	20 and younger	178	89
	21 and older	22	11
Tutors	First-time	66	33
	More experienced	134	67
Majors	Primary	86	43
	Secondary	80	40
	Others	34	17
Education or Planet Unit	PST	166	83
	Non PST	34	17
Practicum experience	Yes	66	33
	No	134	67

3.3.2.2. Case study participants

A sample of participants was selected for the case study in each iteration. In order to recruit the case study participants, 2 weeks before the Moodle group work commenced, students were asked to complete a brief online pre-Moodle task survey. A link to the Google Form-based survey was supplied in an announcement on the EDUC261 news forum. The survey questions inquired as to students' educational background (degree types, majors), their preferred syllabus area(s) and stage level to teach, their confidence with using technology in general, using technology to design learning tasks, using Moodle to design learning tasks (on a fully-anchored 7-point scale with anchor points *Strongly Agree*, *Agree*, *Mildly Agree*, *Neutral*, *Mildly Disagree*, *Disagree*, and *Strongly Disagree*), and their group work preferences. It also contained three questions relating to their willingness to take part in any study conducted during the course and to share the online resources they used and created during the design process. The purposes of the survey were, firstly, to facilitate the placement of students into appropriate design groups and, secondly, to include or exclude potential participants for the focus design groups (see Appendix 4 for the pre-Moodle survey).

Inclusion and exclusion decisions were made on the basis of the responses to the above preliminary questions. The inclusion and exclusion process involved the following steps.

1. Those who indicated that they were willing to participate in all aspects of the study were further considered.
2. Only students who were learning to become Primary teachers (Primary pre-service teachers) were selected to be consistent with the pilot study conducted in **I1**.
3. An online Participant Information and Consent Form (see Appendix 5) was then sent to the selected student participants by the Department of Educational Studies Office staff in order to avoid students feeling pressure from their tutor to participate.
4. Those students who confirmed their participation were then arranged into groups of three based on several other factors such as the class in which they were enrolled, their preferred group partners, their preferred syllabus area(s), and their confidence about using technology in general, using technology to design learning tasks, and using Moodle in particular (in the order of priority). Enrolling in the same class was number one priority criterion for the purpose of investigating collaborative learning design practices.

Data were collected from four such groups in each iteration in case one of the groups discontinued, but only three groups were included for further data analysis to be consistent with **I1**, making it six final groups of three in both **I2** and **I3**. Table 3.3 summarises background information about these six groups of three pre-service teachers.

As can be seen from Table 3.3, these 18 pre-service teachers were all primary pre-service teachers pursuing a Bachelor of Arts with the degree of Bachelor of Education at the Department of Educational Studies, Faculty of Human Sciences, Macquarie University. Although they were all at a young age (ranging from 18 to 25), **I2** had a greater number of 'older' participants in the qualitative study, with

6 out of 9 within the 21-25 age range. In comparison, **I3** had more 'younger' participants (5 out of 9) with ages ranging from 18-20. This might explain why the **I2** case study cohort had higher credit points, 24-80, with most of them being over 70 points; compared to the **I3**'s number of credit points ranging from 21-78 with nearly half of them being under 30 points.

Table 3.3 also shows that the case study participant cohort in **I2** were more experienced than that in **I3**. While two-thirds of **I2**'s participants had some practicum experience, two-thirds of **I3**'s participants did not have any practicum experience. Except for Group 2 in **I2** whose group members all participated in practicum and Group 2 in **I3** whose members had not undertaken any practicum, all the remaining groups had a mix of both people who had practicum experience and who did not have practicum experience. The differences in background of participants who took-part in the qualitative observations were a consequence of the people who volunteered. While the limitations of the different backgrounds are discussed in later chapters, the six groups of three pre-service teachers provided a reasonably consistent basis upon which to examine the practices within **I2** and **I3**.

The design topics covered a variety of syllabus areas such as Personal Development, Health and Physical Education, Geography and English (cross-curricular), Mathematics, Geography, and History. Whereas both **I2** and **I3** case study groups were generally equally confident about using technology to design learning tasks, the **I3** groups were somewhat more confident than those in **I2** about using technology in general, but somewhat less confident than those in **I2** with respect to using Moodle to create technology-enhanced learning tasks. In accordance with ethical requirements, pseudonyms have been used in order to preserve the anonymity of participants but also enable character profiles to be established.

Table 3.3: Background of 18 case study participants in I2 and I3

Iteration	Group	Name	Major (Primary PSTs)	Credit points	Age ranges	Practicum experience	Confidence about using technology			Design topics
							in general	to design LT	Moodle to design LT	
Iteration 2 (2017)	Group 1	Jessica	BABed	80	21-25	Yes	A	MA	MA	PDHPE
		Lucy	BABed	48	18-20	Yes	A	A	N	
		Alyssa	BABed	24	18-20	No	N	N	N	
	Group 2	Paige	BABed	75	21-25	Yes	MA	MA	MA	Geography and English
		Jaden	BABed	72	21-25	Yes	A	A	A	
		Layla	BABed	78	21-25	Yes	MA	MA	MA	
	Group 3	Ellie	BABed	72	21-25	Yes	SA	A	A	Mathematics
		Aria	BABed	24	18-20	No	A	A	A	
		Daisy	BABed	60	21-25	No	A	A	MA	
Iteration 3 (2018)	Group 1	Marley	BABed	72	21-25	Yes	A	MA	MA	Geography
		Evelyn	BABed	72	21-25	Yes	A	A	A	
		Millie	BABed	48	18-20	No	A	MA	MA	
	Group 2	Summer	BABed	24	18-20	No	N	MA	D	PDHPE
		Ruby	BABed	27	18-20	No	SA	A	A	
		Amelia	BABed	24	18-20	No	MA	MA	MA	
	Group 3	Zoe	BABed	21	18-20	No	SA	MA	MA	History
		Jasmine	BABed	75	21-25	Yes	A	A	N	
		Macy	BABed	78	21-25	Yes	A	A	N	
PST = Pre-service teachers LT = Learning tasks BABed = Bachelor of Arts with the degree of Bachelor of Education				PDHPE = Personal Development, Health and Physical Education A = Agree N = Neutral				MA = Mildly Agree SA = Strong Agree D = Disagree		

3.4. Data Collection Instruments

This section describes the current study's methods of data collection and types of data. Table 3.4 summarises quantitative and qualitative methods of data collection and types of data collected in the current study. A description of each instrument follows.

Table 3.4: Methods of data collection and types of data

Quantitative data		Qualitative data	
Methods of data collection	**Data**	**Methods of data collection**	**Data**
Survey	Numeric scores	Group discussions	Text from transcribed conversations and online chats
Assessment of artefacts (scores, grades)	Numeric scores	Semi-structured interviews	Text from transcribed interviews

3.4.1. Quantitative methods

3.4.1.1. Surveys

Schmidt et al.'s pre-service Teachers' Knowledge of Teaching and Technology (TKTT) self-reported survey (2009) was selected as the instrument to collect participants' self-assessed TPACK competencies across the cohort and across the iterations. It was selected because it has been used and gauged by many scholars (Papanikolaou et al., 2017; Tondeur et al., 2020; Valtonen et al., 2019; Young et al., 2013) in the TPACK development measuring studies and was claimed as a reliable and valid measure of TPACK that "encompasses most of the aspects of TPACK associated with pre-service teacher education" (Young et al., 2013, p. 154).

The original TKTT survey consists of nine demographic questions and 47 TPACK question items. The current study made some adaptations to the original survey in terms of demographic questions so that it was suited with EDUC261's schedules and Macquarie University's study programs. Specifically, the survey asked seven demographic questions pertaining to participants' (1) gender, (2) age, (3) the tutorial class they were in, (4) the degree programs they were enrolled in, (5) whether or not they were enrolling EDUC261 as an Education or a Planet Unit student, (6) how many credit points they had completed on their programs, and (7) whether or not they had completed any practicum experience.

Because the survey was conducted at the commencement and completion of the unit in each iteration, examining the change in pre-service teacher responses could provide an indication of the way teacher educators' pedagogical strategies had an impact on pre-service teachers' TPACK development (Research Question 4.1). However, the above demographic factors were taken into consideration to provide a clearer picture of what else might influence the participants' knowledge and skills' development and how similar or different the changes were within each group of variables (e.g. age, gender, tutors, practicum experience, etc.).

Identical to Schmidt et al.'s TKTT survey (2009), the current survey had 47 question items seeking responses to Technological Knowledge (7 questions), Content Knowledge (12 questions), Pedagogical Knowledge (7 questions), Pedagogical Content Knowledge (4 questions), Technological Content Knowledge (4 questions), Technological Pedagogical Knowledge (5 questions), and Technological Pedagogical Knowledge (8 questions). The survey was scored on a fully-anchored 5-point Likert scale with anchor points *Strongly Disagree*, *Disagree*, *Neither Disagree/Agree*, *Agree*, and *Strongly Agree*. The pre- and post-course TPACK surveys were identical in questions. For the complete survey, see Appendix 6.

3.4.1.2. Assessment of artefacts

Assessment of learning design artefacts in the current study related to the Moodle-based online courses and justifications that students submitted for their major assignment task. These submissions were evaluated by a tutor on the unit and inter-rater reliability measures were used to establish the reliability of those evaluations (see Section 3.9). The quantitative, numeric assessment data are referred to as factual information typically found in school grade reports, student records, and other computative and measurable data (Creswell, 2015). These data helped cast light on the relationship between the learning design process and product as well as the impact of the teacher educators' interventions on the pre-service teachers' knowledge (Research Question 2 and Research Question 4.3). More information about how the Moodle courses and justification were assessed and the corresponding analysis can be found in Section 3.8 and Section 3.1.2.

3.4.2. Qualitative methods

3.4.2.1. Group discussions

Group discussions are frequently used in learning design studies as a method for collecting data (Boschman et al., 2015; Koh & Chai, 2016; Nguyen & Bower, 2018). Like other kinds of group discussion, they provide rich and authentic data (Kitzinger, 1994). There might be more meaning within the data than direct interviews due to the spontaneity of the conversations especially when the discussions happen 'live' involving interactions between the group members (Flynn et al., 2018).

The group discussion data utilised in this study is different from focus group data due to the more passive role of the researcher although both methods aim to collect data from a collective and collaborative activity. Focus group discussions are "organised to explore a specific set of issues" (Kitzinger, 1994, p. 103), in which the researcher joins the group discussion and plays a guiding, monitoring and facilitating role (Gill et al., 2008).

Group discussions in the current study included face-to-face design conversations happening in the classroom and online design conversations occurring on Facebook Messenger group chats. The former captured the pre-service teachers' 'live' design thinking over a certain period of time in a compulsory discussion task in each Moodle week. The latter also captured their 'live' thoughts in a sense and was complementary to the face-to-face interactions insofar as the online chats happened any time during the day and any day during the week, adding an additional dimension to the characteristics of their design processes. In this technique, the only role the researcher played was to set up a voice recording system that facilitated the audio recording of group discussions in the on-going classroom context. This source of data mainly facilitated the answering of Research Question 1 relating to pre-service teacher focuses during their group work projects.

3.4.2.2. Semi-structured interviews

Semi-structured interviews were chosen as a follow-up step to confirm and clarify the findings emerging from design conversations in this study since they are flexible and allow space for any topics of interests arising that might be helpful for the research purposes (Gill et al., 2008). That is, beside the pre-defined questions, the interviewer can ask the interviewee to elaborate on one or more responses.

The interview questions for the pre-service teacher participants were divided into three parts. The *firs*t part aimed to elicit the participants' descriptions of the design process of the whole group as well as their individual lessons. While answering the questions in this part, the interviewees could look at and explore their Moodle module on the computer screen. The purpose was to have them recall what they did during the design process and gradually engage them in the interview. The *second* part of the interview sought answers to the questions regarding the positive and negative experiences during the collaborative design and their references to pedagogy in the design process. The *third* cluster of questions covered some questions relating to influence, such as "What were the major factors that led to changes that you experienced throughout the semester?" This question sought students' responses to teacher educators' interventions and the revised pedagogical strategies implemented as part of the redesign of EDUC261 across iterations. Answers to this type of question also had the potential to shed light on other sets of data such as design conversations, students' scores and grades, and TPACK surveys. See Appendix 7 for the interview questions.

3.4.3. Mapping research questions to methods of data collection and types of data

Table 3.5 below offers a summary of how each research question was mapped to certain data collecting methods and types of data.

Table 3.5: Research questions mapped to data collection instruments

Research questions	Corresponding instruments
1. What elements do pre-service teachers focus upon when collaboratively designing technology-enhanced lessons?	Group discussions (text)
2. What factors support and/or hinder the collaborative design of pre-service teacher technology-based lessons?	Group discussions (text) Follow-up interviews (text)
3. Are there any relationships between pre-service teacher learning design practices and the characteristics of their final online artefacts?	Design conversations (numerical – distribution frequencies) Assessment of artefacts (scores of PK, TK, CK, Context)
4. What are the impacts (if any) of the pedagogical strategies of teacher educators upon pre-service teacher knowledge (1), learning design processes (2) and artefacts (3)?	(1) TPACK surveys (numerical) (2) Group discussions (numerical – frequencies) (3) Factual information (grading rubric for online artefacts)

These data collection instruments and sources of data assisted in answering each research question as follows.

<u>Research Question 1</u>: To identify what elements pre-service teachers focus upon when designing technology-enhanced learning lessons in groups, their in-class and online ***design conversations*** were recorded and analysed.

<u>Research Question 2</u>: To identify what factors support and/or hinder the collaborative design of pre-service teacher technology-based lessons, **semi-structured interviews** with student participants were carried out. The participants' **design conversations** were also explored to capture any arising problems or emergent supporting factors.

Research Question 3: To identify whether there were any relationships between pre-service teacher learning design practices and the characteristics of their final online artefacts, the quantified **design focuses** were correlated with the corresponding participants' **scores of their online artefacts**.

Research Question 4: To identify the impacts (if any) of the pedagogical strategies of teacher educators upon pre-service teachers' knowledge, **TPACK survey** results were analysed to find out the changes in pre-service teacher TPACK competencies across and over the years; their learning design processes, distribution frequencies of **design focuses** between two iterations were analysed and compared; and artefacts, design focuses and participants' **final grades** correlated.

More details regarding when, where, how, from whom and in what order each source of data was collected through the whole multiphase mixed methods research process is presented in the next section.

3.5. Mixed Data Collecting Procedure

3.5.1. Ethical considerations

While recruiting participants, collecting data, and analysing data, the researcher fully conformed to the ethics permissions granted by the Macquarie University Human Ethics Committee (Ref. 5201600079, see Appendix 8 for the ethics approval granted to the current study). Great care was exercised during the participant recruitment process, as stated in Section 3.3.2, to avoid a direct personal approach from the researchers to the potential participants. The following processes were taken to mitigate real or perceived coercion.

- Student participants were guaranteed that their progression during the course would not be affected and that there would be no potential risks.
- Consent forms were only sent to those students who showed the willingness to participate in the study on the basis of their responses to the pre-Moodle module survey.
- Consent forms were sent via the third party, the Department of Educational Studies office staff.

- Student participants were made aware that they could withdraw from the study at any time without needing to provide a reason and without consequences.
- The follow-up interviews were not conducted and analysed until the course had completed and the final results had been issued.
- Data were not revealed to any other third parties other than the ones specified in the ethics permissions.
- Publication of results will not identify students in any way. A pseudonym was used for each participant.

3.5.2. Process of collecting mixed data

The two types of data, qualitative and quantitative, in this study were not collected sequentially because the findings of one type of data did not determine what, when, where, and from whom to collect the other type of data and vice versa. Instead, each set of data was collected in the sequences of time in which the unit EDUC261 learning activities occurred. Figure 3.3 shows how each set of data was collected in the order of time from the beginning until after the end of the course.

As can be seen, mixed data collection procedures in two phases of this multiphase mixed methods research or two iterations of this DBR were identical. That is, in both periods of time, data collection took place before, during, and after the Moodle weeks.

First, a set of quantitative data — TPACK pre-course surveys — were collected at the start of the course. Because completing the survey was part of Tutorial 1's learning activities, link to the Google Forms-based online survey was shared on the EDUC261 platform inside iLearn which houses the course's online resources and activities, so that all EDUC261 students of the semester could access it. Each participant had approximately 10 minutes to complete it. Responses to the survey questions were automatically collected using a Google spreadsheet which was conveniently downloaded as an Excel file and transferred to an SPSS file for later analysis. Only those students who response was "Yes" to the research question at the end of the survey were selected for analysis.

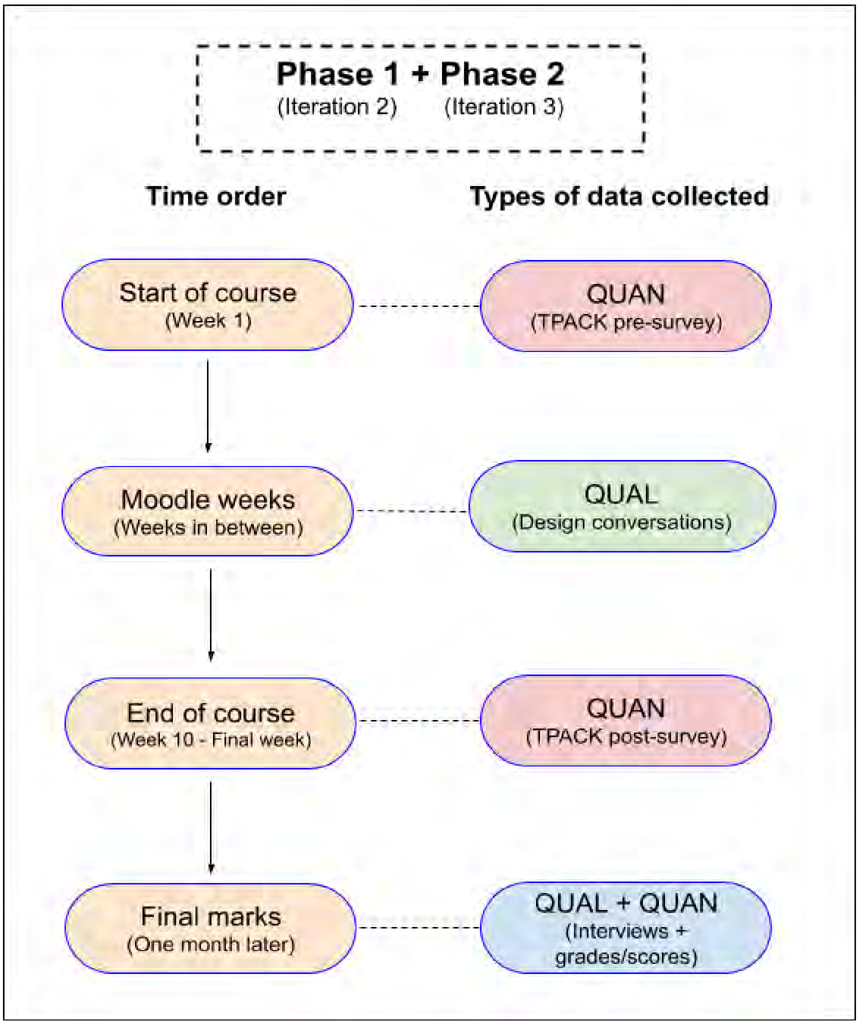

Figure 3.3: Mixed data collection in the order of time over course

Then, a set of qualitative data relating to the design conversations was gathered. The recording of group discussions took place every Moodle week, from Tutorial 6 to Tutorial 10 (5 weeks) for **I2** and from Tutorial 6 to Tutorial 10 plus the last review week (6 weeks) for **I3**. The recording was conducted with six groups of pre-service teachers in both phases who agreed to participate, volunteered to have their Moodle design activities recorded, and agreed for their related online resources such as Facebook chats, scores, grades, and so on, to be gathered. These groups completed the EDUC261 Moodle design task in exactly the same way as their peers did. Like other groups, the selected groups were given 25 minutes on average in **I2** and 40 minutes on average in **I3** to collaborate. When it came to the Moodle task group discussion time, each group would sit at a desk prepared for them. Three headsets with a microphone were plugged into a computer on the desk, on which the OBS recording software was installed to record their conversations. The microphones were connected to the app in a way that enabled everyone's voice to be recorded, and an audio file saved in the app as soon as the recording ended. At the start of each recording session, the participants were asked to introduce themselves and say an extended sentence to minimise the difficulties of recognising their voices during the transcription process. A small recorder was used for each group as backup in case there was something wrong with the voice recording app or the microphone settings.

When it came to the last week of the course (Tutorial 10), students were asked to complete the post-course TPACK survey as a course activity. Where, how, by what means, and from whom the survey was conducted were exactly the same as the pre-course surveys.

The follow-up one-to-one interviews — another set of qualitative data — were conducted after the course completed and students had received their grades. These interviews were not collected or analysed until the final results had been released in order to mitigate any perceived conflicts of interest. The interviews were flexibly organised in various modes, either in person or online (e.g. via Skype), to match participants' availability; however, all the participants chose a face-to-face interview at the researcher's office. Appointments were also made based on the participants' availability. In **I2**, all nine participants of the three groups attended the interviews while there were six (two in each group) choosing to participate in **I3**, resulting in 15 interviews occurring. The interviews were 25-50 minutes each and were all audio-recorded before being later transcribed.

Also, after the final marks were issued, one more set of quantitative data was collected. This included scores and grades of the 18 case study participants' Moodle artefacts which could be respectively found in Turnitin, a plug-in for submitting and marking assignments, and in the EDUC261 iLearn Gradebook.

Table 3.6 below describes the amount of mixed data collected over two phases/iterations to be processed and analysed.

Table 3.6: Amount of data over two iterations

	Phase 1/I2	Phase 2/I3	Total	Length (each)
Surveys (Pre + Post)	110 x 2	90 x 2	400	8 TPACK variables represented by 47 Likert scale items plus demographic data
Class discussions	15	18	33	**I2**: 25 mins; 1000-4000 words **I3**: 40 mins; 1500-6500 words
Online chats	27	21	48	500 words on average
Interviews	9	6	15	20-45 mins 2000-6000 words
Online artefacts	9	9	18	Assessment of Moodle assignments and corresponding justifications
Total	280	234	**514**	

In total, there were 400 surveys, 33 transcripts of in-class discussions, 48 online chats, 15 interviews, and 18 artefacts, resulting in a total of 514 data items to be collected, screened, and analysed. The process of analysing these sets of mixed data is presented below.

3.6. Mixed Data Analysis Procedures

The procedures of analysing mixed data in this study were conducted in the order of when the sets of data were available and ready to be analysed. In this order, Research Questions 1 and 2 were answered first, followed by Research Questions 3 and 4, because the scores and grades needed for the analysis relating to the last two questions were not collected until the final marks of both iterations had been issued. The diagram below (Figure 3.4) summarises the analysis process. A brief description of how each set of data was analysed is provided below, with further details provided in Section 3.7 to Section 3.1.2.

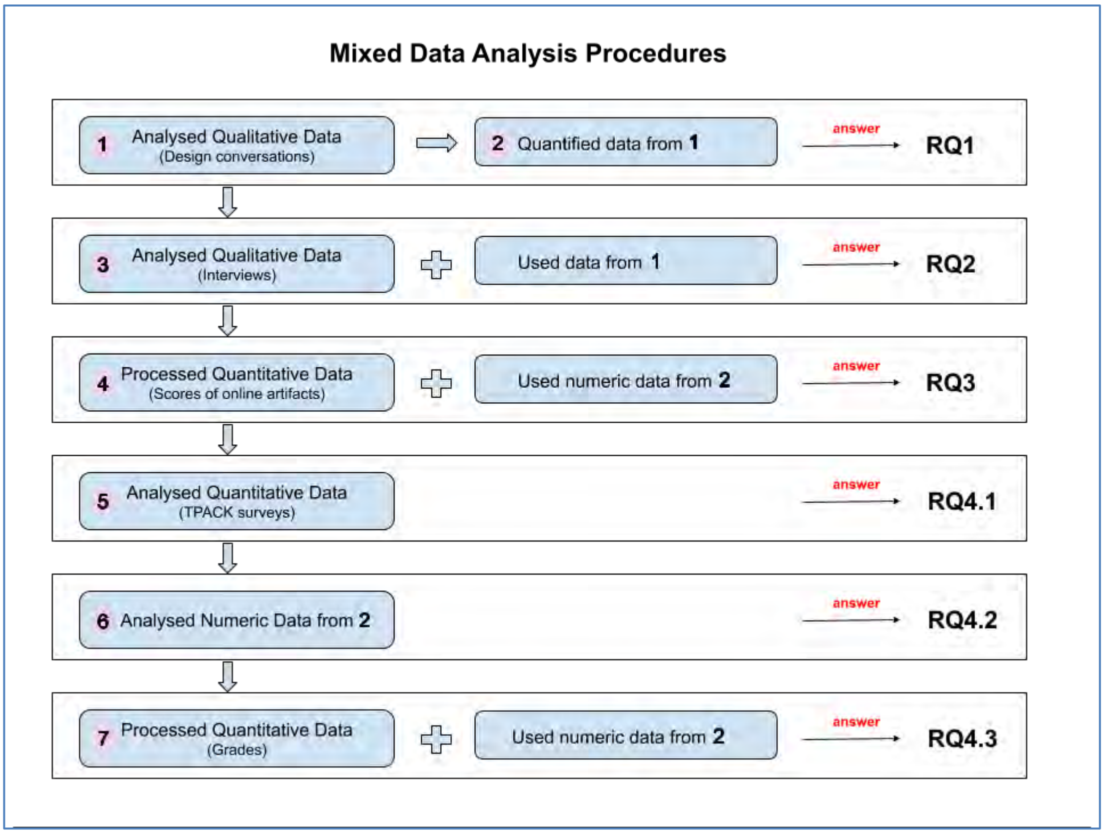

Figure 3.4: Mixed data analysis procedures

To start, the qualitative data of design conversations were coded using a thematic analysis approach (Step 1). After that, the qualitative data were quantified by turning the units coded into counts and percentages via certain NVivo commands (Step 2). These numbers were extracted from NVivo into Excel spreadsheets, from which various pie charts and tables were created to support the report on the findings to Research Question 1 (What elements do pre-service teachers focus upon when collaboratively designing technology-enhanced lessons?).

Some themes emerging from Step 1 contributed to answering Research Question 2 (What factors support and/or hinder the collaborative design of pre-service teacher technology-enhanced lessons?). Follow-up interviews were analysed also using the thematic approach (Step 3) to confirm these themes and to discover more answers to Research Question 2.

The above three steps were carried out in **I2** and then repeated in the same way in **I3**. The combined quantified data in Step 2 were the foundation for numerous statistical tests in the next steps.

After that, scores of 18 case study participants' online artefacts were arranged into tables (Step 3) together with their design focuses, and analysed in Excel using Regression tests. The purpose was to explore the relationships between the characteristics of pre-service teachers' final online artefacts with their learning design practices (Research Question 3).

Afterwards, the TPACK surveys were not analysed until pre- and post-course data were fully collected in both iterations. Fitting the survey data to a Linear Mixed Model helped the researcher understand the changes in pre-service teachers' TPACK across the cohort and over the iterations (Research Question 4.1).

Next, the distribution frequencies of design focuses in **I2** and **I3** identified from Step 1 were compared using Chi-square tests to explore the impacts of teacher educators' pedagogical strategies upon pre-service teachers' learning design processes (Research Question 4.2).

Finally, grades of pre-service teachers' final artefacts in **I2** and **I3** were compared to examine the impact of teacher educators' pedagogical strategies upon pre-service teachers' artefacts. The next section will describe in detail each of the above steps in the order of research questions.

3.7. Analysing Data for Research Question 1

3.7.1. Initial data management

Qualitative data required for Research Question 1 included transcripts of recordings and group Facebook chats. All the related data including the audio recordings were stored, managed, and analysed in NVivo 11, a well-known software package for analysing qualitative data.

A professional transcription service specialising in groupwork transcriptions was used to transcribe all in-class recordings (and follow-up interviews for Research Question 2). The researcher then listened to every recording and corrected the transcripts where necessary to make sure that no information was missing. This simultaneously provided the researcher an opportunity to acquire a sense of the data. After that, the researcher read each transcript carefully again and made sure that words were correctly spelled and sentences were grammatically structured, by which time the researcher was more familiar with the data. During this transcribed data reviewing process, the sentences in the design conversations were carefully demarcated in order to facilitate accuracy in the coding work that followed.

After that, other formatting settings in NVivo were adjusted to facilitate analyses. For example, the style of each participant's name was changed to Heading 4 so that each individual was auto coded and data under each individual label could be exported accordingly (see Appendix 9 for a transcript of a design conversation and Appendix 10 for one of an interview). NVivo 11 was used to organise data and perform analysis because of its capability to efficiently manage numerous sets of data including text, audio, image, and so on (Bazeley & Jackson, 2013; Yin, 2013), to work with a large amount of text, assist the depth and sophistication of analysis (King, 2004), as well as facilitate many aspects of a qualitative study "from the design ... through to the analysis of data, ... and presentation of findings" (Hutchison, Johnston, & Breckon, 2010, pp. 299-300). Plus the nodes "provide 'a simple to work with structure' for creating codes and discovering themes" (Zamawe, 2015, p. 14). Moreover, "... the presence of nodes in NVivo makes it more compatible with ... thematic analysis approaches" (Zamawe, 2015, p. 14). This last point will be explained in more detail in the next section.

3.7.2. Thematic analysis

As "a method for identifying, analysing and reporting patterns (themes) within data" (Braun & Clarke, 2006, p. 79), thematic analysis was used to analyse the qualitative data. It was chosen for the study because it represents a generic, foundational method across qualitative approaches (Nowell et al., 2017), is widely used, theoretically flexible and can detail the description of data in a rich yet complex way, which then allows for interpretations of various aspects of the researched topic (Braun & Clarke, 2006).

Conducting thematic analysis involves looking for patterns of meaning within data, classification of data extracts, and constant comparison between the data being produced with the original dataset (Braun & Clarke, 2006). Therefore, it is helpful in the examination of various participants' perspectives, exploration of similarities and discrepancies, and the attainment of unexpected insight (Braun & Clarke, 2006; Nowell et al., 2017) . This usage was of great help to this study which aimed at looking for patterns within the pre-service teacher groups' design processes, and identifying the factors supporting as well as inhibiting their design practices.

In parallel with adopting the thematic analysis, qualitative researchers have incorporated the concept of trustworthiness into analysing qualitative data in an attempt to make qualitative findings more valid and the data analysis approaches easier to follow (Maguire & Delahunt, 2017; Nowell et al., 2017). The researchers' concept of trustworthiness was reflected through data analysing procedures that had a logical and clear flow with detailed and systematic documentation. It was also reflected through critical reflections, thoughtful explanations, triangulation and continuous engagement with the data (for more information about all the criteria, refer to Nowell et al. (2017).

Both Maguire and Delahunt (2017) and Nowell et al. (2017) used Braun and Clarke's six-phase thematic analysis guide (2006) to maintain the trustworthiness throughout the process of analysing the qualitative data. This study adopted the same approach; that is, the trustworthiness criteria as specified above were interlaced throughout a description of how the researcher attempted to carry out a trustworthy thematic analysis in NVivo. Table 3.7 highlights how the researcher of this study made an effort to maintain the trustworthiness during each phase of thematic analysis. The table was adapted from Nowell et al. 's analysis (2017, p. 4).

Table 3.7: Establishing trustworthiness during each phase of thematic analysis

Phases of thematic analysis	Means of establishing trustworthiness
Phase 1: Familiarising yourself with your data	Prolong engagement with data
	Triangulate different data collection modes
	Starting a coding manual
	Document thoughts about potential codes
	Store and organise data in NVivo
	Set up a parent node system in NVivo
Phase 2: Coding	Developing a coding framework
	Reflexive journaling
	Using a coding framework
	Documentation of code generation
Phase 3: Searching for themes	Detailed notes about development and hierarchies of concepts and themes
	Diagramming to make sense of theme connections
Phase 4: Reviewing themes	Returning to original framework for comparing
	Revisiting codes and sub-codes
Phase 5: Defining and naming themes	Documentation of theme naming
	Documentation of meetings regarding naming themes
Phase 6: Producing the report	Describing process of coding and analysis in sufficient detail
	Referring to all reflective journaling
	Reporting on rationales for different choices and decisions

The thematic analysis method as introduced by Braun & Clarke (2006) adopted in this study and presented in Table 3.7 with detailed descriptions following each phase is actually not as linear and six-phased as it appears because there involved a constant moving back and forth between phases and reflections developed over time in the whole process. The next section will detail the whole six-phased procedures conducted by the researcher using NVivo 11. The sets of data analysed were the qualitative set consisting of transcripts of the participants' in-class design conversations, online Messenger group chats, and interviews with them.

3.7.3. The step-by-step approach to conducting trustworthy thematic analysis in NVivo

3.7.3.1. Familiarising with data

In addition to storing data in safe places and organising them neatly, this phase necessitated the researcher's self-immersion in the data. Through immersion in the data, the researcher became familiar with all aspects of the data, made initial sense of the depth and breadth of the content, and quickly shaped initial ideas and identification of possible patterns in accordance with Braun and Clarke (2006) and Nowell et al. (2017). This was especially helpful for the researcher because she had become familiar with this type of data in the pilot study and could quickly feel intimately involved with it. In fact, a brief summary of each team's weekly main activities was made during this phase, providing a general picture of the design process patterns, which was helpful for more analyses enabling more specific patterns to surface in the next steps. There were also some exciting moments when the researcher identified potential themes which might be different from the existing pre-determined ones.

One important move at this step was to decide on segments of data to which codes could be assigned. A segment (also called a text segment) is a data extract (which can be phrases, sentences, or paragraphs) that carries a unit of meaning relevant to the phenomenon under investigation (Braun & Clarke, 2006; Creswell, 2015). For the in-class design conversations and Facebook instant messages, sentences were chosen as units of analysis due to their characteristics as fine-grained units, providing greater distributions of codes, enabling the emergence of patterns of collaborative design and issues related to it (Bower, 2009). Also, breaking down transcribed textual data by sentence showed that syntactical differences rather than semantic differences were used to identify the textual units and therefore introducing bias to the data prior to coding could be avoided (Koh & Chai, 2016).

The chats in Facebook Messenger were all instant messages sent among the group chat members, who were also the participants, therefore the original texts' syntax had to be considered. In this case, to separate the sentences, the researcher either based it on the punctuation (stops, question marks, exclamation marks) used by the participants, or applied an "invisible" dividing line where the participants typed a big chunk of text without any punctuation marks signalling the end of the sentences. How the participants used the Enter key to break a new line without punctuating helped the researcher decide the border between two sentences as well.

This phase also involved preparing NVivo for coding by setting up a preliminary coding framework consisting of pre-determined themes identified from the literature review as well as from the pilot study carried out by Nguyen (2016). A detailed description of this initial framework will be provided in the next phase.

3.7.3.2. Coding

Braun and Clarke (2006) named this phase *Generating initial codes*. The researcher modified the name to Coding because, in the researcher's opinion, the phase involved more than just producing initial overarching codes. This phase was central to the whole data analysing process, where a comprehensive coding framework was gradually and ultimately developed, which, when each step was done with care and consideration, was likely to enable themes or patterns to surface. In other words, it involved generating accurate codes that identified important features of the data that might be relevant to answering research questions, as well as coding the entire datasets, and after that, aggregating all the codes and all relevant data extracts together for later stages of analysis.

A code is defined as a label (normally in words or phrases) that describes accurately the feature and meaning of the segment it is tagged to (Braun & Clarke, 2006; Creswell, 2015). Codes can be stated in the participants' words, phrased in educational terms or written in the researcher's own words (Creswell, 2015). Segments of data conveying the same meaning are given the same code, and a new code is created and assigned to any new segment whose meaning does not fit in the codes previously created. A code is used interchangeably with a category in this study because, like a code, a category refers to "the descriptive level of text and is explicit manifestation of the participants' account" (Vaismoradi et al., 2016, p. 102).

The coding scheme for the transcripts of design conversations, both in-class and online, in this study was based on two different coding protocols. The first protocol was the one used in the pilot study (Nguyen, 2016), as shown in Table 3.8. The current study was a continuation from Nguyen's study (2016) which also examined pre-service teachers' actual design processes via exploring their 'live' design conversation. It was composed of the following categories resulting from the data analysing process.

Table 3.8: Nguyen's coding scheme (2016)

	Categories	**Definitions**
1	Content	Discussions related to subject content such as subject areas, learning outcomes, content dot points and resources
2	Technology	Discussions related to the use of technologies
3	Pedagogy	Discussions related to different pedagogical approaches
4	Context	Discussions related to the potential school
5	Learners' characteristics	Discussions related to potential learners
6	Others	Discussions on topics not belonging to any above categories (e.g. *Structuring a lesson*, *Scheduling*, *Allocating tasks*, and *Establishing a common-ground knowledge*)

The second protocol was adopted from Koh and Chai (2016), as summarised in Table 3.9 below. The Nguyen framework was selected to promote conceptual continuity from the **I1** pilot study. The Koh and Chai framework was selected as one of the only contemporary and rigorous attempts to code teacher technology-enhanced learning design discourse. Koh and Chai are two of the most eminent researchers in the pre-service teacher education field, and their framework also aligns with the TPACK nature of this study.

Table 3.9: Koh and Chai's coding scheme (2016)

	Categories	**Definitions**
1	Technological knowledge (TK)	Discussions related to the use of technological tools
2	Pedagogical knowledge (PK)	Discussions related to the use of pedagogical strategies
3	Content knowledge (CK)	Discussions related to subject content
4	Pedagogical content knowledge (PCK)	Discussions related to the pedagogies related to subject-content that do not involve the use of ICT
5	Technological pedagogical knowledge (TPK)	Discussions related to how ICT can be used to support particular pedagogies
6	Technological content knowledge (TCK)	Discussions related to content-based ICT tools or the use of ICT for content representation
7	Technological pedagogical content knowledge (TPACK)	Discussions related to the use of ICT to support particular pedagogies for particular subject content
8	Design knowledge (DK)	Discussions related to the design process

As can be seen from Table 3.8 and Table 3.9, the categories of Content, Technology, and Pedagogy in Nguyen's study were respectively similar to Content Knowledge (CK), Technological Knowledge (TK), and Pedagogical Knowledge (PK) in Koh and Chai's study in the way that they referred to the discussions pertaining to subject matter content, the use of technologies, and the use of pedagogical approaches respectively. In addition, Nguyen's list has a category called *Others* encompassing such sub-categories as *Scheduling*, *Allocating tasks*, and *Establishing a common-ground knowledge*. These sub-categories are quite similar to those that Koh and Chai found under the category of Design Knowledge (DK) related to which design process to adopt, how to choose their design goals, how to organise the storage of their design draft, and how to allocate the design work among themselves. They are similar in that they are related to the participants' design strategies rather than other knowledge elements. An important point to note was Chai and Koh did not identify any discussions related to context and learners' characteristics in their study while Nguyen did.

Therefore, upon combining the two protocols together, this current study adopted a preliminary coding framework including 10 initial categories as shown in Table 3.10.

Table 3.10: Preliminary coding framework of the current study

	Categories	Definitions
1	Technological knowledge (TK)	Discussions related to the use of technological tools.
2	Pedagogical knowledge (PK)	Discussions related to the use of pedagogical strategies generally and certain specific approaches.
3	Content knowledge (CK)	Discussions related to subject content.
4	Pedagogical content knowledge (PCK)	Discussions related to the pedagogies related to subject-content that do not involve the use of ICT.
5	Technological pedagogical knowledge (TPK)	Discussions related to how ICT can be used to support particular pedagogies.
6	Technological content knowledge (TCK)	Discussions related to content-based ICT tools or the use of ICT for content representation.
7	Technological pedagogical content knowledge (TPACK)	Discussions related to the use of ICT to support particular pedagogies for particular subject content.
8	Design knowledge (DK)	Discussions related to the design process.
9	Context	Discussions related to potential school-related issues.
10	Learners' characteristics	Discussions related to potential learners.

An abductive approach to coding was applied, which involved both inductive and deductive approaches. That is, although there was a pre-determined list of categories, the researcher was prepared for any unexpectedly emerging categories. Table 3.11 shows an extended coding framework for the design conversations that includes names of codes, the meanings identified by them, and examples of the coded segments. It is the result of several months each year in 2 years working on transcripts of 15 and 18 in-class design conversations in **I2** and **I3** respectively (approximately 3000 words on average each), 27 and 21 Facebook Messenger chats in **I2** and **I3** respectively (on average approximately 500 words each).

Table 3.11: The extended coding framework for design conversations

	Main codes	Meanings (sub-codes)	Examples
1	**Technological knowledge (TK)**	Discussions related to the use of technological tools.	*Can the colour of graphs be changed on this app?*
		- Usage of tools	- *Is there a bit in Moodle where you can speak and record something?*
		- Combination of tools	- *I am just trying to think if there is a way to incorporate all the communication modes.*
		- Choosing and searching for tools	- *Before we do that, do you want to look at digital sandbox and figure out which one we want to because there are four of them that we could use?*
		- Comments on/Understanding about technology	- *It [Powtoon] may be similar to the cartoon comic strip in that there will be a number of slides.*
2	**Pedagogical knowledge (PK)**	Discussions related to the use of pedagogical strategies.	*We can use reciprocal teaching here.*
		- Discussing teaching strategies	- *One of my lessons is going to have a quiz at the end.*
		- Mentioning and elaborating certain pedagogical approaches	- *Let's say Social Constructivism because I feel like that encompasses Constructivism.*
		- Pedagogies in Justification	- *So, the pedagogies for the justification, have you thought about yours yet?*
		- Class management	- *They have 15 minutes to research, then they have to get it done.*
		- Assessment	- *So formative is what you do as you're going throughout the unit to assess their learning and summative is what you do at the end of the unit.*
3	**Content knowledge (CK)**	Discussions related to subject content.	*Salt can be used to lower the temperature of ice.*
		- Mentioning subject content	- *Are you keen on Maths or English?*
		- Selecting content (resources)	- *Plus, for EDUC371 there's the whole phonics stuff and we can probably incorporate some of that to.*
		- Understanding of subject content	- *English is good. You can integrate other stuff.*
		- Types + ideas of learning tasks and activities	- *We can do things like people's perceptions of places.*
		- Choosing learning outcomes	- *Do we need to pick specific outcomes?*
		- Selecting design topics	- *We'll choose a topic first. What are your strengths, guys?*

	Main codes	Meanings (sub-codes)	Examples
		- Teaching and learning scenarios	- *Because it says "unsafe environments" with an 's', do you want to stick with one environment or a multiple environment?*
4	**Pedagogical content knowledge (PCK)**	Discussions related to the pedagogies related to subject-content that do not involve the use of ICT.	*Do you want students explain this to you so that you can assess their understanding?*
			- *Since the initial idea was to engage with this event/debate in history critically so that students would be able to think critically about current events/debates, maybe we should include something about this in Lesson 6 - Slight Chance of Tact.*
5	**Technological pedagogical knowledge (TPK)**	Discussions related to how ICT can be used to support particular pedagogies.	*Students can teach themselves through an app.*
			- *It makes it easier for student assessment while bringing modern tech into the classroom*
6	**Technological content knowledge (TCK)**	Discussions related to content-based ICT tools or the use of ICT for content representation.	*We can ask the students to video record their explanation of this math problem.*
		- Use of ICT for content representation	- *It [English] would probably work better with the Moodle format.*
		- Mentioning technology and content	- *I think I did it [a tool in discussion] when I did Japanese.*
		- Content-based ICT tools	- *They can do things like surveys.*
7	**Technological pedagogical content knowledge (TPACK)**	Discussions related to the use of ICT to support particular pedagogies for particular subject content.	*We will video-record the steps for solving this problem of Peter and post it on the social learning wall: After selling 2/5 of the eggs, Peter has 100 eggs in the bag. How many eggs did he have at first?*
			- *My thought was using it [an app] for the instructional video, where students choose their scenario to talk about and provide/present the emergency procedure for that scenario using their voice to explain the steps to take.*
8	**Design knowledge (DK)**	Discussions related to the design process.	*Let's identify the resources we need for this lesson.*
		- Steps in a design process	- So maybe we should leave the module aims and

	Main codes	Meanings (sub-codes)	Examples
9			come back to that when we have a better idea of what exactly we are going for.
		- Organising storage/Taking notes of design drafts/ideas	- *Should we make this into like a Google Document so we all can edit it?*
		- Allocating tasks	- *How do you want to do the PowerPoint? Should each of us do a part?*
		- Structuring a course or a lesson on Moodle	- *So we can probably just do it in two consecutive sections, not consecutive but two consecutive days or something like that.*
		- Scheduling and setting goals	- *Do you guys want to plan to meet up?*
		- Establishing a common ground awareness	- *Let's refresh our memories of what we were talking about with the English stuff because I can't even remember.*
		- Selecting year group	- *Let's choose what Stage first.*
		- Comments on current assignment	- *How long would the module have to go for?*
		- Comments on group work	- *We are getting through this pretty fast.*
		- Creating a group communication channel	- *We should probably have a communication about who is doing what using Facebook.*
		- Browsing or navigation during designing	- *You can press the arrows and they can show you where to go.*
		- Moodle design and aesthetic ideas	- *Going to make it [the group's online artefact] look pretty.*
9	**Context**	Discussions related to society, potential school, learner cohorts, facilities	Not present in Nguyen's (2016) and Koh and Chai's study (2016)
		- School (past, potential)	- *In my last school what they did was they actually had two separate maths groups.*
		- General questions about context in LDG	- *What is the context [of our online module]?*
		- Potential learner cohort	- *He said our context was like mixed abilities, mixed socio-economic statuses.*
		- Knowledge of NSW primary curriculum	- *In school do they aim to do one hour of tech a week or is it two hours of tech a week?*
10	**Learners' Characteristics**	Discussions related to potential learners benefiting from the design.	*Eight-year-old kids could deal with sorting objects and finding some features of living things*

	Main codes	Meanings (sub-codes)	Examples
		- Learners in relation to Moodle design	- *Is it [displaying course description] too much information though for kids?*
		- Age	- *Just bear in mind that they are Early Stage 1, so it's really going to need to be something simple.*
		- Interests and preferences	- *The kids would love fake news.*
		- Learners in relation to pedagogy	- *We've just got to make sure they [the kids] are very guided in a right way [and] scaffolded well.*
		- Learners in relation to content	- *They [the kids] are obsessed [with TBN].*
		- Learners in relation to technology	- *Would Early Stage 1 be able to use technology like a Moodle page?*
11	**Hindering factors**	Discussion related to hindrances participants encountered while designing in groups	Not present in Nguyen's (2016) and Koh and Chai's study (2016)
		- Lack of technological skills	- *I don't know how to set it [Google Docs] up.*
		- Computer and internet problems	- *My computer is a bit slow at the moment.*
12	**Supporting factors**	Discussion related to supporting factors participants received while designing in groups	Not present in Nguyen's (2016) and Koh and Chai's study (2016)
		- Group support	- *I'll have a look for you tomorrow.*
		- Tutor support	- *So we're asking him [tutor] about what we can use and what we actually really need to include.*
		- Educational past experience	- *When I did my lesson on it the other day, the one piece of advice that my teacher gave me was that you should kind of in a way not trick the students, but get them pre-engaged in Morocco and then bring out this book that has Morocco in it.*
		- Unit's resources and activities	- *I am excited [about the activity because] I need feedback.*

There were several important points to note with respect to Table 3.11. *First*, there were two levels of coding; that is, there was one level of child nodes to the corresponding parent nodes in NVivo. Hierarchical coding is beneficial in a way that the higher-order codes offer an overarching concept while lower-order codes clarify and justify the higher order codes or the main categories (King, 2004). In the current study, level-2 codes functioned as elements that, if put all together, created an operational definition of the level-1 code. This current study found 2-level coding useful and did not try to delve further into level 3 or 4 to avoid the confusion and challenges in data organisation and interpretation (King, 2004).

Second, some codes such as *Learners' characteristics* (LC) were double coded; that is, LC was a separate layer and not counted in the total number of the remaining codes for knowledge elements. Most of the time, the participants discussed LC in relation to one of the TPACK constructs. For example, this sentence, "Maybe we should design some extra parts to tasks which will allow for students to equally participate regardless of language background", was coded as both LC and CK because the discussion was on what type of learning tasks (CK) to create to be suited to the potential learners' diverse language capacity (LC). Similarly, "It's bright for young kids" was coded as both LC (consideration of potential learners' young age) and DK (choice of bright colours in Moodle aesthetic designs).

Third, two more new codes emerging from the design conversations were added to the list of 10 original codes, resulting in 12 elements that the pre-service teachers attended to while designing their technology-based modules in groups. The two added codes were *Supporting factors* and *Hindering factors*, which were respectively defined as the factors that encouraged or motivated participants during the process of collaborative design and as the hindrances the groups encountered while designing in groups. Illustrations of the former were "I'm going to ask the tutor about our lessons." and "If I read any good articles, I'll send them to you." whereas examples of the latter were "I don't know how to set it [Google Docs] up." and "My computer is a bit slow at the moment". The participants did not explicitly identify these examples as facilitating factors or hindering factors during their design conversations. It was the researcher who noticed that their discourses related to factors that supported or hindered their learning design practices. Most sub-categories under these two categories were coded as separate primary layers. The only one sub-category that was double-coded was *Educational past experience* as a supporting factor since their experience could be related to any of the TPACK and DK elements. In either case, their counts were not added to the final total of counts of TPACK and DK elements.

Fourth, extensive efforts were made to establish explicit boundaries between the codes, either main codes or sub-codes when it came to the circumstances where the two codes might look interchangeable. For instance, *Learners* was a sub-code of *Context* while there was a whole category of *Learners' characteristics* standing independently as a main code. However, a sentence was coded as *Learners* under Context when the participant teams discussed learners as an overarching element in determining potential class size and group division or when the teams specifically referred to learners as a contextual factor, whereas a sentence was coded as *Learners' characteristics* when learners were discussed in order to determine what content, technology, and/or pedagogy to use for module being designed. An example of the former was "We are designing our Moodle for Carlingford West public school which has 97% of students from a language background other than English"; an example of the latter was "We should focus on making sure [that] it [the learning task in discussion] is engaging and that we can immerse the learners into it". There were no other major similarity issues with the remaining codes and sub-codes.

Several steps were taken to maintain the trustworthiness of the analysis during this phase. *First*, a coding manual that was created in the first phase (Familiarising with data) was used to detail definitions and examples of both old and new codes. Its content also included various versions of the framework. Reflective thoughts were captured and documented in the manual along the way to identify any interesting emerging aspects of the data. *Second*, changes to the original coding framework – or the addition of new codes and sub-codes – were updated on a weekly basis. In order to be easily identifiable and viewing facilitating, these newly emergent codes and sub-codes were colour-coded in a way that the original codes/sub-codes were black; the next week, red; the following week, blue, and so on. This was particularly helpful for synthesising the whole process as well as reminding the researcher of how the framework was modified instantly. It also helped the researcher have a clearer idea of what new codes were added on and how the framework was developed over time. The trustworthiness in this phase was further enhanced by the inter-coder reliability check carried out twice at the completion of coding **I2** and **I3** data respectively (see Section 3.7.4 for inter-coder reliability results).

In brief, constant efforts were devoted to ensuring the trustworthiness of the phase. The final result toward the end of the **I2** data analysing process was the comprehensive coding framework outlined in Table 3.11. This framework was then utilised for coding **I3** design conversations and was found to be thorough and reliable since no additional emergent codes or sub-codes were added when used to code **I3** data.

3.7.3.3. Searching for themes

Searching for themes amongst the coded data relates to searching for patterns in Braun and Clarke's thematic analysis approach (2006). Braun and her team defined a theme as "a common, recurring pattern across a dataset, clustered around a central organising concept" (Braun et al., 2019, p. 2). In order to discover if there were any themes related to the research questions under investigation, tables representing the distribution of different codes by week, by group and by individual were extracted using Matrix Coding queries in NVivo. For example, via examining the table illustrating Design Knowledge's frequencies over **I2**, the researcher found a repetitive trend around the concept of DK that the pre-service teachers tended to discuss more design-related issues in the final Moodle weeks than in the first Moodle weeks. A closer examination showed that this pattern was not only surfaced from data in **I2**, but also in **I3**. This theme was hard to identify via the memos because the participants discussed design related issues every week. The quantification of qualitative data — or the frequency table — was better to enable it to be surfaced. This theme helped answer Research Question 1 by revealing the pre-service teacher knowledge elements as well as where, when and how frequently they were articulated during the design process.

In addition, some patterns were distilled from the memos written along the coding process and cross-validated with the codes. An example related to the concept of *Context*, where it was noted that all the participating groups rarely discussed *Context* compared to most of the other knowledge elements. This theme was validated by *Context*'s small distribution of the context-related units coded over both iterations.

Some patterns emerged in the design conversations and were confirmed in the follow-up interviews. To illustrate, the theme where the groups had dynamic interaction and collaboration throughout the design process was identified in the design conversations. The same theme was also found from the interviews, supporting and confirming the pattern.

In this phase, the researcher also kept detailed notes of the development of sub-codes alongside the coding manual. All the emergent patterns were documented in notes.

3.7.3.4. Reviewing themes

According to Braun and Clarke (2006) and Nowell et al. (2017), this phase involves the refinement of the themes and, in some circumstances, the changes in the initial coding. Therefore, recoding is expected (Braun & Clarke, 2006). In the current study, a full list of sub-codes created in the first steps were compared and contrasted so that redundant sub-codes were collapsed, and similar and related sub-codes were pulled together to form categories.

In some cases, sub-codes in one big category were moved to another big category. For example, two sub-codes called *Selecting design topics* and *Ideas of learning tasks and activities* were moved from DK to CK with the rationale that topics and learning tasks belonged to the category of what to teach (content). Another example was *Browsing or navigation while design* was moved from DK to TK because during the navigation it was more like the participants were showing their technological understanding, for instance, "You can press the arrows and they can show you where to go".

In other cases, sub-codes that appeared to have similar meanings under the same category were merged in order to provide conceptual clarify and fidelity. To illustrate, upon thoughtful re-consideration, the researcher combined some sub-codes under DK together due to their similar nature. Specifically, *Scheduling* and *Setting goals* were combined to become one sub-code owning to their relevance to the teams' plans for the next design meetings. Similarly, discussions on *Copyright* and *Referencing* were merged into one sub-code since they were related in a way that the participant students needed to acknowledge the sources properly to uphold copyright which is a requirement for designing online courses and providing a scholarly justification. Also, *Getting to know each other* was added to *Establishing common-ground awareness* since self-introduction was also to establish mutual understanding.

The above modifications and reductions not only turned data into a more manageable set, but also allowed the surfacing of significant themes that accurately summarised the text (Nowell et al., 2017). In this phase, the researcher also went back and forth numerous times between the code lists and the original data to see whether any new codes had emerged and reached a point where the code boundaries were clear and comprehensive. This phase in the current study was conducted mainly in analysing **I2** data. The researcher hardly had to change any codes and sub-codes established in the coding framework resulting from **I2** coding process when she carried out a similar analysis on the set of data in **I3**.

3.7.3.5. Defining and naming themes

This fifth phase involves the decisions on what story each identified theme tells and how each story helps elaborate the main concepts to answer the research questions (Braun & Clarke, 2006). If needed, the researchers can choose to further define and label certain themes. In this phase of the current study, detailed rationales were carefully recorded in the coding manual. All the individual themes were documented in full notes at this stage with examples considerately selected and tables extracted from data to be ready to tell stories.

For instance, in Phase 3 (Searching for themes), surrounding the category of *Group dynamics* there appeared three themes: *Peers supporting each other intellectually, Peers supporting each other technologically* and *Peer supporting each other emotionally*. These themes were then told in more complete stories in this phase by adding explanations of their meanings taken from sub-codes and being illustrated with quotes or numbers extracted from the data. These themes and the stories pertaining to them helped elaborate how the concept of *Group dynamics* was one of the factors supporting the pre-service teachers' learning design processes.

3.7.3.6. Producing the report

This final phase happens when all the themes are fully established and are ready for the write-up of an engaging, cohesive, logical, and accurate report (Braun & Clarke, 2006). In this writing up phase, the researcher made full use of the full-paragraph notes, carefully-selected quotes and well-presented tables which were prepared from the previous phases (this reporting can be found in the Findings chapter, Section 4.1.1 and Section 4.1.2). The memos in the coding manual were constantly referenced. Additionally, the researcher also made notes of the implications underpinning each theme for further discussion.

One point to note is when reporting findings from design conversations with reference to what was said by whom and when, the following abbreviations were used: G stood for Group, W for Week, and I for Iteration. For instance, *"Kids would love it." (Paige, G2W3I2)* meant the quote was said by Paige, a Group 2 member, in a design conversation that happened in Moodle Week 3 of Iteration 2.

3.7.4. Inter-coder reliability for design conversations

Inter-coder reliability (ICR) is a method of checking the agreement between two or more coders about how codes are applied to data in qualitative studies to guarantee the reliability and objectivity of findings (Kurasaki, 2000). ICR has been proposed and used in many qualitative studies (Kurasaki, 2000; Nili et al., 2017; Olson et al., 2016), especially in studies that adopted thematic analysis and developed detailed coding frameworks (Belotto, 2018; Roberts et al., 2019).

The ICR check for the set of design conversation data in the current study occurred once in **I2** and once in **I3.** The **I2** ICR check that occurred before continuing coding **I3** data enabled the researcher to make necessary changes to the codes or sub-codes that resulted from the discussions between the researcher and the second coder. This included the researcher returning to the coding of transcripts and making adjustments. Then, the whole process of coding the **I3** design conversations using the **I2** coding scheme, in turn, was a good opportunity to check the reliability of the **I2** coding framework. On both occasions, ICR was conducted using the following steps, as suggested by Nili et al. (2017).

(1) Developing coding scheme

(2) Selecting and training independent coders

(3) Selecting method for evaluating ICR

(4) Calculating ICR

(5) Interpreting results

Step (1) involved the whole process of coding all the design conversations, from which a coding framework was developed by the researcher. Afterwards, an independent coder was recruited and trained (*Step (2)*). The second coder was among the tutors of the unit and, therefore, it was not hard for her to get hold of the key concepts in the TPACK framework as well as other unit-related issues. In **I2**, the researcher dedicated half of a 2-hour meeting to explaining to the other coder the purposes of the study, the role of this specific set of qualitative data (design conversations), the meanings of different concepts and codes involved, the subtle boundaries between some codes/sub-codes, and which codes were single or double coded. After that, the independent coder practised coding with a small amount of data on a randomly selected transcript in NVivo on a separate computer. The results were then compared with the researcher's codes and differences discussed. The same procedure was repeated with another small amount of data on the same transcript, by which time the second coder was more familiar with and confident about coding. Afterwards, she was asked to code another randomly selected **I2** transcript independently without the researcher's presence. In **I3**, because the same independent coder was already familiar with the process, the researcher just needed to re-explain it briefly and let her code another randomly selected transcript from **I3** data.

As for *Step (3)*, Cohen's Kappa coefficient (Cohen, 1960) was selected as a method for evaluating ICR. Cohen's Kappa was suitable because it was applicable for the nominal type of data of this study, allowed the assessment of agreement between two separate coders, reduced the effect of chance in agreement, and enabled the results to be quantitatively reported (Nili et al., 2017). Furthermore, Cohen's Kappa coefficient was conveniently chosen as a method of assessing ICR in NVivo where the coding took place. A simple percentage agreement measure was also used as a point of comparison. This was calculated as the ratio of the amount of coding where the coders agreed to the total amount of coding in the transcript.

In *Step (4)*, the two transcripts fully coded by the second coders, one in **I2** and one in **I3**, were compared with the corresponding transcripts coded by the researcher using Coding Comparison Query in NVivo. The query provided both ways of measuring the degree of agreement between two coders or two groups of coders: via calculating the percentage agreement and Kappa coefficient.

Out of the 12 final main nodes, only nine (KD, TK, CK, PK, TPK, CPK, TCK, TPACK, and Context) were chosen to calculate the final results although the independent coder coded all the possible nodes. The codes that involved two coded layers like *Learners' Characteristics*, *Supporting factors*, and *Hindering factors* were not included in the final calculation to avoid the overlapping counts of the total units coded. The weighted average Kappa coefficient was then calculated, weighted according to the percentage of the transcript coded by each node. Similarly, the weighted average Percentage Agreement was calculated, weighted by the amount of transcript coded by each node. For full ICR results' reports of **I2** and **I3**, see Appendix 11 and Appendix 12 respectively.

Step (5) involved the interpretation of the final results. The respective average Kappa score weighted by coding coverage for **I2** and **I3** were 0.813 and 0.853, the strength of agreement of which were deemed as almost perfect by Landis and Koch (1977). The respective average percentage agreement weighted by coding coverage were 0.738 and 0.781 for **I2** and **I3**. The percentage agreement gained from both approaches to calculating was considered to be high, hence providing confidence in the reliability of the coding.

3.8. Analysing Data for Research Question 2

To find out what factors support and/or hinder the collaborative design of pre-service technology-based lessons (Research Question 2), two sets of data were explored: (1) Group design conversations and (2) Follow-up interviews. The original intent was not to use group design conversations to look for supporting and hindering factors. However, these two categories emerged from the data unexpectedly. Follow-up interviews were then examined to see whether participants reported the same and any more enablers and hindrances compared to the analysis of pre-service teacher learning design practices. The interview data also assisted to confirm the design approaches identified as a result of analysing design conversations.

Like the group design conversations in Section 3.7, follow-up interviews in both **I2** and **I3** were analysed using Braun and Clarke's thematic analysis method (2006). Six same phases (*Familiarising with data, Coding, Searching for themes, Reviewing themes, Defining and naming themes*, and *Producing the report*) were conducted with the trustworthiness (e.g. detailed reflections, thorough documentation, use of a coding framework) interwoven throughout the process. The same abductive (both inductive and deductive) approaches were applied while coding. Three supporting factors – which were also three inhibiting factors – from the findings of the pilot study were set up as pre-defined codes while there was space for any emerging factors. Fewer problems and more facilitating factors were expected given numerous interventions were provided by teacher educators in both iterations. Similarly, three design approaches identified from **I1** (content-based, top-down, learner-centred) were also used in another set of pre-defined codes with an expectation of more approaches emerging from the interview data due to various interventions applied in **I2** and **I3**.

For the follow-up interviews, textual data were broken down by groups of sentences as units of analysis. Content from the interviews was not meant to serve the purpose of describing frequencies; rather, to confirm the frequencies as well as to discover the patterns that did not necessarily surface from every single coded sentence. In addition, each group of interview questions served a distinctive purpose to find out certain themes and, therefore, themes should be explored within groups of sentences in the responses to each question.

3.9. Analysing data for Research Question 3

Data analysis for answering Research Question 3 (What are the relationships between pre-service teacher learning design practices and the characteristics of their final online artefacts?) involved three steps:

(1) operationalising characteristics of the final artefacts (A) and preparing data for (A),
(2) operationalising pre-service teacher learning design practices (B) and preparing data for (B), and
(3) analysing data from (1) and (2) using the Regression in Data Analysis Tool in Excel.

First, final artefacts were characterised by the scores the group members received for each marking criterion on the marking rubric. The joint Moodle courses of the 18 participants in both iterations and their individual justifications for their Moodle modules were marked against the following criteria: Pedagogy, Technology, Content, Contextualisation, Alignment, Scholarship, Argumentation, Referencing, Copyright, and Groupwork reflection. Each criterion was marked against a 5-point scale: *Not evident, Developing, Competent, Advanced, Excellent* (see Appendix 13 for the marking rubrics).

The characteristics of the participants' final artefacts in this study were reflected through the scores the participants gained for Pedagogy, Technology, Content, and Context only. These were among the core elements in the TPACK elements as well as among the factors influencing the 18 participants' design decision identified from their design conversations.

Second, the 18 pre-service teachers' learning design practices were represented by their individual distribution frequencies of design focuses during their design conversations, both face-to-face and online, which were analysed in Section 3.7. There were nine identified elements that characterised their design conversations, but only four of them (Pedagogy, Technology, Content, and

Context) were selected to analyse for Research Question 3 because they were among the central TPACK elements and corresponded with the four above selected characteristics of the final artefacts.

Individual counts of those four focuses in each iteration were first extracted from NVivo to a separate Excel file. Then, data in both iterations were combined together. Next, the focuses' distribution frequencies were proportionated with the total counts of all nine TPACK elements, DK, and Context.

Table 3.12 below shows data gained from the first and second step for the Pedagogy element. For more complete tables of data for Pedagogy, Technology, Content, and Context, see Appendix 14.

Table 3.12: Individual distributions of Pedagogy vs individual Pedagogy scores

		Total	**Pedagogy counts from group design conversations**	**% (Pedagogy counts/Total)**	**Pedagogy score from marking rubric**
1	**Elli**	594	137	**17.5**	**5.0**
2	**Aria**	346	85	**16.2**	**3.0**
3	**Jaden**	391	102	**11.0**	**4.0**
4	**Daisy**	293	47	**10.2**	**4.0**
5	**Millie**	623	79	**9.0**	**5.0**
6	**Macy**	1126	197	**6.8**	**5.0**
7	**Jessica**	473	62	**5.9**	**3.0**
8	**Layla**	305	47	**5.6**	**5.0**
9	**Alyssa**	385	50	**5.5**	**5.0**
10	**Jasmine**	698	132	**5.4**	**3.0**
11	**Marley**	701	65	**5.4**	**2.0**
12	**Zoe**	846	104	**4.4**	**3.0**
13	**Paige**	821	136	**4.3**	**3.0**
14	**Summer**	445	36	**4.0**	**4.0**
15	**Evelyn**	706	54	**3.5**	**4.0**
16	**Ruby**	445	25	**2.2**	**4.0**
17	**Lucy**	248	15	**2.0**	**4.0**
18	**Amelia**	784	34	**1.8**	**3.0**

The last two columns of Table 3.12 show (i) the percentage of pedagogy-related comments among the group members (18 participants total) over the Moodle weeks in both iterations 2 and 3 as well as (ii) the scores out of 5 the group members received for pedagogy for their final Moodle tasks. Items (i) and (ii) were then analysed using Regression in Data Analysis Tool in Excel. A scatterplot was also created in Excel based on the (i) and (ii) to illustrate the relationship between (i) and (ii). These steps were repeated for the three remaining elements: Technology, Content, and Context.

The final artefacts of those 18 students were marked by two independent markers to uphold the reliability of the data. Marker 1 was a tutor of the unit. Marker 2 was the researcher. Each final artefact then gained an average mark of the marks offered by two markers. There was an issue of .5 mark for an average result when creating illustrative graphs that would not work well with 0.5 numbers. Considering the fact that there was a more than 80% agreement on the scores for each marking criterion between the two markers, Marker 1's scores were finally used for analyses. Marker 1 was chosen because the marks assigned by Marker 1 were officially recognised as final results. Also, he assessed the artefacts that had not been created by his students; hence the data could be perceived as more reliable and unbiased. See Appendix 15 for this inter-rater reliability work between two markers.

Note that the researcher also tried a different approach for (B) where the sum of all pedagogy- technology- content- and context-related discussions (e.g. references to technology in TPK, TCK, and TPACK was counted as a sum of technology-related focuses) was computed and used as the final data. This approach did not provide any additional results, and had more ambiguous construct validity compared to using comments that were purely related to a single construct. Therefore the results of the combined constructs analysis has not been included.

3.10. Analysing Data for Research Question 4.1

Research Question 4.1 was to examine the way teacher educators' pedagogical strategies had an impact on pre-service teachers' TPACK development. Data collected from pre- and post-course TPACK surveys were cleaned outside SPSS first and then processed inside SPSS before fitting in an appropriate statistical model called the Linear Mixed Model (LMM) and being analysed and intepreted. This section will detail the process that was followed.

3.10.1. Initial data management

3.10.1.1. Data screening outside SPSS

First of all, pre- and post-course Google Form-based sets of survey responses (four sets in total in both iterations) were exported to Excel files. After that, all participants who had not agreed to let their responses to be used for research purposes were removed from the datasets. In a similar way, those who had responded to the pre-survey but not to the post-surveys and vice versa were also excluded for the sake of comparing the improvement of the same subjects over the years. The number of informants in **I2** and **I3** at this stage was 113 and 91 respectively, making a total of 204 for both iterations.

Afterwards, the pre- and post- Excel files in each iteration were merged together so that the same participant had all their pre- and post- information contained in the same row in the same file. At this point there were two Excel files that contained all pre- and post- responses, one for each iterations.

Next, a final check was performed to see if there were any abnormal and non-serious pre- or post- responses from the same subject. Any identified non-serious attempts were removed from further analyses to avoid any inconsistent data or possible outliers that could distort the analysis and therefore influence the validity of data intepretation. There were a total of 200 participants for both iterations upon this final cleaning (110 for **I2** and 90 for **I3**) .

3.10.1.2. Data processing inside SPSS

Data format

In order to be able to compare **I2** and **I3** using a Linear Mixed Model (LMM) process, all participants were treated as a cohort and thus put into one same file. Therefore, the two merged Excel files mentioned above were imported into SPSS.

At this point, data were in a 'horizontal' format where there was one row per subject and repeated measurements were contained in multiple variables. In order to fit a LMM in SPSS, which will be presented in detail in Section 3.8.2 and 3.8.3, the data needed to be in a 'vertical format', where there are several cases (or rows) corresponding to observations on an individual unit of analysis collected over time. The *Restructure* command under the *Data* menu was used to convert the data set into a vertical structure. Figure 3.5 shows an example of the vertical statistical data structure in this study.

ID	PRE_OR_POST	YEAR	GENDER	AGE_POST	TUTORS	PRAC_EXPERIENCE	PST_OR_NON_PST	AVERAGE_ALL_TPACK
1	0	1	1	2	1	1	1	2.66
1	1	1	1	2	1	1	1	3.73
2	0	1	1	2	2	1	1	2.80
2	1	1	1	2	2	1	1	3.29
3	0	1	1	2	1	1	1	3.11
3	1	1	1	2	1	1	1	3.79
4	0	1	1	2	1	1	1	2.39
4	1	1	1	2	1	1	1	2.68
5	0	1	1	1	2	1	1	2.71
5	1	1	1	1	2	1	1	3.20
6	0	1	1	2	2	1	1	2.91
6	1	1	1	2	2	1	1	3.70
7	0	1	2	2	2	1	1	2.34
7	1	1	2	2	2	1	1	3.00
8	0	1	2	2	1	1	1	2.30
8	1	1	2	2	1	1	1	2.79

Figure 3.5: Vertical data format in SPSS for fitting LMM

As can be seen from Figure 3.5, data were iteration-based double-stacked; that is, the same subject (ID)'s data were presented in two consecutive rows with the first row containing statistics collected from the same respondent in the pre-course survey while the next row, in the post-course survey. Only after this, was further work performed on (re)-naming, creating, and organising different categories and variables.

Demographic statistics

As described in sub-section, there were seven demographic items asked about in the pre- and post- course TPACK self-assessed surveys: (1) gender, (2) age, (3) the tutorial class they were in, (4) the degree programs they were enrolled in, (5) whether or not they were enrolling EDUC261 as an Education or a Planet Unit student, (6) how many credit points they had completed on their programs, and (7) whether or not they had completed any practicum experience. Item (4) was to determine whether the participants were primary pre-service teachers, secondary pre-service teachers, or non-pre-service teachers. Item (5) was to divide the cohort into two groups: pre-service teachers and non-pre-service teachers. LMM would treat these two sets of data as one identical set. Therefore, item (4) was removed out of the model. Item (6) was also removed out of the model because many participants did not provide their answers. Plus, the credit points were to determine whether they were the first or the second year students, which could also be determined by their practicum experience question. Finally, there were five demographic items to be analysed: Gender, Age, Tutor, Practicum Experience, and Target Degree.

These five factors were treated as independent variables when analysed within the LMM. Because a record was kept of the student identification number, whether the response was pre- or post- course, and which year the student was enrolled, in total, there were eight independent variables. These were (in the order that they were arranged on the SPSS spreadsheet): Student ID, Pre_or_Post, Year, Gender, Age, Tutors, Prac_Experience, and PST_or_Non_PST. Table 3.13 shows how each of the above eight factors were processed, numericised and named in SPSS to prepare for the LMM process.

There was a minor issue concerning the grouping of ages in SPSS. Because the pre-course survey and post-course survey were carried out 5 months apart, a small number of participants (below 10 of them, accounting for below 5% of the population) reported 1 year older in the post-course survey. This 1 year difference typically resulted in 1 age range difference (e.g. from 20-25 to 26-30). The age range reported in the post survey were selected for further analyses due to it being more updated and closer to the completion of collecting data as well as nearing the end of the unit.

After the independent variables were processed, the next step involved the statistical organisation of the TPACK items.

Table 3.13: Independent variables preparation in SPSS for LMM process

	Independent variables	Constants	Coded as	Names in SPSS
1	Student ID	Each email assigned to 1 numeric code	1 - 200	Student ID
2	Pre- or post- course responses	Pre- response	1	Pre_or_Post
		Post- response	2	
3	Year	2017 (**I2**)	1	Year
		2018 (**I3**)	2	
4	Age	20 and younger	1	Age_Post
		21 and older	2	
5	Gender	Female	1	Gender
		Male	2	
6	Tutors	First -time tutor	1	Tutors
		More experienced tutor	2	
7	Practicum experience	Yes	1	Prac_Experience
		No	2	
8	Target Degree	Pre-service teacher	1	PST_or_Non_PST
		Non pre-service teacher	2	

TPACK data

The first step was to code the five Likert-scale responses to all the 47 TPACK items (TK, CK, PK, PCK, TCK, TPK, and TPACK). *Strongly Disagree, Disagree, Neither Disagree Nor Agree, Agree, Strongly Agree* were coded as 0 1 2 3 4 respectively. Next, each participant's average score for TK was calculated from the scores gained for all the pre- and post- TK items namely TK1 TK2 TK3 T4 TK5 TK6 and TK7. In the same way, an average score for CK, PK, PCK, TCK, TPK, and TPACK was also calculated. Resulting from this step, seven new dependent variables were created and entitled Average_TK, Average_CK, Average_PK, Average_PCK, Average_TCK, Average_TPK, and Average_TPACK (meaning TK, CK, PK, PCK, TCK, TPK, and TPACK average score). As a final step, another dependent variable named Average_All_TPACK was created – an average of averages - which was calculated from all the above seven average scores, making a total of eight dependent variables.

In summary, the SPSS data were now ready for further statistical analyses with eight coded independent variables such as Student ID, Pre or Post, Year, Gender, Age, Tutors, Prac_Experience, and PST_or_Non PST, as well as eight dependent variables like Average_All_TPACK (referred to as TPACK ALL), Average_TK, Average_CK, Average_PK, Average_PCK, Average_TCK, Average_TPK, and Average_TPACK.

3.10.2. Using Linear Mixed Model in SPSS

3.10.2.1. About Linear Mixed Models

The Linear Mixed Model (LMM) represents a procedure that provides a flexible and powerful approach to analysing statistical correlated longitudinal data (Ker, 2014; Pusponegoro et al., 2017). It is especially helpful for researchers who study individual change over time and want to "fit a variety of advanced regression models to longitudinal data sets with continuous dependent variables that correctly accommodate the unique statistical properties of longitudinal data" (West, 2009, pp. 207–208).

The LMMs are also referred to in various literatures as mixed-effects models, multilevel models, hierarchical linear models, and random coefficient models. Although under different names, these models are generally appropriate for reseach that investigates the relationships of variables in data sets with some form of dependency introduced by a hierarchical study design (Fitzmaurice & Laird, 2015; Harrison et al., 2018; West, 2009). In particular, it has been encouraged to be used by educational researchers to analyse hierarchical data which are common in educational research (Ker, 2014).

There are several key advantages of LMMs compared to other techniques for the analysis of longitudinal data. *First*, LMMs are able to fully accommodate all of the data that are available for a given subject, without dropping any of the data collected for the subject. This is not the case in other traditional statistical procedures like repeated measures ANOVA, where a single missing data point on a subject's data record causes all of that subject's data to be dropped from analysis (West, 2009). *Second*, in this approach, one can account for unobservable differences between individuals by specifying specific effects that can vary over subjects (Bruno & Benedetto, 2018). *Third*, the advantages of LMMs also include producing statistically efficient estimates of standard errors, confidence intervals, and significant tests (Ker, 2014).

LMM analysis was appropriate for the current study for several reasons. First of all, statistical data from this study was longitudinally collected and participants' changes in TPACK capacities were observed over time. Also, the study had a hierachical data structure with students belonging to two different cohorts (2017 and 2018), having various ages, backgrounds, studying in different classes, taught by different tutors, pursuing different study programs (education and non education), and having different practicum experiences. Different years, ages, tutors, projected degrees, or levels of practicum experience could possibly have a number of different common effects on the student participants, making it possible that the improvement in TPACK of students in the same year, at the same age group, taught by the same tutors, pursuing the same degree, or having the same amount of practicum experience would be more similar than that of the counterpart students. This correlation between the results of students in the same groups means that year, age group, tutors, degrees, and practicum experience could be thought of as clusters of students. In other words, students could be nested in different groups. This kind of data structure is suitably described by a LMM.

3.10.2.2. Fixed effects and random effects in LMM

The Linear Mixed Model is named as such because it includes a mix of both fixed effects and random effects in one model. *Fixed factors* are categorical factors with levels that are not randomly sampled from some larger population of levels; rather, all levels are included in the study design. Therefore, they are expected to have a systematic and predictable influence on data. Any effects of these variables are correspondingly labelled as *fixed effects*. These are the fixed, unknown, constant regression parameters that are of primary interest for intepretation of the results (West, 2009; Winter, 2013).

In contrast, *random factors* are categorical factors in a research design with levels that can be thought of as being randomly selected from a larger set of levels. They tend to influence data in a non-systematic, idiosyncratic, unpredictable, or 'random' way. Any effects of these variables are correspondingly labelled as *random effects* (West, 2009; Winter, 2013). In addition, random effects may describe correlational patterns between fixed factors among subjects or heterogeneities among subjects or both (Pusponegoro et al., 2017). These unsystematic parameters, in most cases, are not of primary interest for the interpretation of data.

There are two types of random effects model to fit in an LMM intercept random model and slope random model; that is, both the intercept and the slope can be considered as random. Whereas baseline differences are accounted for and the effect of the variables of interest is assumed to be the same for each individual in a random intercept model, subjects are allowed to have not only different intercepts, but also different slopes for the effects of the variables under consideration in the random slope model (Bruno & Benedetto, 2018).

In this study, the fixed factors included Pre_or_Post, Year, Gender, Age, Tutors, Prac_Experience, and PST_or_Non_PST. These factors were considered fixed effects. Meanwhile, Student ID was considered a random effect. After specifying the random effect in the model, the differences between predicted and observed values of the outcome are considered conditionally independent (Bruno & Benedetto, 2018).

Some mixed model researchers recommend fitting the maximal random effects structure possible for the data (Barr et al., 2013); that is, if there are four predictors (fixed factors) of interest, all four should be allowed to have random slopes. Howerver, Harrison et al. (2018) believed that allowing four random slopes is not realistic for studies with small amounts of data, nor sufficient to estimate variances and covariances correctly. Furthermore, it has been evidenced that models with too many parameters specified as random effects may have difficulty in convergence involving a high dimensional covariance matrix that can greatly increase computational instability (Ker, 2014; Peng & Lu, 2012). Therefore, it was suggested to either fit random slopes but remove the correlation between intercepts and slopes or to fit no random slopes at all but accept that this is likely to increase the Type I error rate (Schielzeth & Forstmeier, 2009). This study adopted the approach of fitting only fixed effects and fitting no random slopes at all to minimise the risk of computational instability. Fitting random slopes was attempted, but this proved to be resource intensive and was beyond the computational power of the machines available. Practicality and less pressure were chosen over the risk of potentially having high Type I error.

In summary, the above two sub-sections have provided some background knowledge about LMMs. They have also specified the fixed effects and the random effect used in this study. The next section will detail how the LMM was used to analyse longitudinal and hierachical data of this study.

3.10.3. How the LMM was applied in this study

3.10.3.1. Minimal Adequate Model approach

Now that the issues relating to the fixed effects and random effects were addressed, another question arose: what fixed effects and random effects should be included to best fit the model? This entailed a procedure of model selection which "seeks to optimise the trade-off between the fit of a model given the data and that model's complexity"(Harrison et al., 2018, p. 20).

This study adopted a stepwise deletion approach called Minimal Adequate Model approach. This is a process of reducing the model from a maximal model, which contains all factors and interactions that might be of any interest, to a minimal adequate model (Crawley, 2013). This process often involves a stepwise p-value deletion; that is, non-significant factors and/or interactions are sequentially dropped from the maximal model. The final model (i.e. the minimal adequate model) consists of the significant factors and/or interactions.

3.10.3.2. Steps involved in model simplification

Fitting models to data is an extensive process, the objective of which is to determine a minimal adequate model from the large set of potential models that might be used to describe the given set of data. Although it is time consusimg, the time is well spent because it reduces the risk of overlooking an important aspect of the data (Crawley, 2013). Crawley also stressed that "there is no guaranteed way of finding all the important structures in a complex data frame" (2013, p. 393).

As mentioned in the previous section, Crawley's model simplifying process involves removing insignificant terms (factors and interactions) one by one out of the model until reaching a minimal adequate model that contains only significant terms from a maximal model that contains all the factors and interactions of interest. It comprises of the following steps:

1. Fit the maximal model
2. Begin model simplification
3. Delete the least significant term first
4. Keep removing insignificant terms from the model sequentially
5. Arrive at the minimal adequate model (for more detail, refer to (Crawley, 2013, p. 393)

This study adopted a similar stepwise p-value deletion approach to analysis; however, due to the fact that this study had eight different dependent variables to consider and desired to arrive at a model that suited all of them with a possible inclusion of different 'good' terms, the steps were slightly different. It did not involve deleting non-significant terms one by one; but deleting all non-significant factors and interactions at once for each dependent variable and including all the significant factors and interactions in one final "minimal" model for all the dependent variables. The process applied in this study is summarised in Table 3.14 below:

Table 3.14: Model simplification process

Step	Procedures	Explanations
1	Fitted the maximal model for Average_ALL_TPACK	Fitted all the factors and interactions of interest.
2	Began model simplication	Inspected mean difference significances; Documented all the significant effects and/or interactions (p-value<0.05).
3	Repeated Step 1 and Step 2 with the remaining seven dependent variables one by one	Inspected mean difference significances; Document all the significant effects and/or interactions (p-value<0.05).
4	Fitted the simplified model	Fitted all the significant factors and interactions identified from Step 2 and 3. This was the final model for all the 8 dependent variables.

Before fitting the first maximal model for Average_ALL_TPACK (Step 1), it was important to select what main effects and interactions were fitted to the maximal model and justify for the selection. A careful approach to the minimisation of all the main effects and 2-way interactions as well as the justification for the main effects and interactions added to the maximal model for Average_ALL_TPACK can be found in Appendix 16.

The next step was to run the Average_ALL_TPACK maximal model so that non-significant effects and interactions with p<0.05 were identified and excluded. For different steps demonstrate how the maximal model was set up in SPSS, see Appendix 17.

After that, the whole similar procedures were repeated for the seven remaining dependent variables: Average_TK, Average_CK, Average_PK, Average_PCK, Average_TCK, Average_TPK, and Average_TPACK.

3.10.3.3. Fitting the final simplified model

All the significant factors and interactions with the p-value smaller than 0.05 were selected to add to the final simplified model. The factor and/or interaction with a p-value that was too marginal (e.g. 0.045-0.049) was removed from the final model. Table 4.15 summarises all the significant factors and interactions gained from Step 3 specified in Table 4.14.

As can be seen from Table 3.15, four main effects (Pre or Post, Gender, Practicum Experience, and PST or Non PST) and two interactions (Year*PST or Non PST and Pre or Post*Practicum Experience) emerged to be significant after running eight maximal models. So the primary maximal model of eight main effects and 11 interactions were reduced to a tentative minimal adequate model of five main effects and two interactions, as shown in Table 3.16.

Table 3.15: Significant main effects and interactions pulled up from 8 maximal models

	DEPENDENT VARIABLES	SIGNIFICANT FACTORS	SIGNIFICANT INTERACTIONS	Sig. (P value < .05)
1	AVERAGE ALL TPACK	Pre or Post		.000
2	AVERAGE TK	Pre or Post		.000
			Year * PST or Non PST	.035
3	AVERAGE CK	Pre or Post		.000
		PST or Non PST		.034
4	AVERAGE PK	Pre or Post		.000
		Practicum Experience		.000
5	AVERAGE PCK	Pre or Post		.000
		Practicum Experience		.000
6	AVERAGE TCK	Pre or Post		.000
7	AVERAGE TPK	Pre or Post		.000
		Gender		.043
		PST or Non PST		.002
8	AVERAGE TPACK	Pre or Post		.000
		Gender		.023
		Practicum Experience		.023
			Pre_or_Post* Prac_Experience	.005

Table 3.16: Tentative minimal adequate model for all dependent variables

Tentative minimal adequate model for all dependent variables	
Main Effects	**Interactions**
Pre or Post Year Gender Practicum Experience PST or Non PST	Pre or Post * Practicum Experience Year * PST or Non PST

As can been seen in Table 3.16, the main effect Year was fitted because Year was present in the significant Year*PST or Non PST interaction. Once an interaction between two fixed factors was fitted, each factor in that interaction should be fitted as main effect as well.

One important point to note was that because one of the purposes of this study's statistical analyses was to examine whether all the TPACK elements' scores were improved across the cohort over the years as well as between the years, the interaction of Pre or Post*Year was included in the final minimal adequate model for the sake of reporting and discussing findings. In other words, although Pre or Post*Year did not come up as significant for all the TPACK elements, this interaction was included in the final model because it responded directly to the research question about whether the interventions in **I3** (2018) in any way had a different effect from those in **I2** (2017) (Was there a different improvement between the years?). Therefore, the minimal adequate model shown in Table 3.16 was not the final simplied model yet. The final reduced model fitted 5 main effects and 3 interactions as illustrated in Table 3.17 below.

Table 3.17: Final simplified model for all dependent variables

Final simplified model for 8 dependent variables	
Main Effects	**Interactions**
Pre or Post Year Gender Practicum Experience PST or Non PST	Pre or Post*Year Pre or Post * Practicum Experience Year * PST or Non PST

This model was fitted to data for all eight dependent variables following the same SPSS procedures and justifications as in Appendix 16.

3.11. Analysing Data for Research Question 4.2

Research Question 4.2. sought to explore the impact of the pedagogical strategies of pre-service teacher learning design practices. In order to answer the question, the relationship between the design focuses (nine of them such as DK, TK, CK, PK, PCK, PTK, PCK, TPACK, and Context) of the nine case-study pre-service teachers in **I2** (2017) and those of the nine case-study pre-service teachers in **I3** (2018). Chi-square tests (Field, 2017) were used to find out the differences between each corresponding pair of design focuses and whether these differences were significant.

First, the number of units coded for all categorial variables of DK, TK, CK, PK, PCK, PTK, PCK, TPACK, and Context was extracted each separate year from NVivo to Excel files. These frequencies were then weighted and analysed in SPSS using Chi-square tests for the final results.

3.12. Analysing Data for Research Question 4.3

The aim of Research Question 4.3 was to explore the impact of teacher educators' pedagogical strategies upon pre-service teacher learning design artefacts. Final grades of 18 qualitative pre-service teachers were categorised into iterations (**I2**-2017 and **I3**-2018) and into groups of the final Moodle assignments that were evaluated as either Fail, Pass, Credit, Distinction, and High Distinction. These groups were then compared to see if there were any differences between iterations. The scores of pedagogy, technology, content, and context between two groups of pre-service teachers in two iterations were compared as well. In order to accord with the way the scores used to analyse Research Question 3 were selected, the grades assigned to final Moodle assignments by Marker 1 were selected for the same reasons (see Section 3.9 for more information).

3.13. Summary of the Methodology chapter

In summary, Table 3.18 below shows what the Methodology chapter has detailed in terms of the current's study research design, context, participants, methods, data collection and analysis procedures. A DBR approach was applied to identify practical problems and solve them iteratively. Within the cycles of the DBR conducted on pre-service teachers attending an education program at a university, a multiphase mixed methods approach was adopted so that both qualitative data (design conversations, group interviews) and quantitative data (surveys, scores, grades) were collected and analysed to answer four research questions. Methods of analysing data included thematic analysis qualitative data and LMM, Regression, and Chi-square tests for quantitative data. Results of these analyses will be reported in the next chapter.

Table 3.18: Mapping research questions to instruments, participants, data collection and data analysis

Research questions	What instruments	From whom	When to collect/analyse	How
1. What elements do pre-service teachers focus upon when collaboratively designing technology-enhanced lessons?	In-class design conversations Online group chats	6 groups of 3 PSTs (18 PSTs)	Across Moodle weeks (**I2**, **I3**)	Thematic analysis (NVivo)
2. What factors support and/or hinder the collaborative design of pre-service teacher technology-based lessons?	In-class design conversations, online group chats Interviews	15 PSTs	During After design End of the course	Thematic analysis (NVivo)
3. Are there any relationships between pre-service teacher learning design practices and the characteristics of their final online artefacts?	Quantified design focuses Scores of online artefacts	6 groups of 3 PSTs (18 PSTs)	After thematic analysis of design conversations After final marks revealed (**I2**, **I3**)	Regression in Excel
4. What are the impacts (if any) of the pedagogical strategies of teacher educators upon pre-service teacher knowledge (1), learning design processes (2) and artefacts (3)?	(1) Pre- and post-course TPACK surveys; (2) Quantified design focuses (3) Grades and scores of student design artefacts	200 PSTs 6 groups of 3 PSTs (18 PSTs)	After all three above steps have been completed;	(1) Linear Mixed Model (SPSS) (2) Chi-square test (SPSS) (3) Excel

Chapter 4. Findings

This chapter is presented in the order of research questions to accord with the order in which data were collected and analysed. Each section begins with an overview of the answers to the research question, followed by detailed presentations of the findings that are illustrated with tables and/or graphs, and ends with a brief summary of the findings. Findings are frequently compared between **I2** and **I3** as well as related back to **I1** when possible. The chapter concludes with a summary of the findings of all the four research questions.

Research Question 1: What elements do pre-service teachers focus upon when collaboratively designing technology-enhanced lessons?

Findings for Research Question 1 in both iterations have been reported together to support an easier comparison and contrast. Figure 4.1 and Figure 4.2 show the frequency distribution of units when coded for seven TPACK elements, Design knowledge (DK), and Context (C) categories in **I2** and **I3** (Note each unit of analysis was a sentence as specified in sub-section 3.7.3.2 in the Methodology chapter). It can be seen from Figure 4.1 that issues related to DK, CK, PK, and TK dominated the pre-service teacher **I2** design conversations, constituting nearly 85% of the units coded. The pre-service teachers did not often focus on TPACK and TCK as these only constitute approximately 10% of the units coded. The other elements — PCK, C, and TPK — occurred least frequently with only 2.9%, 1.9% and 0.8% of the discussions respectively.

Similarly, DK, CK, PK, and TK were also the dominant references in **I3**, accounting for almost 90% of the units coded in **I3** (Figure 4.2). The remaing 10% was allocated among TCK, PCK, TPACK, TPK, and C (4.1%, 3.5%, 2.1%, and 0.7% respectively). The similar distributions of different elements indicate the remarkable consistency between the two iterations 2 and 3. A more detailed expository at each element in both iterations will be provided in the following sub sections. The elements are presented in the order of their distribution frequencies in both iterations.

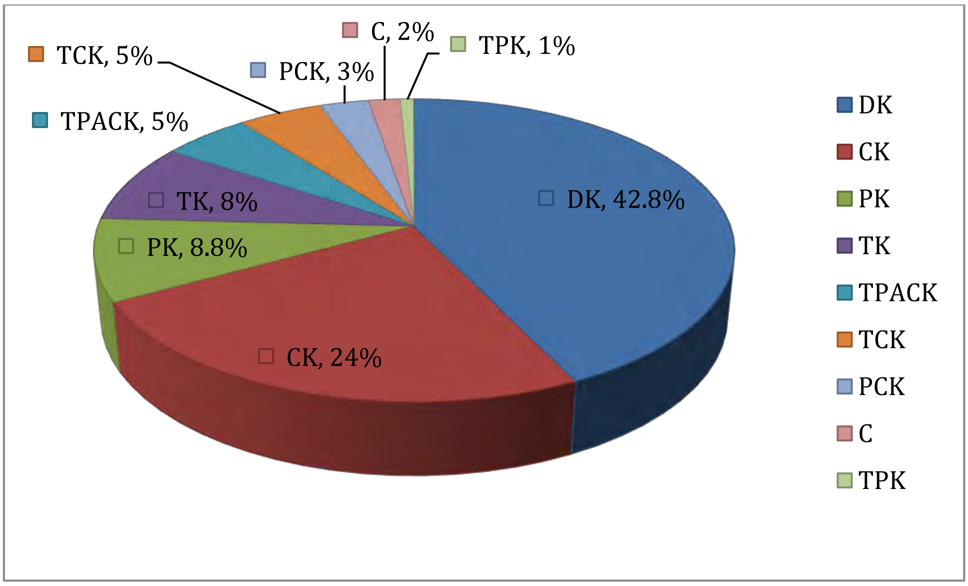

Figure 4.1: Distribution of design focuses in I2 (2017)

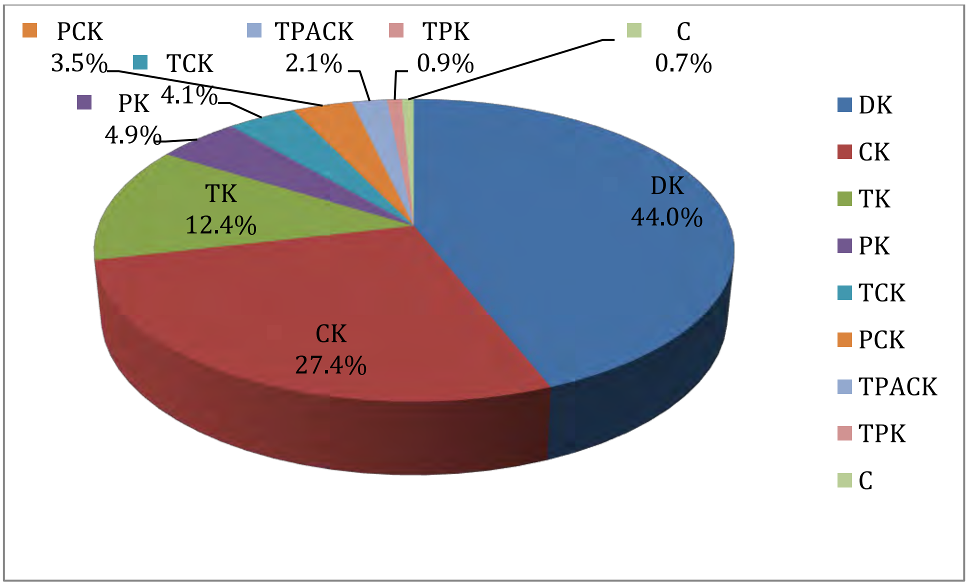

Figure 4.2: Distribution of design focuses in I3 (2018)

4.1.1. Design focuses

4.1.1.1. Design Knowledge (DK)

In both iterations, the design teams placed a considerable emphasis (well over 40%, as indicated in Figure 4.1 and Figure 4.2) on discussing non-TPACK issues that were related to the whole design process such as allocating tasks: "Do you guys have any preferences about which two lessons you want to do?" (Paige, G2W4I2), creating a group communication channel: “Let’s make a group chat [via Facebook Messenger].” (Alyssa, G1W1I2), making schedules and setting up personal design goals or mutual goals for the next group meeting: “I know we’re all short on time, but I think it’d be good to actually have something on our Moodle before Monday.” (Jaden, G2W4I2), and establishing a common-ground awareness: “Summary first before we go anywhere” (Macy, G3W3I3).

Interestingly, in the DK data in both iterations it seems all the groups’ design conversations over 5 weeks shared a similar pattern. For instance, the opening dialogue in each team’s transcript consistently involved introductions and sharing of background so that they could pick an appropriate design topic for the Moodle modules. Across the weeks, there were times the team members would distribute tasks amoung group members and create a collective communication channel like Facebook Messenger to keep in touch out of the classroom. After the first week, at the beginning of each design talk, the teams would typically aim to establish a common-ground awareness by summarising what they had finished or had not been able to do yet in the previous week. All teams involved in the study had two or more individuals who voluntarily sought a way to store and share their design drafts or ideas. Almost all of the teams chose Google Docs or a similar collaborative Web tool 2.0 like Popplet to save and share their evolving design plans and ideas. This pattern showed design teams’ collective knowledge of designing collaboratively, where team members were supposed to share responsiblity and make use of technologies to facilitate the design process with only approximately 30 minutes each week to work face-to-face in groups.

Another observed trend was that the teams evidently focused more on the designing aspects in the last Moodle-focused weeks of the course in both iterations. For instance, as shown in Table 4.1, while the **I2** teams devoted less than 40% of the weekly discussion to DK in Week 1, Week 2, and Week 3, the percentages of their Week 4 and Week 5 DK discussion were roughly 45% and 62% respectively. The amount of DK discussion was particularly substantial in the last week, comprising most of the teams’ design focus distribution of the week (62%). A similar trend was seen in **I3**. It can be seen from the data in Table 4.2 that the calculated ranges of DK discussion out of the **I3** weekly total design focus distribution were roughly 32% to 39% for Week 1 to Week 3 while those for Week 4 to Week 6 were approximately 42% to 67%. When the primary data were analysed to determine why the proportion of design conversation increased in the later weeks, it was apparent that the teams attended more to the aesthetic and other specific design aspects of the Moodle courses toward the end of the design process, supporting a top-down approach to designing (where overall elements such as learning outcomes are considered first and more specific design details considered last in the design process) that will be analysed in detail in sub-section 4.1.2.2.

Table 4.1: Percentages of DK discussion vs the total of design focuses across 5 weeks in I2

2017	Week 1	Week 2	Week 3	Week 4	Week 5	Total
DK	292	146	199	339	673	1649
Total	815	552	647	757	1084	3855
% DK	35.8	26.4	30.8	44.8	62.1	42.8

Table 4.2: Percentages of DK discussion vs the total of design focuses across 6 weeks in I3

2018	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Total
DK	406	360	306	691	380	661	2804
Total	1043	1104	969	1030	912	1316	6374
% DK	38.9	32.6	31.6	67.1	41.7	50.2	44.0

Also, **I3** witnessed a notable spike concentration of DK discussion in Week 4 (nearly 70% of the week's total discussion). This could be explained by an 'incident' happening to Group 3 where one member was not present and the two other members chose to dedicate most of their discussion time (nearly one hour) to working on their Moodle course's settings, theme colours, and so on, which might be easier for the absent student to catch up with. Table 4.3 reflects more clearly Group 3's Week 4 concentration on DK compared to other weeks, as well as to other groups in the same week.

Table 4.3: DK distribution by group for I3

DK	Group 1	Group 2	Group 3
Week 1	123	135	148
Week 2	115	158	87
Week 3	111	60	135
Week 4	90	123	**478**
Week 5	140	143	97
Week 6	195	273	193

4.1.1.2. Content Knowledge (CK)

Discussions related to the content were substantial as indicated by their high frequencies across the Moodle weeks (24.3% and 27.4% for **I2** and **I3** as shown in Figure 4.1 and Figure 4.2 respectively). The groups' content-related conversations revolved around the subject matter, learning outomes: "If it is Geography and English, how many outcomes are going to be the limit?" (Layla, G2W1I2), design topics: "I think we need to choose tesselation or 3D shapes." (Ellie, G3W4I2), content dot points: "One of the dot points we were talking about earlier mentioned some Geography skills." (Jaden, G2W1I2), resources: "Here's another thing I found accidentally you could use for exploring the Aboriginal perspective of caring for the Country." (Paige, G2W4I2), types of learning tasks: "We could even have reflection tasks at the end like 'How is this still occurring today? What things can we do about it?'" (Macy, G3W1I3), and learning scenarios: "For the lessons leading up to it we should do different situations and emergency plans for each different situation" (Lucy, G1W2I2).

Parts of the conversations about what to include in the collective online modules were sometimes long and insightful. For instance, Group 1 (W1I2) had a knowledgeable discussion on two content points in the learning area of Personal Development, Health and Physical Education, specifically focusing on strategies their potential learners could adopt in their community to empower individuals to lead healthy, safe, and active lifestyles for the benefit of their own and others' wellbeing. The two content points under exploration were differently worded but, in their opinion, were similar in nature.

> Jessica: 'Action plans'. That's really similar to this one.
> Lucy: Yeah 'in the home, school, and local environments'.
> Alyssa: That basically is this one though: 'formulates emergency situations'. That's also 'practising emergency response procedures.' Would you say? Yeh, it overlaps quite a lot.
> Jessica: Yeah, that's true.
> Alyssa: Should we take out 'practises emergency response procedures' since it's the same as or similar to 'formulates and practises action plans'?

> Jessica: I think that covers it. Otherwise why would they have that though? [*reading to herself*] ‘practises emergency response procedures’. Well, a student’s formulating their own action plans with things at home. Are they devising their own things?
> Alyssa: I guess that's good because everyone's houses are different. You need a different action plan for each house or each situation.
> Jessica: I think it's easier just to do that one because that one incorporates other things where students are formulating their own practices.
> Alyssa: Delete it?
> Jessica: I think so.

In the above excerpt, the team analysed back and forth the meaning of each different dot point, reached an agreement that the two dot points were incorporating and covering the same content, and finally took one of them out of the design draft. The discussion reflected Jessica, Lucy, and Alyssa’s in-depth analysis of the subject content, from which they could choose what scenarios and what activities were suitable for their potential learners.

In contrast to DK, CK frequencies decreased throughout the Moodle design weeks in both iterations. The percentages of CK distribution in the first **I2** and **I3** Moodle week were almost three times larger than those of CK distribution in the last week, as suggested in Table 4.4 and Table 4.5 (roughly 43% and 41% in the first week as opposed to around 15% and 13% in the last week for **I2** and **I3** respectively). This trend suggests that once the content was agreed, participants then moved to focus on other aspects of the modules. It also supports a content-based and top-down approach which are discussed further in sub-section 4.1.2.1 and sub-section 4.1.2.2 respectively.

Table 4.4: Percentages of CK discussion vs the total of design focuses across 5 weeks in I2

2017	Week 1	Week 2	Week 3	Week 4	Week 5	Total
CK	352	124	120	175	165	936
Total	815	552	647	757	1084	3855
% CK	43.2	22.5	18.5	23.1	15.2	24.3

Table 4.5: Percentages of CK discussion vs the total of design focuses across 6 weeks in I3

2018	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Total
CK	426	497	369	130	151	174	1747
Total	1043	1104	969	1030	912	1316	6374
% CK	40.8	45.0	38.1	12.6	16.6	13.2	27.4

4.1.1.3. Pedagogical Knowledge (PK)

Different from the pilot study (**I1**) where student participants hardly mentioned — let alone substantively discussed — pedagogies, in the **I2** there were quite a large number of units coded pertaining to pedagogies (338 and 313 referneces, accounting for approximately 9% and 5% of the units coded in **I2** and **I3** respectively, as shown in Table 4.6 and Table 4.7). However, there was not a noticeable trend concerning PK discussion distribution across the weeks in both iterations.

Table 4.6: Percentages of PK discussion vs the total of design focuses across 5 weeks in I2

2017	Week 1	Week 2	Week 3	Week 4	Week 5	Total
PK	47	54	87	58	92	338
Total	815	552	647	757	1084	3855
% PK	5.8	9.8	13.4	7.7	8.5	**8.8**

Table 4.7: Percentages of PK discussion vs the total of design focuses across 6 weeks in I3

2018	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Total
PK	68	55	60	74	8	48	313
Total	1043	1104	969	1030	912	1316	6374
% PK	6.5	5.0	6.2	7.2	0.9	3.6	**4.9**

It was found that all the teams not only discussed various pedagogical perspectives, but also attended to the possibility of incorporating different approaches in one module, for example, "Yeah, I was going to say we could probably incorporate everything [Inquiry Learning and Connectivism]" (Daisy, G3W1I2). Additionally, almost all design team members agreed that there should be a main approach, an overarching one, for the whole module they were working on, for instance, "Yeah, I think a balanced approach would be fine, but I think the main one should be Social Constructivism" (Ellie, G3W1I2). The pre-service teachers also showed an understanding of the similarities and differences between different pedagogical approaches. An example was "But let's say Social Constructivism because I feel like that encompasses Constructivism" (Layla, G2W1I2).

PK was also reflected in the way the groups discussed their teaching strategies. Some approaches underlay their discussions without being clearly named. For instance, when explaining strategies for teaching tessellation, Ellie (G3W3I2) said, "You'll probably drill it [the concept of tessellation] into them so much. You'll have to show it to them. And it's on the Moodle [that] they're going to see it written everywhere". Apparently, Ellie's intention was to scaffold the course's potential beneficiaries as much as possible.

Assessment and class management, two important concepts in teaching methodology, or pedagogy, were repeated among the group design talks. Group 3 (**I2**) dedicated a major part of Week 3 in-class conversation to assessment. The discussion showed that their knowledge of different types of assessment (diagnostic, formative, summative) went far beyond just naming and defining the types. The team members considered what the problems and different choices should be like and what else could also be considered assessment (e.g. feedback). After that, the team decided on the best types of assessment for their online modules. In terms of class management, some groups attended to how to time different activities in a potential 50-minute lesson.

With respect to pedagogy, some teams' knowledge of various pedagogical approaches was particularly reflected in their conversations about what pedagogical perspectives to write about in their justifications for their technology-enhanced Moodle modules. In fact, participants generally had a sound understanding of which pedagogical perspectives could be related to particular technologies or learning tasks/activities. For instance, Zoe (G3W6I3) explained to her team in their Messenger group chat about the alignment of a learning activity on their Moodle module in a very critical way: "I think it's most aligned to Constructivist because they are experiencing the sources [resources] and the information individually and then using social [communication] a little to construct meaning and 'real-life' it/enact it/apply it". Some more examples were "Behaviourism is shown through the quiz." and "Worksheets are a bit of Behaviourist" (Ellie, G3W4I2). Ellie's group partners also elaborated on certain approaches. To illustrate, Daisy (G3W4I2) said in the same design conversation, "Because they're using objects and they're doing it in class and it's a hands-on activity, it's a bit of Constructivism as well". At first, the team struggled between whether the underlying approach was Behaviourism or Constructivism. After a thorough discussion, they agreed that it was Constructivism since "you're going out there, getting real world applications, experiencing it, and constructing meaning for yourself" (Aria, G3W4I2).

4.1.1.4. Technological Knowledge (TK)

As can be seen from Table 4.8 and Table 4.9, pre-service teachers placed as much emphasis on technology as on pedagogy while working on their technology-enhanced designs together (slightly below 9%) in **I2** but shifted the emphasis away from technology and toward pedagogy in **I3** with almost 5% of the units coded for PK and over 12% for TK. Table 4.8 and Table 4.9 do not show an obvious trend, as was the case for PK, though evidently the teams discussed technology throughout the Moodle-focused weeks of the course with most concentration on technology in **I2** Weeks 2 and 3 as opposed to in **I3** Weeks 5 and 6.

Table 4.8: Percentages of TK discussion vs the total of design focuses across 5 weeks in I2

2017	Week 1	Week 2	Week 3	Week 4	Week 5	Total
TK	48	92	101	57	28	326
Total	815	552	647	757	1084	3855
% TK	5.9	16.7	15.6	7.5	2.6	8.5

Table 4.9: Percentages of TK discussion vs the total of design focuses across 6 weeks in I3

2018	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Total
TK	95	95	110	101	182	209	792
Total	1043	1104	969	1030	912	1316	6374
% TK	9.1	8.6	11.4	9.8	20.0	15.9	12.4

There were times when the teams only named the tools they were using or exploring without explaining much about their usages or functionalities. For the most part and particularly evident in the in-class design talks, there was a tendency towards searching for the tools and browsing a list of tools together in front of a computer screen among team members. During this journey of browsing and navigating, participants also made comments on the websites: "This is really good. It has lots of stuff." (Alyssa, G1W3I2), described the tools: "It [Logitec Webcam Avatars] detects your face and your movements of your face." (Jessica, G1W3I2), and elaborated on what they knew about the tools: "This one says with Crazy Talk teachers can make famous historical people come to life as funny talking animated characters." (Jessica, G1W3I2), and "Because Google Docs is so connected, we'll also be having a discussion on the chat and this has video conferencing as well" (Madelaine, W1G1I3).

On top of that, the participants' articulation of TK was at times comparative, where they contrasted the uses of different technologies having similar functionalities. Some tools were introduced to the participants in the numerous resources provided in the unit. Some were searched and found by the participants themselves. As in a Facebook Messenger excerpt below, three tools (Avatar, Cartoon Comic Strip, and Powtoons) were mentioned, compared, and considered.

> I am finding it hard to locate a free avatar app that is good, so I am thinking of using Powtoons, which is free and has really good reviews. It has a voice over

> and cartoons. It may be similar to the Cartoon Comic Strip in that there will be a number of slides…. I think I need to scrap the Avatar thing and just go with the instructional video. It's pretty much the same as the avatar concept except the characters in the video won't be speaking, just the sound of their voice will be there. (Jessica, G1W3I2)

This quote reflects not only Jessica's sound knowledge of different aspects of each tool but also her attempt to take into account the advantages and disadvantages of the tools. Her thinking constitutes a fundamental foundation for the next step: combining technology with corresponding pedagogy for a successful conveyance of content to learners.

At a higher level, the participants were aware that if too many technologies were to be introduced into their online modules, the focus of the modules would possibly change to teaching technologies instead of teaching technology-enhanced content. For example, Alyssa (G1W2I2) questioned the possible shift in focus when she remarked, "But then would you want it to be more like technology-based or more about all the teaching because it could go off track as well?"

4.1.1.5. Technological Pedagogical Content Knowledge (TPACK)

As illustrated in Table 4.10 and Table 4.11, TPACK discussions were almost equally distributed over the weeks in both iterations except for its absence in Week 4 in **I3**. Although the percentage of the units coded with TPACK was comparatively marginal (approximately 5% and 2% in **I2** and **I3** respectively), there were several interesting findings about TPACK.

Table 4.10: Percentages of TPACK discussion vs the total of design focuses across 5 weeks in I2

2017	Week 1	Week 2	Week 3	Week 4	Week 5	Total
TPACK	24	38	35	49	54	200
Total	815	552	647	757	1084	3855
% TPACK	2.9	6.9	5.4	6.5	5.0	**5.2**

Table 4.11: Percentages of TPACK discussion vs the total of design focuses across 6 weeks in I3

2018	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Total
TPACK	20	24	20	0	30	38	132
Total	1043	1104	969	1030	912	1316	6374
% TPACK	1.9	2.2	2.1	0.0	3.3	2.9	**2.1**

At a basic level, TPACK discussed in a sentence was as simple as technology being mentioned together with content and how content was delivered (pedagogy). For instance, Alyssa (G1WI2) said, "I'd do a quiz online or do a video on why someone doesn't wear a seat belt and then, 'Oh what's wrong with this?'" Although the participant referred to technology (online quiz, video), content (safety practice – why someone is not wearing a seat belt), and teaching strategies (a question to elicit responses from learners), it would have been possible to articulate the whole design idea in a more specific and explicit manner the way Paige (G2W1I2) did below:

> You could make a survey using something like SurveyMonkey, give it to the public, your parents, your friends, your sports coach, asking for some opinions about "What's a cool place in our school zone that we could heritage site?"

The above quote was more specific in terms of suggesting what technology to use (Survey Monkey) and pedagogy deployment. Surprisingly, this was articulated in the very first week of the Moodle weeks, when the participants were not fully introduced to the TPACK framework yet. Similar findings were observed in Group 1 in **I2** and three groups in **I3** as well.

Toward the later weeks, the participants seemed to hold a more sophisticated level of conversations pertaining to TPACK. An illustration was a design conversation in the Week 4 of **I2** among Group 1 members:

> Lucy: Yeh, for emergency [first aid] response procedures like "DRABCD", drop and roll and stuff like that, for mine they watch a short video, then there's a worksheet with screenshots of parts of the video, [and] they then have to write about like 'What would you do?'
>
> Alyssa: Then they research, not confirm, everything they've learnt, [which] then gives them what they're meant to have learnt already.

In the first sentence of the quote, Lucy pointed out the teaching strategies by which her potential students could learn the content point of emergency response procedure via the use of a video, a worksheet, and screenshots. Alyssa added to this by providing more strategies and the underlying idea of the activity. This amplification of how the participants wanted to plan out their learning activity gave an impression that Lucy and Alyssa had an in-depth understanding of pedagogy in general and TPACK in particular.

In fact, the smaller frequency of TPACK distribution was not considered to be a worrying trend. It did not apparently mean participants failed to understand and know how to apply TPACK. On one hand, their TPACK should be formed from a long process of understanding content, technology, and pedagogy. On the other hand, frequently in the teams' design conversations, the sense of TPACK came from a group of sentences, not in a single sentence, whereas the adopted coding approach was analysing every single sentence. This implies that there might have missed chances of coding TPACK within a cluster of sentences. In addition, the manifestation of TPACK tends to be holistically reflected in the whole lesson created, which makes it hard to capture TPACK coded, either at a single sentence level or a group of sentences level.

4.1.1.6. Technological Content Knowledge (TCK)

Receiving equal attention from the pre-service teachers compared to TPACK in **I2** (192 references, constituting 5% of the units coded), yet twice as much attention as TPACK in **I3** (260 references, being composed of slightly over 4% of the units coded, , as indicated in Table 4.12 and Table 4.13), TCK showed up in the data when it came to the conversations surrounding content-based ICT tools and the use of ICT for representing and storing content, for instance, "I'm still going to play around with the Moodle to see how to control the access of content and see if I can find what you need" (Ellie, G3W5I2).

Table 4.12: Percentages of TCK discussion vs the total of design focuses across 5 weeks in I2

2017	Week 1	Week 2	Week 3	Week 4	Week 5	Total
TCK	27	56	41	41	27	192
Total	815	552	647	757	1084	3855
% TCK	3.3	10.1	6.3	4.4	2.5	**5.0**

Table 4.13: Percentages of TCK discussion vs the total of design focuses across 6 weeks in I3

2018	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Total
TCK	3	24	31	18	108	76	260
Total	1043	1104	969	1030	912	1316	6374
% TCK	0.3	2.2	3.2	1.7	11.8	5.8	**4.1**

More specifically, emerging from these conversations was the discussion on how the technological affordances could accommodate the learning activity in discussion. Some examples were "I am looking at the Number and Algebra and I'm thinking about what would be easy to assess and look at on Moodle site." (Ellie, G3W1I2), and "[I] was thinking it might be better to do something like a Forum, but I want it to be individual and not seen by everyone on the Moodle and then you can't edit them either" (Zoe, G3W6I3). It was also emergent when participants opted for a tool in place of one they were not fluent at using, Feedback instead of Quiz, as in this example: "I couldn't figure out how to use the Quiz for the revision task so I used the Feedback element that allows open end answers" (Jasmine, G3W6I3). The quotes indicate that the pre-service teachers were flexible in making a choice of what tools to use for certain learning activities knowing what they wanted their potential learners to achieve out of the content.

Evidently, the participants kept in mind that content and learning activities cannot be built without technology. Their view was that teaching and learning with technology means that teachers and learners should work on a computer ("You should probably see if we can record the debate so it's not an isolated thing off the computer." [Paige, G2W3I2]). They could have taken into account whether their course supported totally online interactions or blended learning.

4.1.1.7. Pedagogical Content Knowledge (PCK)

PCK received the second least attention compared to other TPACK elements in **I2** and **I3**, constituting almost 3% and 3.5% of the total units coded respectively (refer to Table 4.14 and Table 4.15). Over the Moodle-based design weeks, there was evidence of the participants selecting a certain pedagogical approach for certain tasks and elaborating on why the approach should be used. For instance, Macy (G3W5I3) said in one design conversation, "I think we'd need to add some good scaffolding to Lesson 6 so that they can apply what they've learned to something current".

Table 4.14: Percentages of PCK discussion vs the total of design focuses across 5 weeks in I2

2017	Week 1	Week 2	Week 3	Week 4	Week 5	Total
PCK	27	56	41	41	27	192
Total	815	552	647	757	1084	3855
% PCK	0.9	1.6	8.7	3.0	1.5	**2.9**

Table 4.15: Percentages of PCK discussion vs the total of design focuses across 6 weeks in I3

2018	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Total
PCK	5	42	43	15	27	93	225
Total	1043	1104	969	1030	912	1316	6374
% PCK	0.5	3.8	4.4	1.5	3.0	7.1	**3.5**

Most importantly, the teams showed capacities of articulating the pedagogical perspective soundly in connection with content, taking into account not only the learning outcomes but also how each of the outcomes fitted in different cognitive levels in Anderson and Krathwohl's (2001) cognitive process model.

> So, anyway, this is just based on me trying to put the outcomes and the content into Anderson Krathwohl, trying to have it be in order of the cognitive processes that they're using from like lower order Understand up to Create at the end. (Paige, G2W4I2)

4.1.1.8. Technological Pedagogical Knowledge (TPK)

Table 4.16 and Table 4.17 provide summary statistics for how TPK was distributed over the Moodle weeks. It was apparent that among the seven knowledge constructs in the TPACK framework, TPK was the most overlooked in both iterations, receiving only 0.8% of the total distribution in **I2** and 0.9% in **I3**.

Table 4.16: Percentages of TPK discussion vs the total of design focuses across 5 weeks in I2

2017	Week 1	Week 2	Week 3	Week 4	Week 5	Total
TPK	1	13	3	5	9	31
Total	815	552	647	757	1084	3855
% TPK	0.1	2.4	0.5	0.7	0.8	**0.8**

Table 4.17: Percentages of TPK discussion vs the total of design focuses across 6 weeks in I3

2018	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Total
TPK	8	6	22	0	13	7	56
Total	1043	1104	969	1030	912	1316	6374
% TPK	0.8	0.5	2.3	0.0	1.4	0.5	**0.9**

Despite its low frequency, there were several interesting points to note about the pre-service teacher discussions on TPK. First, it was observed from their design conversations that the teams acknowledged the importance and effectiveness of technologies in facilitating the pedagogy implementation (e.g. assessment) in the classroom. Summer (G2W2I3) stated, "It [the development of technology] makes it easier for student assessment while bringing modern technology into the classroom".

More specifically, the importance was placed on the consideration of technological affordances in the adaptation of technological approaches in the teams' design conversations, as Jasmine (G3W1I3) exchanged with other group members, "Based on our affordances we can use to facilitate pedagogies". In other words, they took into account what the technologies could offer in order to develop their pedagogical approaches for the tasks accordingly. Two more examples were "Do we want to be a bit of Social Constructivism with the use of Chat and stuff?" (Millie, G1W3I3) and "Actually, we could have that Storyboard as formative assessment throughout which is like assessment as learning" (Ruby, G2W2I3).

4.1.1.9. Context (C)

It is apparent from Table 4.18 and Table 4.19 that the pre-service teachers did not discuss context as much as expected in both iterations (the units coded constituting only 1.9% for **I2** and 0.7% for **I3**). As described in Section 3.1.2 in the Methodology chapter, the convenor of the unit prescribed a default context, being "a mixed ability coeducational environment in a school with good access to technological infrastructure but also with students from a wide range of socio-economic backgrounds", which was stated in EDUC261 Moodle Task Specifications in iLearn, for all the pre-service teachers with the assumption that the teacher trainees would have prompts to consider context in association with different aspects of their designs. The result was that context was discussed in almost 2% of the units coded (72 references) compared to being hardly mentioned in **I1**. More interventions (links to two real-life schools provided) were implemented in **I3** to encourage extra discussion on context. Contrary to the researcher's expectation, there were few references to context (42), accounting for only 0.7% of the units coded, even lower than found in **I2**.

Table 4.18: Percentages of Context discussion vs the total of design focuses across 5 weeks in I2

2017	Week 1	Week 2	Week 3	Week 4	Week 5	Total
C	17	20	5	10	20	72
Total	815	552	647	757	1084	3855
% C	2.1	3.6	0.8	1.3	1.8	**1.9**

Table 4.19: Percentages of Context discussion vs the total of design focuses across 6 weeks in I3

2018	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Total
C	12	1	8	1	13	10	45
Total	1043	1104	969	1030	912	1316	6374
% C	1.2	0.1	0.8	0.1	1.4	0.8	**0.7**

The teams' conversations surrounding context mainly occurred when the teams answered the two questions asked in the Learning Design Guide in Week 1, *What is the context?* and *What are the best ways to promote students' motivation and engagement within that context?* When answering the first question, the teams often referred back to the above default context. Although allowed to create another context of their own for their Moodle-based online modules, the participants seemed to want to keep the default context because in their opinion it was a common setting in their real-life teaching circumstances; to illustrate, "I think we decided on mixed-ability since that would be the most likely event for when we go out to teach" (Amelia, G2W3I3). This is also the underlying implication of the default context.

On the other hand, in addition to keeping the core features of the default context, they added more characteristics to their potential learner cohorts, for example, one team decided on an English as an Additional Language or Dialect (EALD) group with mixed-ability students ranging from "people with learning difficulties and disabilities, EALD students to gifted students" (Group 2, W1I2), based on which they selected suitable materials and technologies for the target group. As Paige said when sharing with her team what she had written in her justification for the context behind their mutually created modules, "I've used a lot of speaking and listening stuff and graphic organisers which have both been research proven to help with EALD students".

The quote suggests that the pre-service teacher took a careful approach to developing technology-enhanced teaching material for such a special group as EALD students. Both the material for certain skills and the technologies were evidenced in the search as useful to EALD learners.

The participants' understanding of context was also associated with their knowledge of New South Wales primary schools' schedule, as Aria (G3W2) discussed with her team, "So I think instead of having it [maths] at the daily basis, because I'm sure that kids do have maths every day or almost every day, they should have it on a weekly basis". More importantly, the members in Group 3 understood that "every school is different" (Ellie, G3W2I2) to come up with their own syllabus for their technology-based modules.

Discussions related to context also involved discussions on potential school facilities. Two participants in Group 1 (W4I2) took these into account during their design conversations, as Lucy asked, "Do we assume they [learners] have [access to] iPads?" and Alyssa answered, "[I assume] most schools have".

The addition of two real-life schools' websites (one was primary; the other, secondary) to the context specification for Moodle assignment task in **I3** meant that all three **I3** groups explored the primary school website, looking for information about school facilities and learner cohort's background to provide rationales for their design decisions. Group 1 and Group 2 in **I3** had similar concerns to Group 1 in **I2** in terms of whether their potential learners would have access to technologies such as website, apps, or laptops. They found their answers to their concerns by looking at the website.

> Also [I am wondering] if you [can] use laptops in your lessons. I looked at the annual report thing and [found that] each class has a set of iPads. So make sure in your justification talk about the reason why we use iPads. (Group 1, W6I3)

> It [the report] talked about how they actually have class sets designated. That's why in my lesson I was like 'We use iPads because every child has access to one'. (Group 2, W4I3)

> I just saw on iLearn and I had totally blanked about [the fact] that we are designing our Moodle for Carlingford West public school which has 97% of students from a language background other than English. (Group 3, W5I3)

4.1.1.10. Learners' characteristics (LC)

Note that LC was coded as a separate layer (see sub-section 3.7.3.2 for more detail) and therefore counts of the units coded could not be proportionated to the total of references. However, the distribution of discussions related to learners could still be demonstrated via number of counts over the weeks as in Table 4.20.

Table 4.20: Discussions related to learner characteristics in I2 and I3

	Iteration 2 (2017)			**Iteration 3 (2018)**		
	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
Week 1	10	13	6	22	0	4
Week 2	10	0	10	3	10	5
Week 3	0	10	19	8	0	3
Week 4	2	0	2	6	0	8
Week 5	5	3	9	2	0	18
Week 6				11	5	8
Total	**27**	**26**	**46**	**52**	**15**	**46**

It can be seen from Table 4.20 that all the groups in both iterations except for Group 2 in **I3** took learners into account in almost every Moodle week in-class and Facebook Messenger design conversations. For example, potential learners' age and maturity were considered in selecting the appropriate level for the whole course, as illustrated by how Zoe (G3W2I3) elicited more ideas from peers, "Should we go Year 6 because we can do more with them?" Some design decisions were also made based on how the content should be made more appealing and less complicated to small children, for example, "I am also thinking of scrapping the mini emergency quiz at the beginning just because the lesson will be too much for the kids." (Jessica, G1W3I2), and "I mean it [the information log in each Moodle module] is amazing but it could be overwhelming for a kid" (Jasmine, G3W6I3).

Additionally, potential learner linguistic capabilities and cultural backgrounds were taken into consideration when it came to the decision on what online resources to provide, as Evelyn (G1W6I3) suggested to her group, "I was wondering if we should add a link to a translation site as a significant proportion of students are ESL."; what tasks to create, as Macy (G3W5I3) wondered, "Maybe should we design some extra parts to tasks which will allow for students to equally participate regardless of language background?"; and what content to incorporate in order to create an engaging learning environment, as Summer (G2W1I3) contributed, "So yeah we're incorporating their culture, their heritage into what they're going to be learning, which will hopefully translate into a higher engagement". In particular, the participants attached importance to designs for possible learner mobility and disability as well. Marley (G3W1I3) discussed the use of suitable technologies for prospective special-needs learners: "We could even include that [a task in discussion] with some students and create a video diary to upload to Moodle of their experience rather than writing if they, say, have a learning disability".

A majority of the units coded regarding LC reflected participants' considerations about Moodle designs, for example aesthetic aspects, in relation to small children's interests and preferences. Several instances were "I just made it bigger so it's easier for little eyes to read." (Layla, G2W5I2) and "We fiddled around with the structure to make sure it's really readable for the students and also user friendly" (Macy, G3W4I3). In brief, the participant designers seemed to understand what content engaged young children, what they were capable of doing, and what technologies and assessment types suited them. The evidence in this section supports well different variants of a learner-focused approach presented in Section 4.1.2.3.

4.1.1.11. Summary of design focuses

Section 4.1.1 reported the distribution of design focuses over the Moodle weeks in order to partly answer Research Question 1 (What elements do pre-service teachers focus upon when collaboratively designing technology-enhanced lessons?). The main findings were that discussions pertaining to design (DK), content (CK), pedagogy (PK) and technology (TK) dominated the pre-service teacher design conversations in both **I2** and **I3**. The distributions of other elements such as TPACK, PCK, TCK, and TPK, and particularly Context were quite low. Learners' Characteristics (LC) was among the aspects considered while designing. Findings of the design focuses, particularly CK and Context, also suggest various design approaches which will be presented in more detail in the following section.

4.1.2. Design approaches

Both design conversations and post-course interviews allowed the possibility of observing different approaches to designing among pre-service teachers. Similar to the pilot study's findings, the teams in both iterations 2 and 3 adopted the following approaches in their learning design process: content-based, top-down learner-centred, and context-oriented.

4.1.2.1. Content-focused approach

One broad shared theme identified from the group design conversations in **I2** and **I3** was content-focused, reflected in the evidence that the participants in both iterations tended to focus on discussing content-related issues in the first weeks of the Moodle weeks (see sub-section 4.1.1.2 for more information). That is to say, all the **I2** and **I3** groups started the design of their Moodle module from a content-area focus. Most learning activities and assessment forms were developed and sequenced surrounding these content points. The interview data sustained this finding, as shown in the below quote.

> We really had to focus on what the syllabus content was asking. And then we wrote indicators based on that, so then we could plan our learning experiences. (Ellie, G3I2)

Ellie's quote indicates that she and her group based their design of all the learning experiences in their modules on the main general content and other specific indicators, which indicates they may have had to refer back to these content points again and again during the design process so that the design would not be deviated from the content focuses of the lessons. Marley (G1I3) shared the same view as Ellie:

> I think it's really important to make sure that the content you are putting into online modules doesn't actually waver from the curriculum because it is very easy to get lost in what you are doing.

The purpose of considering content back and forth during the learning design process was to guarantee that the alignment between the content (what is planned to teach) and the curriculum (what is supposed to be taught) was established. Marley (G1I3) emphasised this connection in the following account.

> It is really fun making online modules for students so I think it's very important that we use each other as an anchor to come back to what the content originally

> was so there were times where we'd come up with an idea and we'd be like 'That'd be great but how is it linking?'. We'd always make sure the curriculum went back into the content that we were meaning to teach the students, so I think it's really important that you create fun and engaging activities but making sure that they are actually aligned to the curriculum. (Marley, G1I3)

Ellie and Marley's quotes indicate that content as well as its alignment with the curriculum requirements could influence the participants' decisions on the design of tests and learning activities. As a whole, it suggests how significant content is as a starting point for design in providing some conceptual ideas for the pre-service teachers as a foundation for other related tasks in the lesson.

4.1.2.2 Top-down approach

Observed for all the six teams' design conversations across the weeks was the adoption of a top-down design approach to designing, which could be understood as one where designs were developed based on a plan of key points. The groups all had a general overarching scheme of learning outcomes and design topics before they considered the more subtle design considerations such as learning activities, assessment tasks, technology use, feedback, and time/task designation.

These observations were supported by the evidence provided in Table 4.21 and Table 4.22 showing the domination of discussions on learning outcomes and design topics during the participants' collaborative design activities over weeks in both iterations.

Table 4.21 indicates that these two sub-categories not only dominated the participants' discussions on content-related issues over 5 Moodle weeks in **I2** (109 and 72 counts of the units coded respectively), but also mostly concentrated in the first week of the iteration. The same trend was true for the distribution of learning outcomes and design topics in **I3** with 138 and 217 counts of references to learning outcomes in Week 1 and Week 2 respectively and 134 counts of references to design topics, as shown in Table 4.22.

Table 4.21: Distribution of CK sub-categories over Moodle weeks in I2

Distribution of CK sub-categories over Moodle weeks in I2					
	Week 1	Week 2	Week 3	Week 4	Week 5
Learning outcomes	**109**	3	8	9	23
Design topics	**72**	12	5	27	8
Learning tasks and activities	44	33	40	51	67
Subject content + resources	53	48	57	16	24
Content (dot points)	52	21	9	36	33
Subject matter and skills	17	0	0	0	0
Learning and teaching scenarios	3	5	0	36	11
Integration of different subject areas or skills	6	0	1	0	0

Table 4.22: Distribution of CK sub-categories over Moodle weeks in I3

Distribution of CK sub-categories over Moodle weeks in I2						
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Learning outcomes	**138**	**217**	51	49	17	46
Design topics	**134**	27	4	0	0	2
Learning tasks and activities	24	97	157	45	72	58
Subject content + resources	76	85	39	13	44	35
Content (dot points)	35	16	92	12	13	29
Subject matter and skills	6	26	9	10	3	0
Learning and teaching scenarios	10	15	13	0	0	0
Integration of different subject areas or skills	3	14	4	1	2	4

The follow-up interviews with participants also supported the observations regarding a top-down approach to design. For example, two of the groups reported such a strategy as below.

> We all pretty much agreed on that [a subject area], and then we decided to have a look at the different outcomes. Because PE [Physical Education] is quite a physical subject, we had to find an outcome that was going to able to be completed online, so we chose our outcome that was Safety. After that we

> started throwing ideas around about what kinds of activities we could do, and just made a whole list of those. And it wasn't until a bit later when we had a good couple of ideas that we decided who would do which lessons. (Lucy, G1I2)

> So for the first two-ish weeks we were mainly drilling down on what outcomes we wanted to meet, what content we wanted to cover, how they were going to link with each other… In the following weeks we began to actually set out our lessons and no lesson was created individually... Then, we designated lesson to each person and we would work on it from there…. The final week was just final touch ups, making sure all the links worked, that we had done appropriate copyright, and that there weren't really any spelling mistakes or grammatical errors. (Marley, G1I3)

The top-down approach also occurred when the process involved discussions on an overarching outline for the whole course as the first step and more details as the next steps. As Jessica (G1I2) said:

> In the beginning stage, we talked about the skeleton of the lessons. We didn't actually go into much detail or select any of the technologies in the beginning. We just talked about the structure and who would be doing what tasks. And then towards the end we kind of fleshed it out more, got into more detail, specifically chose technologies.

As can be seen from the participants' descriptions, the main steps involved in a top-down approach in their design process include the focuses on: (1) Topics, 2) Outcomes, 3) Syllabus/Content points, 4) Lesson/Task allocation, and 5) Individual lesson design. Subsequently, the group developed activities, searched relevant online resources for each lesson, and attended to minor design details toward the end of the process. These accounts reflect a top-down approach.

4.1.2.3. Learner-focused approach

The close examination of the design processes also revealed that the teams were very likely to adopt a learner-focused approach to designing, with numerous conversations centred on learners' ages, interests, competences, preferences, and background (although there were possibly variations between groups with relation to this approach). Unlike the top-down and content-focused approaches, a learner-focused approach relies on learners' characteristics as a starting point for designing either the whole module, a single lesson, and a learning activity, or even for deciding on what technology to use.

This approach to basing design decisions on learner features was further confirmed in the follow-up interviews where all the groups reported that they had adopted a learner-focused design approach from the very beginning to the end of the design process, taking into consideration potential learners in both drafting design ideas and implementing the actual Moodle designs. The teams were aware that thinking of their potential learners as a foundation for designing was essential and beneficial for both their learners and the whole design process, as indicated in the following account.

> At the very beginning you really have to consider ... who your students are because it can differ so much… Also I think you really have to keep your students in mind throughout the whole learning design process because then it will be more accustomed to them. (Zoe, G3I3)

Sharing the same view, Marley (G1I3) said, "it is that idea [students' technological abilities are different] that you need to make sure your lessons underpin your students so that they can learn most effectively".

According to the aforementioned quotes, young learners emerged as the first and foremost factor underlining the design decisions. More specifically, the teams seemed to deliberate on what stage to work on so that the whole course would be designed upon that supporting grounding. For example, Paige said on behalf of her group,

> We discussed back and forth what stages we wanted to do, what stages we had done for prac, what stages we think would work really well for the Moodle, and we mutually decided Stage 2 would be a really good stage to go for because maybe Stage 1 might have difficulties navigating an online type of thing. (Paige, G2I2)

The quote also suggests that small children's technological capabilities must be an overarching high priority to discuss in a technology-based online course design process. An equally high-priority consideration was learner literacy competencies, from which it could be decided whether or not to design tasks that expected the learners to combine both their technology and literacy skills.

> I think you should definitely consider the ability of the students so what they are capable of doing so whether they can type on a keyboard or whether they have the literacy skills to be able to type or write. (Ruby, G2I3)

Individual technological competencies were also considered in designing learning tasks so that learners with different technological abilities could acomplish the same tasks as required, as indicated in the quote below, where Marley argued that the important design factors included:

> making sure that the task that you're setting is meeting the technological abilities of your students and making sure that you have differentiated tasks so if there are students who aren't as technologically advanced there is an option for them to complete the same content, but in a way that is accessible for them. (Marley, G1I3)

Interestingly, the pre-service teachers even put themselves in their potential learners' shoes by trying to understand what their primary learners liked and disliked to guarantee that they would fully engage their younger learners and have their attention. The two following excerpts are cases in point.

> I thought of students in my class, like later when I started teaching and I thought about them and I was like, 'What is something that I would like when I was a little kid?' And then I tried to think to their level and to see what they would like. (Aria, G3I2)

> I think you need to reflect yourself as well. So you need to think about what you would like to do as a student [and] what you would find fun. Often times if you just make a lesson and find it really boring to teach or you're not excited for it, then chances are that the kids would find it boring, too. (Jaden, G2I2)

Particularly, games were often chosen among the learning resources and materials that the pre-service teachers thought their learners would find exciting and engaging.

> I found this game and it gave them as if they were spies and as if they were on a mission and they had to achieve this mission. I had fun with it so I figured they would. I found that if I'm excited, and I'm really engaged in the learning that's taking place, then they're likely to be. (Ellie, G3I2)

Moreover, the pre-service teachers even specified the need for the chosen games to be interactive and educational to gain the maximum effects on small children. This was illustrated by Ruby's (G2I3) account, "We tried to look for educational and interactive games so the students can think they're just playing a game but they're actually learning".

Similar thoughtful design approaches were also reflected in the way the teacher candidates envisaged early-age learners' short attention spans to come up with an appropriate time frame for a designed module or task.

> I made sure for Year 1 you keep them about 40 minutes, so I tried to stick within that time frame. Anything longer and they lose it. So I made sure that my lessons were engaging but they also didn't stay on one thing for too long. They changed activities and showed they were able to demonstrate their understanding of the concept in a number of different ways to show the teacher if it was me what they know and if they can apply it. (Ellie, G3I2)

Some interviewed pre-service teachers also emphasised the importance of their learners' prior knowledge in deciding desirable learning outcomes and thus the difficulty level of the learning tasks, as emphasised by Evelyn (G1I3): "[It is important] knowing your students' prior knowledge so not just putting out an outcome and thinking that your students are going to get it straight away".

One notable point is that the teams appeared to recognise the main emphases on their potential learners' characteristics such as interests, needs, strengths and weaknesses in association with the completion of the learning outcomes put forward.

> Catering towards the students' needs I think is really important and ensuring that they all have an equal opportunity to reach their maximum potential in the lessons no matter where they're up to. (Evelyn, G1I3)

> I think that you need to cater to their interests and their strengths. That way you can get them to reach particular outcomes and goals. (Jaden, G2I2)

It can be seen from the two quotes above that the ultimate purpose of taking learners into consideration is to have learners achieve the desired outcomes, or the target content, as well as certain technological skills. This circle of related factors not only involves learners, content, and technologies, but also pedagogy. In fact, the pre-service teachers reported that it was necessary to consider what pedagogical approaches would work for certain groups of learners because learners might respond differently to different pedagogies. For instance,

> I think that you need to make sure that you're catering for your students and so I think pedagogy gives you a way to take a step back, look at what your students are doing and seeing how they are responding and taking their responses and applying them to the pedagogies that you use in the classroom to strengthen their understanding. (Summer, G2I3)

In their opinion, it was vital to be flexible in adopting various pedagogical approaches and "not to just blanket it in one pedagogy" (Zoe, G3I3).

In conclusion, the learner-focused approach was apparently thoughtfully adopted among the teams during their design processes in both iterations. The designed modules were expected to be relevant for potential learners who were considered with respects to their capabilities, skills, interests, preferences, age, and prior knowledge, so that choices of content, technology and pedagogy were made and, therefore, the success and engagement of the modules could be guaranteed to be maximised.

4.1.2.4. Context-oriented approach

Despite its low frequency in design conversations (see sub-section 4.1.1.9, context was found to be the topic of different discussions concerning the potential learner cohorts, the curricula, and school facilities. These findings were confirmed in the follow-up interviews, which indicated a context-oriented approach to designing among the pre-service teachers. When asked what the most important aspect was to consider while designing, four interviewees thought context was the most influential factor to consider at the commencement of the design process, as Zoe (G3I3) and Jaden (G2I2) revealed respectively: “At the very beginning I think you really have to consider context because it can differ so much.” and “The most important things would be looking at your students and the context of the learning that's occurring”.

Ellie (G3I2) elaborated on her responses about taking context into account as an initial step in learning design by clarifying that “it is really important to consider what you have access to in the classroom so in terms (of) technology and what you have”.

There was also evidence that the interviewed participants thought highly of and utilised the prescribed real-life context treatment in **I3** as a potential workplace to look for information upon which they could make further design decisions, as Evelyn (G1I3) accounted,

> We went onto the schools' website. Marley and I knew from other units how important it was to look at the annual reports of schools to get more information. Millie was only in her second year of education so that's what we got to teach her how to do as well. So we looked at the annual report which showed us that every class had access to iPads, so we put that information on board.

She went on explaining how the school report found on the website assisted her team in design Moodle-based learning activities.

> That's why a lot of the activities and lessons we created [where] learners would use iPads because we knew, [in] the school, every class had access to those. There was other information we found in the annual report programs. So we looked a bit further than just the school website. (Evelyn, G1I3)

The utilisation of the real school’s website was also confirmed by another participant in the same group as Evelyn. Marley (G1I3) detailed below how her group selected appropriate technologies based on the background information about the big cohort of learners found on the website.

> I think Carlingford West was the primary school that had a significant percentage of students that were studying English as a second language. So we had applications put onto our websites to help support that so we made sure that students knew that they could access translation tools if they needed to and that there was always a teacher to help them further if they needed to. I think that impacted how we designed our lessons.

Beside deciding on relevant tools to use in their design, a real-school context also helped Marley and her team attend to the cohort's cultural background and hence a corresponding design, as Marley (G1I3) elaborated, "Knowing the countries where they're from, [we considered] making it more relevant to them so that they engage better."

4.1.3. Summary for Research Question 1

The purpose of Section 4.1 was to provide answers to Research Question 1 (What elements do pre-service teachers focus upon when designing technology-enhanced learning tasks for their students?). Close investigation into 15 in-class design conversations and 22 Facebook Messenger chats in **I2** as well as 18 in-class design conversations and 18 Facebook Messenger chats in **I3** revealed dominant distributions of DK, CK, PK, and TK among six groups in both iterations over 5-6 Moodle weeks. Four main design approaches (content-based, top-down, learner-centred, and context-oriented) were also identified from both design conversations and end-of-course interviews. Answers to Research Question 2 are presented in the next section.

Research Question 2: What factors support and/or hinder the collaborative design of pre-service teacher technology-based lessons?

In the pilot study (**I1**), participants' technological capabilities, tutor support, and group dynamics emerged from the interview data as both enablers of, and barriers to, the teams' collaborative design of technology-based lessons. In the subsequent iterations forming this study, that did not seem to be the case; that is, these three factors were perceived as only enablers in both design conversations and the end-of-course interviews. Moreover, there emerged two more supporting factors from both the design conversations and the follow-up interviews: the participants' past learning and teaching experience and the program's resources and activities.

4.2.1. Technological capabilities

In-class conversations and online group chats showed that although the groups encountered several difficulties and confusion concerning technology during the design process, they could actually resolve their issues on the spot either by themselves or with the help from the other team members and tutors. Occasionally, they expressed a slight lack of confidence in skills with apps, software, or the Moodle LMS. Examples included Jaden (G2W1I2) who observed, "I don't know how to set it [a Google document] up", or Millie (G1W5I3), who remarked, "Now it's bugging me". More complaints were made by Ruby (G2W1I3), "I'm still stressed about embedding a file", and Alyssa (G1W4I2), "Does anyone know how I can edit the quiz/add more questions in?" In all cases, however, the person could find a solution immediately either on his/her own via googling or with peer and tutor support, which could be the reason why the student teachers did not report any technological hindrances in the end-of-course interviews.

Technological capabilities emerged from the data as a supporting factor to the design process in several ways in **I2** and **I3**. First of all, all the interviewed pre-service teachers showed no fear of a wide variety of tools introduced to them during the course, although they were confused at some points. In fact, the teams did not feel overwhelmed or discouraged from applying technologies at first. Instead, they apparently enjoyed looking for technology and applying it at the end. As Daisy (G3I2) elaborated:

> There was a wide variety [of tools] and I had a difficult time finding the perfect ones. …But it made it more *worthwhile* when I did find it because I was like 'You know what? This is the one!'

Daisy's comment suggests that she considered the vast repertoire of tools an exciting challenge posed to her; she was willing to take it and finally discovered a gratifying technology. Sharing a similar view, Paige (G2I2) and Lucy (G1I2) found intrinsic rewards from this challenge, making it something useful in sharpening their critical thinking when it came to selecting technologies for their designs. Paige and Lucy's respective quotes are below:

> It was a challenge, but I don't think it was hard exactly. I think it was *enjoyable* to actually look through all the stuff and have the critical view of looking for THE technology.

> Choosing ones [the right tools to use] was hard … But if you find them, there are some really great free ones. And it was really *fun* during this EDUC261 to really get to look through all of those. I found out a lot of new ones.

Their critical skills pertaining to the use of technology were reflected in the way they set their own criteria for selecting the suitable technologies, based on which they examined the tools' affordances. In the following quote, Lucy (G1I2) felt the need to make sure that the tools were appropriate for small school children by playing around with the tools before embedding them to her technology-enhanced online lessons:

> I find what's really helpful for me is to think critically about all of the software that I came across, like 'Is this going to be helpful or is this just going to make it harder for the kids?' I also made sure that I'd actually do the activity first. Not just put it up there and then find out later it doesn't work or it's not what you thought it was.

In the same vein, the pre-service teacher technological competences were shown in the way they knew well what they wanted for each tool chosen. They asked themselves numerous questions before searching for tools and when having found ones:

> Because we've been introduced to a lot [of technologies] in the lectures and the tutorials, we kind of knew what we were looking for. We were like 'I like this, so I'm going to use this' or 'I like this, but I wish that it had this element to it. I wish that it had this affordance in it.' And then we'd go out and look for something more specific that we were looking for. (Paige, G2I2)

The participants demonstrated some skillfulness in the way that they went beyond what was provided for them and taught to them to search for the right tools for their designs. This enthusiasm for learning evidently contributed to the improvement in their technological capacities, a finding echoed in Paige's comment about going beyond core unit requirement:

> We were all researching a lot and using the tools that were given to us, the web 2.0 tools and the software that were suggested in the course, and then trying to go beyond that if something that we found we didn't quite like and we needed something a little extra. (Paige, G2I2)

At a higher level, the pre-service teachers indicated a critical understanding about one of the underpinning philosophies of using technology in the classroom that technology should not be used because one is asked to do use it. That is, teachers need to make sure the activity for which their potential learners are using technology is engaging and meets the syllabus outcomes and content in a way that encourages creativity and critical thinking rather than having learners, for example, type up their narrative because it ticks the box of using technology in the classroom.

> I find sometimes you can use technology for the sake of using technology and it's not actually giving the kids anything other than 'Oh we're using the iPads 'cos we're using the iPads.' I feel like you have to have a reason. You need to be able to justify, 'Well this app on the iPad has this, that can enhance this part of the content for the syllabus'. (Ellie, G3I2)

It is apparent the teams learned that their technological capabilities not only had to do with their ability to justify the selection of a technology in association with learners and content, but also their ability to find out which pedagogy underpins the technology, as reflected in Evelyn's comment below:

> When I enrolled into the unit, I did think it was more going to be 'Here's a technology. Here's how to use it. And this is what can go wrong with it when you have students in your class and this is what can go right.' So I was quite surprised with how much it was about the connection between technology and pedagogy. I found it really interesting and useful how pedagogy does align with

> certain technologies, thing I hadn't really thought about that way before. (Evelyn, G1I3)

These in-depth views of using technology in the classroom show the success of the unit in transforming the student teachers' views toward what technology to use, how to use it and why to use it in their teaching environment.

There was also evidence that the constant exposure to examining technologies throughout the unit was not only useful for the pre-service teachers' current design practice but also beneficial for their future job as primary school teachers, as reported by Evelyn (G1I3):

> My favourite part was definitely learning how to use Moodle because that's something that's become very useful. I feel like that's now a tool that I have to use when I go out teaching.
>
> Before the course I was hesitant to implement technology into some of my lessons on prac, but this course gave me the confidence to be able to implement some of the things I'd learnt or some of the sites we were sharing. Especially, because at the time that I was doing EDUC261, I was on a Year 3 class, being able to use some of the sites our tutor had shown us was really good. That made me feel a lot more confident. So now I'm just more confident to use technology and use it within the classroom than I was before the unit (Evelyn, G1I3).

The quotes also indicate the role of the tutors or course trainers in lifting the pre-service teachers' confidence about technology to a higher level, there being no signs of indecisiveness toward the end of the course.

In conclusion, the pre-service teachers' abilities to select and use the tools they needed among a wide variety of technologies emerged from the data as a support to their design processes. The whole Moodle weeks as well as the whole course period witnessed the teams' technological evolution from knowing little to knowing more, from being unsure to being confident and from being reliant to being independent, in selecting appropriate technologies. A range of diverse technologies presented participants with challenges about which tools to include in their design and at the same time with opportunities to look at the tools from different insightful angles. And they did this with tutor and peer assistance, which will be presented in the next two sections.

4.2.2. Tutor support

Unlike in the pilot study where tutors were identified as both helpful and unhelpful to the design process, in this study tutors were seen as overwhelmingly supportive in the design process. This was observed both in design conversations and post-course interviews.

To begin with, in-class and Messenger conversations showed that help from tutors was requested in almost all lessons, especially while the participants were discussing their designs in groups. This could be illustrated by numerous occasions when the team members suggested asking tutors for help among themselves. Several examples were "Ok, so we're asking him about what we can use and what we actually really need to include." (Summer, G2W2I3), "I need to ask the tutor about the information for referencing." (Lucy, G1W4I2), "Should we grab our tutor when she's free next?" (Aria, G3W4I2), "I'm going to ask him about our lessons." (Marley, G1W5I3), and "I think that's something we need to ask the tutor" (Alyssa, G1W5I2).

One notable point was the teams were quite selective in what to seek advice on. They only consulted with tutors on what they were not sure of or what was totally new to them. Other than that, they would find the solutions together with their peers (see Section 4.2.3). Receiving a compliment from tutors was motivating and reassuring to them as well; to illustrate, "Do you think we should run it by her just to make sure?" (Jasmine, G3W5I3), "Should we ask him to have a look quickly? It's good to have his opinion." (Jessica, G1W5I2), "Maybe we'll just ask about the ones we're not sure of." (Evelyn, G1W5I3), and "Maybe ask our tutor 'cos I've never seen anything like that before" (Amelia, G2W4I3).

Contrary to the findings in the **I1** study in 2016 that tutors could be both supportive and unsupportive to the design process, all the interviews conducted in **I2** (2017) and **I3** (2018) revealed that tutors were consistently seen as supportive. In fact, tutors were found to contribute greatly to the teams' design processes. More specifically, tutors were generally seen as organised and students felt they were provided with a sufficient amount of time to interact with their groups on the mutual designs.

> They [the tutors] were really supportive. They gave us plenty of time at the end of each tutorial to work on it for five weeks or so. That was really helpful. (Lucy, G1I2)

In addition, tutors' attentiveness was shown via the instant and detailed feedback they provided to the teams during the tutorial. One group representative said:

> When we were halfway through our Moodle, it was really good to have our tutor come over and have a look at it from a different eye. He could let us know what he thought we could improve on. (Evelyn, G1I3)

This timely expert advice given at regular intervals when needed at critical points in planning was apparently appreciated. On-the-spot tutorial explanations helped clarify any problems which were clouding the students' thinking, as Ellie (G3I2) and Marley (G1I3) pointed out respectively:

> It was really good our tutor was able to show us how to do it, where we were going wrong or if we were pressing the wrong button.

> We did discuss with our tutor certain ideas to see if we were on the right track. Having that support there was really beneficial because he had such a wide bank of knowledge that by asking him, we were able to clarify our understanding.

It was evident that during the design process tutors were consulted because they had a great depth of knowledge which students could tap into. This was efficient and time saving because students could stay on track and not make the same mistakes or "reinvent the wheel".

Even better, the feedback was not explicitly direct but suggested enough for the students to realise the problems and work on them by themselves. This way of guidance helped the student teachers work more independently and confidently to complete their designs.

> Our tutor gave us really good guidance and we'd show her our plan and be like 'How about this part?'. And she would say, 'Just think about what the assignment says. That element's not really going to help you out, is it?' And we'd say, 'Oh yeah we better change the debate.' That's the main one that she helped us to work out what was not going to work. … That was very helpful because I think maybe we wouldn't have been fulfilling the requirements of the assignment had we not had her guidance. (Jasmine, G3I3)

> When it came around to checking whether we were on the right track and making sure that the elements that we were including were broad enough and effective enough, she pointed us in the right direction without making our minds up for us, which was really good. (Zoe, G3I3)

The above quote suggests that the tutor made sure students stayed on point and did not stray too far from the questions asked. She gave indications about which solutions would not work in order to steer students away from solutions that would possibly cause more problems for them.

Not only did the pre-service teachers receive feedback in person in the classroom, but they also received timely and prompt online feedback from the tutors, for instance, via email. Lucy (G1I2) was very happy with her tutor because he "… was really great. He would respond to things online. He was always responding in a pretty timely fashion".

This further confirms tutors' important roles as active supporters in a blended course where teachers are supposed to attend to students' needs not only in the physical class but also in the virtual class. The quote also indicates tutors' enthusiasm and passion about teaching which, in turn, was passed down onto students, generating their motivation and creating an exciting class atmosphere. This was also echoed in Paige and Zoe's following remarks:

> It makes a massive difference when the tutors are really invested in the assessments. And it was really obvious that our tutor was really interested in and passionate about what we were doing. He gave us advice and praise, which is always good and very helpful. (Paige, G2I2)

> She [the tutor] was really excited and opportunistic [enthusiastic] about the class even though it was difficult, which made all the students excited. (Zoe, G3I3)

The quotes suggest that tutors acted as mental supporters to students. The tutors evidently showed genuine interest in, and paid compliments to, students, which was apparently perceived as a positive supporting strategy for students.

On top of that, tutors were supporting of the participants' design processes by teaching modelling and giving examples. According to the participants, this strategy worked for them, made them understand technology, and stimulated their creativity. As both Jaden and Evelyn reported:

> I don't consider myself very strong in technology, but I found all of the lessons, all of the tutorials leading up to the assignment, really helpful. So I think having it modelled to us was really good. Allowing us to go off and do it was creative for our own little Moodle. (Jaden, G2I2)

> I found the best way to understand that for me was through examples, like real life examples in the classroom. I know there were a few times our tutor would give us some examples and I'd just write them down just so I could understand it a bit more. (Evelyn, G1I3)

The exemplification could exert an influence on students without them being aware of it. The following quote shows how the teacher did not need to explicitly taught pedagogy, but performed it in the right way, which was apparently more powerful than words. Zoe (G3I3) expressed how she perceived her tutor's pedagogical strategies as a mirror:

> There wasn't a lot of direct teaching, which was good. … By ensuring that we got our learning intentions and our outcomes at the beginning of the lesson and then moving through the lesson in the way that she planned, she was showing us how to embody that pedagogy again. It was like she was teaching us in the way that we should be teaching. It was really good to have someone to exemplify that.

Following these demonstrations and examples were the hands-on experience activities where students could explore the technologies by themselves. The tutors seemed to be aware that hands-on teaching worked for most students and made it one of the main activities in most classes, as observed by Evelyn (G1I3):

> Probably the best bits were the tutorials when we actually learnt how to do things on Moodle. I really enjoyed going to those ones because I knew we'd get to log onto the computer and actually be shown how to create things in Moodle.

This engagement with the tutors and resources as well as technologies was very likely to trigger the desire to learn more and, more meaningfully, to encourage active learning. It also allowed multi-dimensional learning experience to occur. As Marley (G1I3) reported:

> In general, the tutorials that we engaged with our tutor were incredible. Rather than just being like 'Ok this is what it looked like', we actually explored it ourselves and had first-hand experience with the applications, which I think is really important. As a teacher if somebody goes 'Oh this application is great', you're not really going to dive into it unless someone actually shows you and engages you with the application.

On top of that, the supportive tutors created an inspiring and safe environment for students to study in. Students were encouraged to make open dialogues and feel comfortable in asking questions. Marley (G1I3) continued reflecting:

> By having that with our tutor, he then expanded on it and made sure that he gave us opportunities to ask questions. We didn't feel overwhelmed. We didn't feel as though we couldn't ask questions. It was a very comfortable environment and the tutor gave us the opportunity to ask questions both in tutorials and lectures.

Tutors were also supportive in a way that they delivered information in small attainable "building blocks" so it was easy for the students to digest information. Thus, the students' confidence was built along the way toward the final mastery of applying technology to teaching.

> How our tutor went through everything each week and taught us different sections helped lead us up to doing the Moodle ourselves. For our group we weren't very confident at first at the idea of making a website. We were kind of scared because we had no idea what's going on with that but then it was fun. We

> weren't scared any more with him showing us and answering our questions. (Summer, G2I3)

The above analyses show the significance of the teacher's role in supporting and scaffolding students in constructing learning design knowledge and skills. The teacher not only provides inputs and provokes students' thinking, but also creates a good interactive environment. The tutor was not only an intellectual support, but also an emotional support to students.

4.2.3. Group dynamics

In **I1** group collaboration was found to be both a challenge and an enabling factor to the teams' design process. A similar finding was not the case in **I2** and **I3**. In the last two iterations positive group interactions among the participants which supported the design process in numerous ways were evidenced via both design conversations and follow-up interviews.

In-class and Messenger group chats showed that there was a lot of peer mutual feedback provided within each group. For example, the participants helped each other add referenced links under the images and videos and clarified different related issues . Also, there were many times when the teams would look at the computer screen together and discuss the interface overview of the course, names of the whole modules, course settings, etc. A member was also willing to help another member once they did not know how to use a technology. They shared files and resources with each other. For instance, (Paige, G2I2) texted her team in their shared Messenger group chat: "If you guys have any feedback on it, let me know. I'll get into this justification tomorrow and if I read any good articles, I'll send them to you". Especially, the groups showed an understanding of negotiating skills when the group discussion came to a disagreement. They would reassure each other with comments like "People can come up with their own ideas." (Summer, G2I3), and "Yeah, this is just brainstorming. We could always change this later" (Jasmine, G3I3). Furthermore, the teams kept encouraging each other when one of the team members showed impatience, tiredness, fear, or worries concerning their designs. The group clarification and encouragement seem to help individuals feel less confused and more motivated.

Thorough investigation into the end-of-course interviews revealed similar and more supporting themes with respect to group dynamics. Firstly, the team members tended to always provide mutual support for each other when it came to the tasks that required a collective effort and this led to the consistency of the whole module such as assessment, troubleshooting the designs, or formatting. As Evelyn (G1I3) accounted:

> If one of us wasn't sure about what type of assessment we could do for our lesson, we always made sure we collaborated and helped each other a lot. So we didn't want to leave one of our group members with lessons that weren't up to the standard of, say, another. (Evelyn, G1I3)

It seems this specific collaboration helped to make sure that no one would be left confused and that everyone’s work met the unit design task requirements. In addition, the pre-service teachers provided assistance and shared expertise within the group whenever they could.

> Working in a group didn't have much hindrance. It was helpful because we got to share our ideas. Especially we got to share different technologies that we could use. (Jessica, G1I2)

The sharing of technologies was particularly appreciated when one or more members encountered technological difficulties. In this case, clarifying and demonstrating within the group came up as a strong contributor, as shown in Jasmine’s reflection below:

> I guess when we were together, we explored the technologies that we could use. There's one of us who'd say, ‘Oh look! I found this technology. I think we can use it. I'll show you how it works.’ … To demonstrate we relied on Zoe a lot to help us how to embed things because sometimes it wouldn't work how it was supposed to and she just had a knack to that. (Jasmine, G3I3)

The quote suggests that the lack of technological skills was turned into a learning starting point for a team member. With team support his/her technological expertise was lifted to a higher level, which in turn assisted a smoother collaborative design process.

Proofreading and editing each other's work was also found to be a group supportive factor. How helpful it was to have their work double checked by peers was well reasoned by Ellie (G3I2):

> At the end we each took it in turns to go through and edit. So every time someone finished a lesson, we sent a message to each other and said 'Hey, can you check this?' And fantastic! Daisy she was on top of that grammar. It was really good to have those different skills and different sets of eyes because I know sometimes when I've read things over and over again you don't see the mistakes.

Furthermore, group collaboration was considered a strong mental support for the design process among the participants. Understanding that design work could be tedious and challenging at times and therefore required patience, the pre-service teachers kept encouraging each other when it came to the moments of feeling lost or distracted.

> On Facebook there was a little bit of emotional support, a bit of 'You can do it. You're on prac. Keep going!'… We really supported each other. We used the time in class to collaborate in a way that was useful rather than get distracted. (Ellie, G3I2)

Apparently, peer support was helpful for a less confident pre-service teacher, as accounted below by Jasmine (G3I3):

> Ellie and I are in our 4th year. Zoe was in her 2nd year, so sometimes she lacked confidence. Like she was amazing, but she just didn't think she was sometimes, so we just had to try to encourage her a lot. She always did the work that she needed to do. She was never slack. She was just nervous about the assignment, not knowing what she was doing when she actually did though.

In addition to mutual help, both personal and emotional, the interview responses showed a mutual understanding among the team members on their Moodle journey. The participants took into account several factors such as each other's background and strengths so that smooth initial steps of the design process could be established.

> I'm a primary teacher. Daisy was an Early Childhood teacher. Aria was a primary teacher. So we wanted to make sure we covered something that everyone could do. Daisy would probably have no clue what to do with Year 6, so we tried to make sure that we had something that everyone could share their strengths in. (Ellie, G3I2)

The pre-service teachers even took into consideration one another's schedules and workload so that appropriate decisions pertaining to the group design tasks like task allocation could be made accordingly.

> We have opinions, but we're not overly opinionated. We consider each other's schedules, busyness, and other stuff. And we take into consideration each other's ideas. Even though each of us was assigned to one different blog, we came together as a whole. And the entire unit is a reflection of all of our work, all of our planning, not just one or two people, taking reign of everything and doing everything. (Jaden, G2I2)

The two quotes above by Ellie and Jaden indicate a strong commitment to one another among the group members. Once they reached an agreement and mutual understanding, they committed to their negotiated position. They seemed to understand that everyone was an important link in the chain and once one was not cooperative, the whole chain was negatively affected. As Alyssa (G1I2) also pointed out instantly when asked what contributed to the successful elements of their Moodle course:

> I think working as a group, updating each other with what to do, staying on the same page, and knowing that one person is doing this which also leads to my one and which also leads to help another person.

As important as making sure that everyone was in agreement was the communication and negotiation skills among the participants. This was considered the key to a smoothly flowing design process.

> A lot of times we have our own ideas, we bring out the ideas, and none of us will shut down another person. We'll take it and we'll give suggestions on how to improve it. 'Oh I like that idea. But we can do this, add onto this instead.' So we'll

> keep the idea as it is, change it a little bit, and then we come to an agreement. (Jaden, G2I2)

This quote indicates that not turning down the other person's ideas does not mean all the ideas were accepted uncritically. On the contrary, ideas were respected, considered, and analysed to come up with the best possible design solutions, which was a positive group work spirit.

On top of this, team members seemed to feel satisfied about how tasks were equally delegated between group members to ensure fairness of work and timely completion of activities, which was another facilitating factor. This was representatively accounted by Daisy (G3I2):

> We didn't have any disagreements, no disgruntlements. I feel like it was really important that we all contributed an equal amount. So we worked out at the start, 'I'm going to do week 1 and 2, Ellie week 3 and 4, Aria week 5 and 6', which was really helpful because a lot of group assignments that you do at university, the reality of it is, one person does 80% and another person does 20%.

Additionally, emerging from the data as a supporting factor to the design process was a two-heads-are-better belief by most interviewees. Most interviewed participants thought that they could learn more when exposing themselves to different ways of thinking and bouncing ideas off one another. That way, their ideas were made more insightful and more compelling. As Lucy (G1I2), Marley (G1I3), and Ruby (G2I3) put it respectively:

> It's good how in a group people can think of things that you would never have thought of yourself. And you can think of things that they wouldn't have thought of. So when you put it all together, it turns into be something much more in depth and much more interesting. A lot better with a lot of minds than just one mind working on it.

> I really enjoyed working collaboratively with other student teachers because it gives you another perspective…We each had different and incredible ideas, so it just exposes you to other ways of thinking.

> I definitely enjoyed the group work and having two other really great people in my group who I could bounce ideas off. I found because they were in a year above me at uni they had a lot of knowledge to share as well.

While holding people accountable among the group members was an issue in **I1** when a certain assigned task was not done on time, this did not seem to be a problem in **I2** and **I3**. In fact, the participants in the last two iterations reported a collective sense of responsibility, being determined to fulfill the shared tasks in a punctual manner so as not to affect the flow of the design process. As Lucy (G1I2) explained:

> We had a deadline and said we wanted to be finished by this and everybody took responsibility for their own part and made sure that they had it finished and weren't letting the team down... We all worked that way and made sure that they were at a high standard.

Finally, a shared positive spirit running through the whole journey seemingly was a big contributor. The teams seemed to be very enthusiastic and thrilled about their design tasks. As Paige explained, her team's Moodle task was both a joy and a success:

> We were very excited about it (their Moodle design task), [which] made it really enjoyable to do. We were all enthusiastic… [and] all very keen. ... that's what made the Moodle so successful. If we didn't really care that much, we could've just been like 'Oh I'm just going to google this and I'm just going to put it in without that kind of critical thinking about what tools we were using'. (Paige, G2I2)

Sharing the same view, Summer (G2I3) and Zoe (G3I3) admitted that the excitement within their groups further engaged them with the tasks and probably therefore made the design process more efficient and productive:

> [That] we worked so well as a group was a really big contributing factor. If we didn't work together, then I don't think it would've come as quickly. We were so on time and organised. Summer (G2I3)

> The group was really good. I was really fortunate to have people who were so engaged and excited about the unit because it made me more excited, and they knew a lot more as well so I was learning with, from them. Zoe (G3I3)

Similarly, according to Evelyn (G1I3), the joy she received from working with her team was transformational and inspirational.

> I really enjoyed the group process of the Moodle as well, a lot more than I thought I would. The people I was paired with were really great team members. I feel like if you didn't get someone who was just motivated as you to succeed in the assessment, it wouldn't have been as enjoyable.

4.2.4. Educational past experience

It was observed both in the design conversations and in the follow-up interviews that the pre-service teachers based their design decisions on their past learning and teaching experience. Table 4.23 shows the number of times the pre-service teachers tapped into their past experience to support their design practices.

Table 4.23: Distribution of educational experiences in I2 and I3

	Iteration 1	**Iteration 2**	**Total**	**%**
Past practicum	33	12	**45**	**37**
Previous course	33	2	35	29
Past assignment	8	10	18	15
Previously attended schools	7	6	13	10
Tutoring experience	7	4	11	9
Total	88	34	122	100

As can be seen, the participants' design practices were most informed by their past practica compared to other educational experiences, accounting for 37% of the units coded related to educational experience in both iterations' design conversations. The participants reflected on how they created learning tasks, managed class, and received feedback from the mentor teacher during group discussion. For example, Ellie (G3W2I2) shared the way of organising class: "[In my] last school, what they did was they actually had two separate maths groups." while Jaden (G2W3I2) shared one of the learning tasks he created for practicum:

> I did a thing at my first prac school called Take Three For The Sea, which was all about minimising waste on the beach to help the sea creatures so that the turtles don't get choked by plasticy things and all that sort of stuff.

These reflections appeared to inform them of what was (not) useful for designing their artefacts, as Layla (G2W3I2) reflected on a bad incident: "It was such a bad prac experience this time around and I have so much room for improvement for this course [we are designing]" and Jessica (G1W3I2) shared expert knowledge:

> When I did my lesson on it the other day, the one piece of advice that my teacher gave me was that you should kind of in a way not trick the students, but get them pre-engaged in Morocco and then bring out this book that has Morocco in it.

Memories of their own schooling experiences (kindergarten, primary, and secondary) also informed the participants' design process. For instance, Jasmine's (G3W3I3) thought about her kindergarten years ("When I was on Kindergarten, I couldn't believe how much work they got through.") may have helped her adjust the workload she would want to allocate to her potential learners. Similarly, Daisy (G2W1I2) reflected, "I remember in Year 1 we'd go into this computer room and get to go on the magic school bus", Alyssa (G1W4I2) accounted, "So we've learnt in our school that you're meant to look both ways, cross over the zebra lines and follow the green walking man", and Millie (G1W1I3) recalled, "[It was] one lesson, like one unit of work in particular, that I remember doing constantly as a child in Year 5 in order to learn about Parliament and important stuff". These short stories possibly informed their respective choices of technology for teaching Year 1 learners, learning scenarios related to their design topic, and focus of a lesson.

As well, memories of a previous course also informed the pre-service teachers' design practices. Specifically, Jaden (G2W5I2) probably helped his group choose an appropriate tool when describing a technology he used in one previous unit: "Because I did a Japanese unit where there was an actual thing on the Moodle [that] records you talking and then send it on there". Zoe (G3W3I3) asked her group members whether they attended TEP248 yet, provided feedback about how good the unit was, and then commented, "All about making sure that all the needs of the student are met in the classroom, and that means that you might alter the process of a task or a product of a task". This comment apparently further educated other group members who had not completed a practicum yet.

Experience in completed assignments evidently supported the participants' design activities. For instance, Paige (G2W5I2) shared a lesson learned from an incident with her team to avoid them making the same mistake: "Oh! Also top tip for the QR code maker: tell the kids to just make it black because I used a red one for an assignment once and tried to scan it while I was presenting it to the class, and it didn't work". Daisy (G3W2I2) and Jasmine (G3W5I3) recalled respectively, "I've had to do group oral presentations on iLearn before." and "I had an assignment once which was run on a Moodle site like ours [where] the teacher created discussion forums and put us into groups". These reflections apparently guided their peers and themselves as to which tools to choose for certain activities on their Moodle-based sites.

Tutoring experience was another supporting factor to the pre-service teachers' learning design practices. Working at a school as a part-time tutor helped Jessica (G1W2I2) know that one learning task her group were designing was a meaningful task as she guaranteed, "I saw it being done at one of my schools I worked at last week and it was pretty successful". Similarly, when Macy (G3W2I3) might have had more experience to share when revealing to her group, "I've done that as a lesson for a year 6 group". Her group partner then followed up, "So your expertise can come in" (Zoe, G3W2I3).

The end-of-session interviews sustained the above findings. To illustrate, via knowledge learned from the previous units, Evelyn (G1I3) and her partners knew where and how to search for more information relevant to their group design: "Marley and I knew from other units how important it was to look at the annual reports of schools to get more information".

Through real-life practicum experience teaching small children, some participants developed a deeper understanding of them and therefore could add more dimensions and colours to the online course they were co-designing with their teams. Paige (G2I2) exclaimed, "I know that the kids that I had, at prac, at the time would've loved that [a graphic organiser]". Then she connected the statement to a story about how successful a practicum teaching activity was with the use of a similar but simpler technology:

> In the prac that I was on at the time, we didn't have a lot of access to technology and the interactive whiteboard was not great. But I did use Scribble Maps for a History lesson where we had to talk about where our parents were from and where our families were from. I could annotate the map with all of the students' parents' birth places. Especially, in the EALD classroom, so many students were from so many different places. It was just like 'Such a beautiful display! Look at all of our backgrounds!' So yeah, I really love that website. It's great.

Likewise, Aria's (G3I2) knowledge of small children from tutoring strengthened her view of how young schoolers learned, from which she was able to design what her potential learners would enjoy.

> I tutor kids so I know how they learn and how they are. When I relate those students to what we're learning and then sometimes even introduce them and see how they do it, I can see that there is a change in attitudes towards learning. They find it more fun 'cos it's on the computer and it's not something that they always get to do. Aria (G3I2)

In summary, this section emphasises the important role of the participants' reflections on their related educational experiences as an enabling factor to the learning design process. There was evidence from both design conversations and post-course interviews that students' education-related past stories, good or bad, helped enlighten not only themselves but also other less experienced group members.

4.2.5. Unit's resources and activities

Resources and activities that the unit of EDUC261 provided emerged from the data as among the factors facilitating the participants' learning design practices. It occasionally appeared in the design conversations. Layla (G2W2I2) commented on the Moodle task assignment from the first week, "I feel this is a good assignment because we don't have to write too much essays for a while until we have to do the reflection thing". Showing her preference for the group feedback activity, Amelia (G2W6I3) exclaimed, “I'm excited [about the activity because] I need feedback”.

More evidence was found in the post-course interview that showed how the resources and activities contributed to the design process. One of the interventions applied in **I2** and **I3** was a more extensive use of the Learning Design Guide during Moodle group work. Five interviewed participants reported positively on its use, as Evelyn (G1I3) narrated, “we used it as a guide for what we knew we needed to think about and include in our assessment”. Marley (G1I3) in the same group with Evelyn provided a more detailed account:

> It was a good scaffold for us to use and I think we used it more for designing our Moodle module. Personally I used it more when actually designing my Moodle module.

Paige (G2I2) elaborated on how the Learning Design Guide helped her skeleton her Moodle module and guided her in the whole learning design process as below.

> It helps you flesh it out and understand the motivation behind what you're doing… This flowed into what kind of tasks we were going to do and what kind of assessments we were going to do. Having that plan before we went into it really helped us have a focus for what we needed to do rather than just playing with all the cool stuff.

Zoe (G3I3) used the Learning Design Guide as a checklist for her Moodle module that had all the essential aspects of a learning design such as pedagogy, content, and technology. As Zoe accounted,

> With the Learning Design Guide we made sure that we looked at assessments and we looked at pedagogy, affordances, outcomes, and all of that. So it was like a checklist at the beginning of our structure.

Another emergent enabler belonging to this category was the program’s weekly reading inputs and lectures. Responses from seven of the interviewed participants suggested this finding. Evelyn (G1I3) thought the textbook’s easy flow and informative content facilitated her all through in completing the unit:

> It [the textbook] was easy to read, very clear, and to the point. That gave me motivation to constantly do the readings because I feel like that helped me with the overall completion of the unit.

Paige's (G2I2) learning design practices were supported due to the practicality of the book's content, as she accounted:

> I liked the readings for this unit because they were very practical. There was theory to it, but then following the theory, it was 'How can this be applied in practice? Here are some case studies and examples of how this is actually happening and how this can actually be applied'… It just made my learning so much easier and so much more concrete. I feel so much more confident talking about the content from the unit because I can relate it to stuff.

Furthermore, the tutorials themselves were a great supporting factor. Marley (G1I3) described how she was engaged in her tutorials and other resources:

> The tutorials that we engaged with the tutor were incredible… We actually went in [our Moodle course] and explored it ourselves and had first-hand experience with the applications… [It's important that] we actually got to engage with the resources that we were learning about.

One participant was impressed with how sample Moodle courses introduced to them during the tutorials were beneficial to her and other students. She expressed her thoughts about how useful it was as below:

> Having the example modules really helped us 'cos it was hard to visualise what our end product would look like until we actually got a chance to see other Moodle modules. It flicked a switch in us like 'Oh ok! So this is the kind of thing that we should be like aiming towards'. It should be like how it's set out and taking little bits of inspiration from each of the other Moodles [Moodle modules]. (Evelyn G1I3)

Moreover, the readings and lectures were connected with each other in a way that they complemented each other. Evelyn (G1I3) and Katherine (G3I3) recognised that and reported it in their respective responses.

> Lectures sometimes repeated what was in the reading, which is fine because then you're just reminding yourself of what you've learnt. I thought that was good because a lot of unit these days would be completely off track to what was in the lecture. So I did like that.

> The way the readings, the lectures and the tutes all matched up was helpful to reinforce what we were learning about… I think that's a successful lecture when you actually are motivated to listen to it from home and I loved the way the lecturer made it live so that you were interacting with him whilst listening to the lecture.

For Jessica (G1I2), the connection above was described as the alignment of different aspects introduced within the EDUC261 structure to her previously learned knowledge. She explained as follows:

> I had come across the theories like Social Constructivism and Constructivism with units in previous lessons. I had never really thought about how to attach it to activities. EDUC261 aligned it so perfectly with technology that we were being given examples of how to employ it. The whole unit was so intertwined that by the end of it you were like Oh my Goodness!

The interviewees also mentioned how they were supported with a vast variety of resources such as links to technologies, websites and YouTube videos, as Paige (G2I2), Jasmine (G3I3), and Zoe (G3I3) listed respectively:

> There were also a lot of resources and websites and all sorts of YouTube videos that we could check out if we wanted more information, which was just so helpful.

> I was equipped with a lot of technologies in this course… which has so many resources in it and they've given me websites that list different resources that I can use so I think probably that has been the most valuable thing that I've taken away from this course.

> The other thing that I learned a lot of was the different types of technologies. As we moved through the unit, we looked at Web2.0 and social media networking and how to best employ them as well, which was interesting. They introduced us to Minecraft and Secondlife and how these can be educational. All these really

> amazing technologies that have so many affordances if you use them in the right way.

In summary, the finding that the resources and activities provided during the program were a considerable facilitating factor matched with one of the treatments applied in both iterations. This treatment was greater emphasis on weekly reading inputs and scholarly evidence.

4.2.6. Summary for Research Question 2

Research Question 2 (What factors support and/or hinder the collaborative design of pre-service teacher technology-based lessons?) was answered in Section 4.2. The three obstacles (participants' technological capabilities, tutor support, and group dynamics), which were also the supporting factors, identified in **I1** were found to be no longer obstacles in **I2** and **I3**. They were solely observed and reported as contributors to the design process in both iterations. In addition, two more enablers were observed, which were the participants' past experience pertaining to tertiary teaching and learning and the program's resources and activities. Findings related to the Research Question 3 are detailed in the following section.

Research Question 3: Are there any relationships between pre-service teacher learning design practices and the characteristics of their final online artefacts?

As specified in Section 3.9, in the Methodology chapter, in order to find out the relationships between pre-service teacher learning design practices and the characteristics of their final online artefacts, Regression tests were conducted and four scatterplots were created based on the comparison of (1) the percentage of PK, TK, CK, and Context related comments among the group members (18 participants total) over the Moodle weeks in both iterations 2 and 3 with (2) the corresponding scores out of 5 the group members received for each of the above elements for their final Moodle tasks. Figure 4.3 and Figure 4.5 do not show a strong correlation between the frequencies of PK and CK and the scores gained pedagogy and content for the final artefacts. Alternatively, Figure 4.4 and Figure 4.6 show a more marked correlation between the frequency of TK and Context discussions and the scores gained for technology and context for the final artefacts.

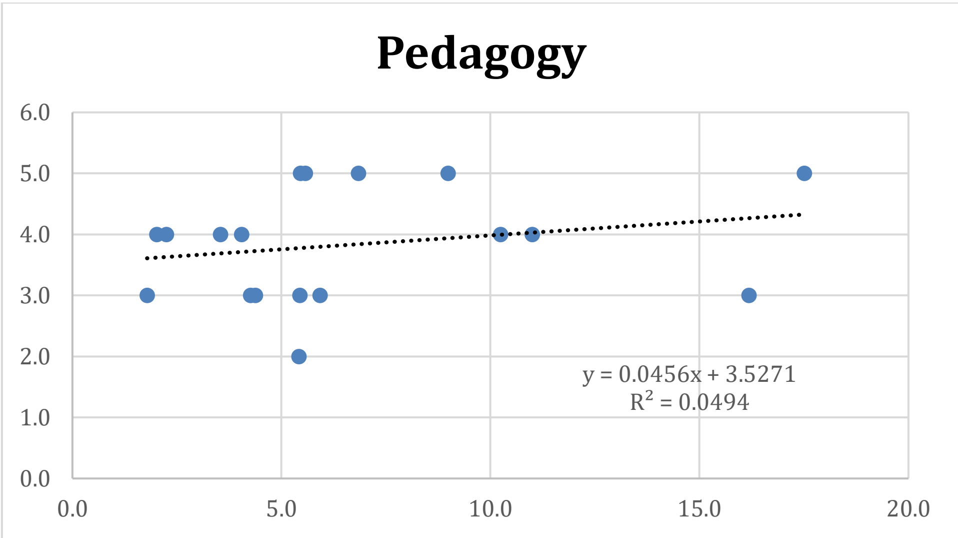

Figure 4.3: Relationship between PK distribution and score for pedagogy

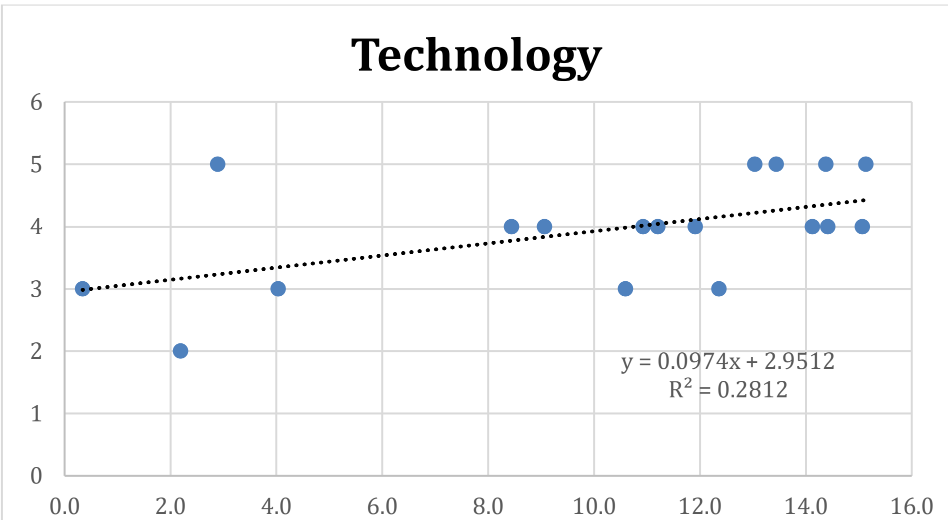

Figure 4.4: Relationship between TK distribution and score for technology

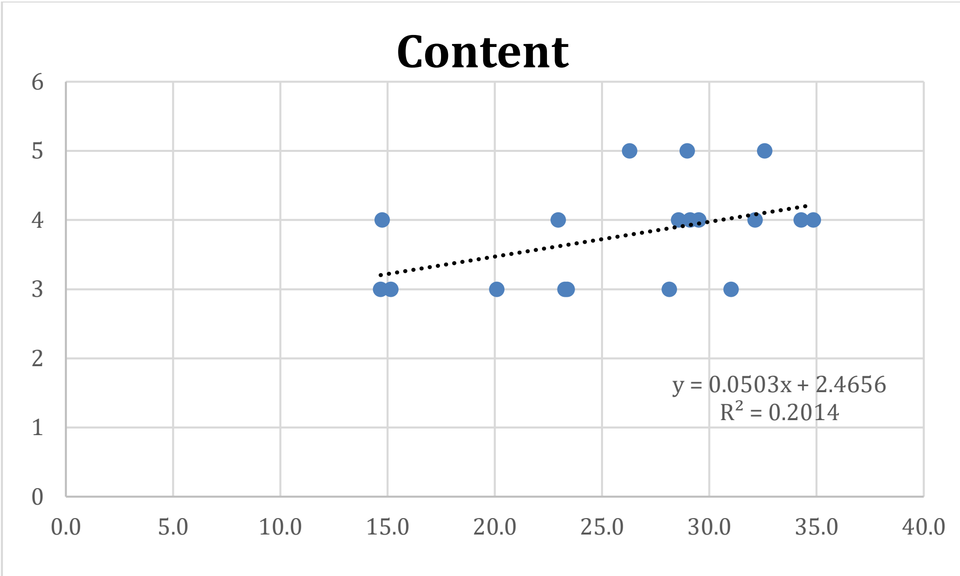

Figure 4.5: Relationship between CK distribution and score for content

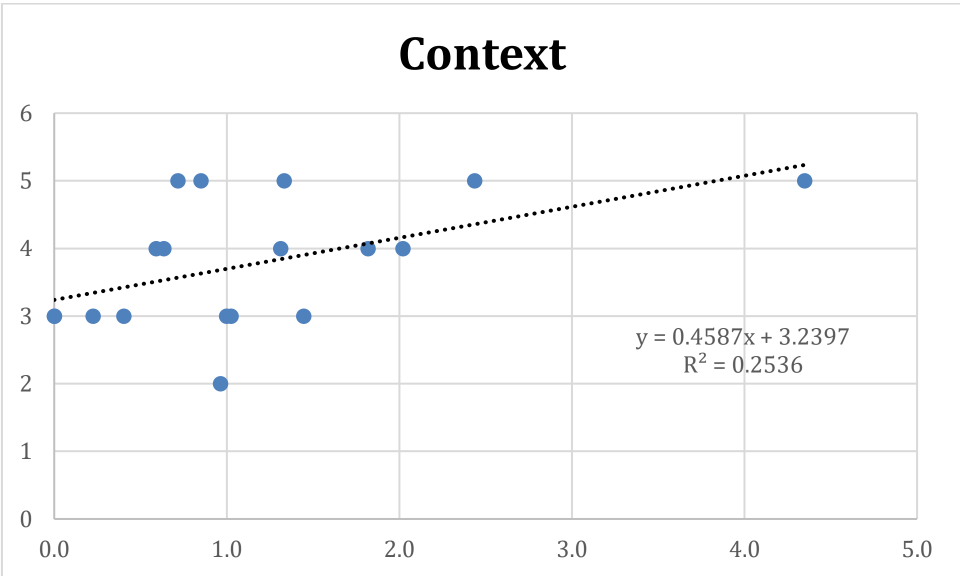

Figure 4.6: Relationship between Context distribution and score for context

Table 4.24 indicates more detailed results as follows. First, there was a non-significant positive relationship between the percentage of PK discussion and the scores gained for PK for the final artefacts, $r(16) = .22$, $R^2 = .05$, $p = .37$. Similarly, there was a nonsignificant positive correlation between percentage of CK discussion and the scores gained for CK for the final artefacts, $r(16) = .45$, $R^2 = .20$, $p = .06$.

However, there was a significant positive correlation between frequency of TK discussion and the scores gained for TK for the final artefacts, $r(16) = .53$, $R^2 = .30$, $p = .02$. Also, there was a significant positive correlation between frequency of Context discussion and the scores gained for Context for the final artefacts, $r(16) = .50$, $R^2 = .25$, $p = .03$. Refer to Appendix 18 for the Regression tests' detailed results for all four elements of PK, TK, CK, and Context.

Table 4.24: Regression test results for PK, TK, CK, and Context

	Multiple R	R Square	P-value
Pedagogy	.22	.05	.37
Technology	.53	.30	.02
Content	.45	.20	.06
Context	.50	.25	.03

This finding serves to illustrate a direct tangible relationship for between the focus of design conversations (for technology and context, in this instance) and the quality of the corresponding products that are designed.

Research Question 4: What are the impacts (if any) of the pedagogical strategies of teacher educators upon pre-service teacher TPACK development, learning design processes and artefacts?

4.4.1. Impacts of the pedagogical strategies of teacher educators upon pre-service teacher TPACK development

As mentioned in the Methodology section, the Linear Mixed Model (LMM) was used to analyse the statistical data from both years' pre- and post- TPACK surveys. Analyses of data using the final model show that the factors of Pre_or_Post, Practicum Experience, Gender, and PST_or_Non_PST as well as the interaction between Pre_or_Post and Practicum Experience had a significant impact on the improvement of participant TPACK competencies while Pre_or_Post*Year exerted no influence. Significant factors and/or interactions for each of the dependent variables are shown in Table 4.25.

Table 4.25: Significant factors and interactions

	DEPENDENT VARIABLES	SIGNIFICANT FACTORS	SIGNIFICANT INTERACTIONS	Sig. (P value < . 05)
1	TPACK ALL	Pre_or_Post		.000
		Practicum Experience		.013
2	TK	Pre_or_Post		.000
		Practicum Experience		.010
3	CK	Pre_or_Post		.000
		Practicum Experience		.022
4	PK	Pre_or_Post		.000
		Practicum Experience		.000
5	PCK	Pre_or_Post		.000
		Practicum Experience		.000
			Pre_or_Post * Practicum Experience	.008
6	TCK	Pre_or_Post		.000
7	TPK	Pre_or_Post		.000
		Gender		.013
		PST_or_Non_PST		.007
8	TPACK	Pre_or_Post		.000
		Gender		.017
		Practicum Experience		.004
			Pre_or_Post * Practicum Experience	.020

Table 4.26 shows post hoc analysis means and mean differences of the significant factors and interactions in the final model for each dependent variable (for full statistical outputs of fitting eight dependent variables in LMM, refer to Appendix 19). Pre_or_Post*Year was included for the purpose of presenting and discussing findings. All the findings related to the eight dependent variables (TPACK ALL, TK, CK, PK, PCK, TCK, TPK, and TPACK) presented from sub-section 4.4.1.1 to sub-section 4.4.1.8 are reported based on the statistical data in Table 4.26 below. Note that the scores assigned to Strongly Disagree, Disagree, Neither Disagree nor Agree, Agree, and Strongly Agree in the TPACK surveys were 0 1 2 3 and 4 respectively.

	DEPENDENT VARIABLES	SIGNIFICANT FACTORS	SIGNIFICANT INTERACTIONS	Sig. (P value < . 05)	Post hoc (Estimated Marginal Means)			Pairwise Comparison		Mean	Mean Difference	Std Errors
1	AVERAGE ALL TPACK	Pre_or_Post		.000				Pre		2.548	-.432*	.031
								Post		2.980	.432*	.031
		Prac_Experience		.013				Yes		2.832	.136*	.055
								No		2.696	-.136*	.055
			Pre_or_Post * Practicum Experience	.108	Yes	Pre	.000	Yes	Pre		-.382*	.051
						Post	.000		Post		.382*	.051
					No	Pre	.000	No	Pre		-.481*	.036
						Post	.000		Post		.481*	.036
					Pre	Yes	.004	Pre	Yes	2.641	.186*	.064
						No	.004		No	2.455	-.186*	.064
					Post	Yes	.158	Post	Yes	3.023	.086	.061
						No	.158		No	2.937	-.086	.061
			Pre_or_Post * Year	.979	2017	Pre	.000	2017	Pre		-.432	.040
						Post	.000		Post		.432	.040
					2018	Pre	.000	2018	Pre		-.431	.044
						Post	.000		Post		.431	.044
					Pre	2017	.177	Pre	2017	2.600	.103	.076
						2018	.177		2018	2.496	-.103	.076
					Post	2017	.157	Post	2017	3.032	.105	.074
						2018	.157		2018	2.927	-.105	.074
2	TK	Pre_or_Post		.000				Pre		2.611	-.407	.042
								Post		3.018	.407	.042
		Practicum Experience		.010				Yes		2.698	-.232*	.089
								No		2.930	.232*	.089

			Pre_or_Post * Year	.606	2017	Pre	.000	2017	Pre		-.427	.055
						Post	.000		Post		.427	.055
					2018	Pre	.000	2018	Pre		-.387	.060
						Post	.000		Post		.387	.060
					Pre	2017	.109	Pre	2017	2.710	.198	.123
						2018	.109		2018	2.512	-.198	.123
					Post	2017	.039	Post	2017	3.137	.239*	.115
						2018	.039		2018	2.898	-.239*	.115
3	CK	Pre_or_Post		.000				Pre		2.601	-.291	.035
								Post		2.892	.291	.035
		Practicum Experience		.022				Yes		2.826	.160*	.069
								No		2.666	-.160*	.069
			Pre_or_Post * Year	.444	2017	Pre	.000	2017	Pre		-.317	.046
						Post	.000		Post		.317	.046
					2018	Pre	.000	2018	Pre		-.266	.051
						Post	.000		Post		.266	.051
					Pre	2017	.832	Pre	2017	2.611	.021	.098
						2018	.832		2018	2.590	-.021	.098
					Post	2017	.416	Post	2017	2.928	.072	.088
						2018	.416		2018	2.856	-.072	.088
4	PK	Pre_or_Post		.000				Pre		2.661	-.381	.039
								Post		3.042	.381	.039
		Prac_Experience		.000				Yes		3.021	.339*	.070
								No		2.682	-.339*	.070
			Pre_or_Post * Year	.697	2017	Pre	.000	2017	Pre		-.366*	.051
						Post	.000		Post		.366*	.051

					2018	Pre	.000	2018	Pre		-.395*	.056
						Post	.000		Post		.395*	.056
					Pre	2017	.186	Pre	2017	2.727	.131	.099
						2018	.186		2018	2.596	-.131	.099
					Post	2017	.268	Post	2017	3.093	.103	.093
						2018	.268		2018	2.991	-.103	.093
5	PCK	Pre_or_Post		.000				Pre		2.434	-.441	.050
								Post		2.875	.441	.050
		Prac_Experience		.000				Yes		2.834	.359*	.066
								No		2.476	-.359*	.066
			Pre_or_Post * Prac_Experience	.008	Yes	Pre	.000	Yes	Pre		-.306	.082
						Post	.000		Post		.306	.082
					No	Pre	.000	No	Pre		-.576	.058
						Post	.000		Post		.576	.058
					Pre	Yes	.000	Pre	Yes	2.681	.494*	.090
						No	.000		No	2.188	-.494*	.090
					Post	Yes	.003	Post	Yes	2.987	.224*	.075
						No	.003		No	2.763	-.224*	.075
			Pre_or_Post * Year	.516	2017	Pre	.000	2017	Pre		-.410*	.066
						Post	.000		Post		.410*	.066
					2018	Pre	.000	2018	Pre		-.472*	.072
						Post	.000		Post		.472*	.072
					Pre	2017	.386	Pre	2017	2.478	.088	.101
						2018	.386		2018	2.391	-.088	.101
					Post	2017	.770	Post	2017	2.889	.026	.090
						2018	.770		2018	2.862	-.026	.090

6	TCK	Pre_or_Post		.000				Pre		2.417	-.527	.052
								Post		2.944	.527	.052
			Pre_or_Post * Year	.251	2017	Pre	.000	2017	Pre		-.584*	.068
						Post	.000		Post		.584*	.068
					2018	Pre	.000	2018	Pre		-.471*	.075
						Post	.000		Post		.471*	.075
					Pre	2017	.735	Pre	2017	2.397	-.039	.116
						2018	.735		2018	2.436	.039	.116
					Post	2017	.490	Post	2017	2.981	.073	.106
						2018	.490		2018	2.907	-.073	.106
7	TPK	Pre_or_Post		.000				Pre		2.706	-.447	.045
								Post		3.154	.447	.045
		Gender		.013				Female		3.004	.149*	.060
								Male		2.856	-.149*	.060
		PST_or_Non_PST		.007				PST		3.042	.224*	.082
								Non PST		2.818	-.224*	.082
			Pre_or_Post * Year	.395	2017	Pre	.000	2017	Pre		-.411*	.059
						Post	.000		Post		.411*	.059
					2018	Pre	.000	2018	Pre		-.483*	.064
						Post	.000		Post		.483*	.064
					Pre	2017	.066	Pre	2017	2.795	.177	.096
						2018	.066		2018	2.618	-.177	.096
					Post	2017	.210	Post	2017	3.206	.104	.083
						2018	.210		2018	3.101	-.104	.083
8	TPACK	Pre_or_Post		.000				Pre		2.415	-.528	.047
								Post		2.943	.528	.047

		Gender		.017				Female		2.762	.168*	.069
								Male		2.595	-.168*	.069
		Prac_Experience		.004				Yes		2.782	.207*	.072
								No		2.575	-.207*	.072
			Pre_or_Post * Prac_Experience	.020	Yes	Pre	.000	Yes	Pre		-.418*	.077
						Post	.000		Post		.418*	.077
					No	Pre	.000	No	Pre		-.638*	.054
						Post	.000		Post		.638*	.054
					Pre	Yes	.001	Pre	Yes	2.573	.317*	.091
						No	.001		No	2.256	-.317*	.091
					Post	Yes	.230	Post	Yes	2.991	.097	.080
						No	.230		No	2.894	-.097	.080
			Pre_or_Post * Year	.716	2017	Pre	.000	2017	Pre		-.512*	.062
						Post	.000		Post		.512*	.062
					2018	Pre	.000	2018	Pre		-.544*	.067
						Post	.000		Post		.544*	.067
					Pre	2017	.386	Pre	2017	2.460	.091	.105
						2018	.386		2018	2.369	-.091	.105
					Post	2017	.546	Post	2017	2.972	.059	.097
						2018	.546		2018	2.913	-.059	.097

Table 4.26: Means, mean differences of factors and interactions in the final model

4.4.1.1. TPACK All

Pre_or_Post

The mean TPACK ALL (overall average score of all questions in the TPACK survey instrument, referred to as Average_All_TPACK in Table 4.26) for pre-test score for the entire cohort including both iterations was 2.55 (halfway between Neutral and Agree), and the mean TPACK ALL post-test score was 2.99 (Agree), indicating an improvement of 0.44, which was a significant difference (p<0.001).

Practicum Experience

Those who completed practicum before entering the course reported an average TPACK ALL score of 2.83 while the average TPACK ALL score gained by those who had no practicum experience prior to the course was 2.70, showing a significant difference of .130 (p=.013).

Pre_or_Post * Year

The interaction between Pre_or_Post and Year apparently did not impact the pre-service teacher TPACK ALL scores significantly (p=.98). That is to say, the difference in treatments applied in **I2** (2017) versus **I3** (2018) had no significant effect on the *improvement* in average TPACK ratings – the increase in average overall TPACK ratings across the two years was similar. However, post hoc analyses showed some interesting points as elaborated below.

Comparing Pre_or_Post

The mean difference between the pre- and post- TPACK ALL scores in both 2017 and 2018 was 0.43, which was a significant difference (p<.001).

Comparing Year

On a macro-level, considering pre-service teachers' knowledge across the domains at both pre- and post- stages (TPACK ALL), post-hoc tests showed that each year sample showed similar characteristics, with no recognisable improvement from one year to the next. The mean pre-survey TPACK ALL score in 2017 was 2.6 and in 2018 was 2.5, indicating a difference of 0.1. This was not a significant difference (p=.177).

The mean post-survey TPACK ALL score in 2017 was 3.03 and in 2018 was 2.93, indicating a difference of 0.1. This was not a significant difference (p=.157).

In general there was an improvement in TPACK ALL score across the cohort, but there was not a significant difference in TPACK ALL score *changes* over the years, as shown in Figure 4.7.

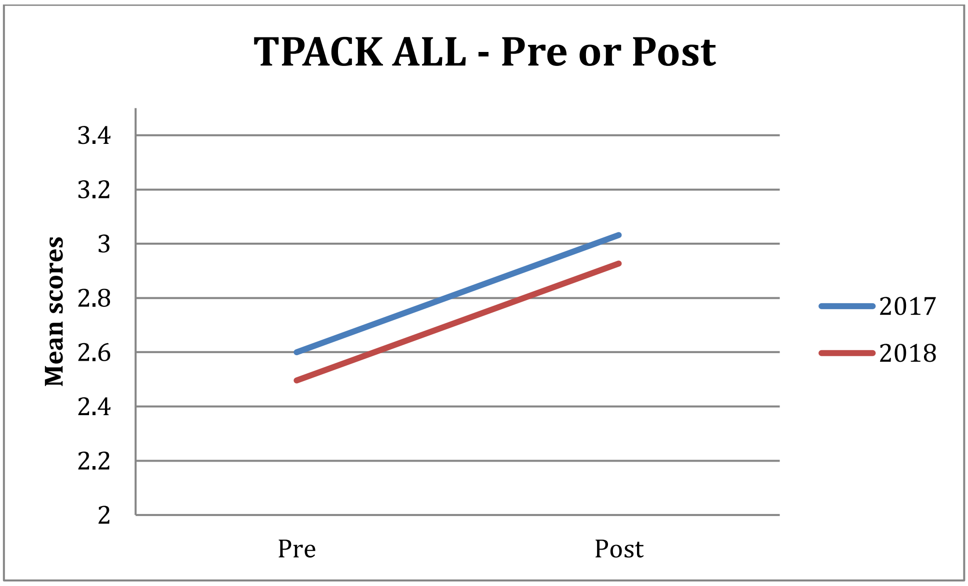

Figure 4.7: TPACK ALL improvement across the cohort

4.4.1.2. TK

Pre_or_Post

The respondents reported a significantly higher post-test score (3.02) of TK than pre-test score (2.61), indicating an improvement of 0.41 (p<0.001).

Practicum Experience

Across the cohort, those participants who did not go through one or more practicum placements prior to the course reported an average higher TK score

(2.93) compared to those who did (2.69), making a significant difference of 0.24 (p=0.010).

Pre_or_Post * Year

The interaction of Pre_or_Post * Year apparently did not lead to an improvement in TK (p=.61), suggesting that pre-service teachers' knowledge of technologies in the unit did not vary greatly across the 2 years sampled. However, in both years the pre to post TK score differences were significant while there were no significant score differences between the years. Post hoc analyses revealed more details as follows.

Comparing Pre_or_Post

The mean difference between the pre- and post- TK scores in 2017 was 0.43, which was a significant difference (p<.001).

The mean difference between the pre- and post- TK scores in 2018 was 0.39, which was a significant difference (p<.001).

Comparing Year

The mean pre-survey TK score in 2017 was 2.7 and in 2018 was 2.5, indicating a difference of 0.2. This was not a significant difference (p=.11).

The mean post-survey TK score in 2017 was 2.83 and in 2018 was 2.67, indicating a difference of 0.16. This was a marginally significant difference (p=.039).

The pre to post improvement in TK in 2017 and 2018 are shown in Figure 4.8.

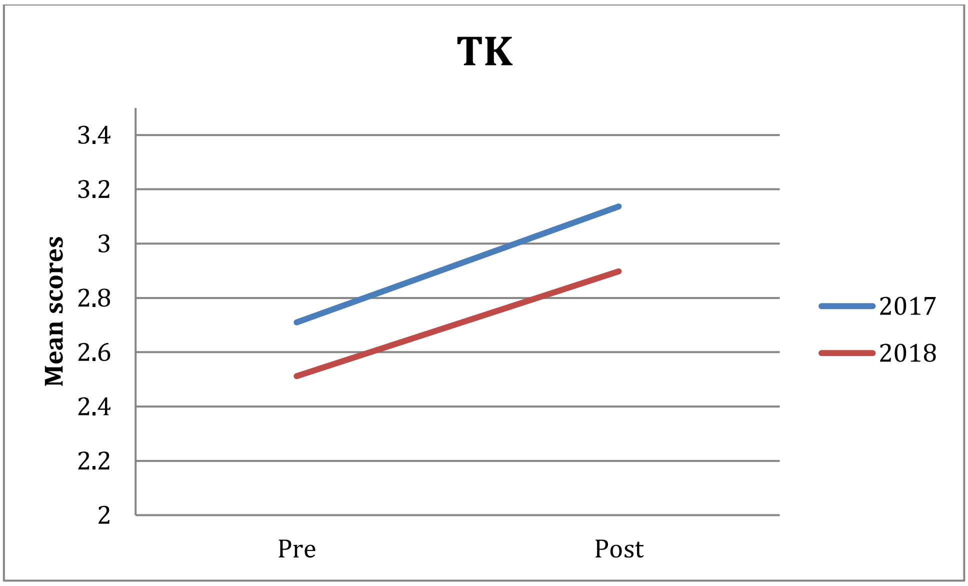

Figure 4.8: TK improvement across the cohort

4.4.1.3. CK

Pre_or_Post

The pre-surveyed partcipants reported an average CK score of 2.6 while the same post-surveyed students reported an average CK score of 2.9, indicating an improvement of 0.3, which was a significant difference($p<0.001$).

Practicum Experience

Those who completed practicum before entering the course reported an average CK score of 2.83 while the average CK score gained by those who had no practicum experience prior to the course was 2.67, showing a significant difference of 0.16 ($p=.022$).

Pre_or_Post * Year

The interaction of Pre_or_Post * Year apparently did not lead to an improvement in CK ($p=.45$). However, in both years the pre to post CK score differences were significant while there were no significant score differences between the years. Post hoc analyses revealed more details as follows.

Comparing Pre_or_Post

The mean difference between the pre- and post- CK scores in 2017was 0.32, which was a significant difference ($p<.001$).

The mean difference between the pre- and post- CK scores in 2018 was 0.27, which was a significant difference ($p<.001$).

Comparing Year

The mean pre-survey CK score in 2017 was 2.61 and in 2018 was 2.59, indicating a difference of 0.02. This was not a significant difference ($p=.83$).

The mean post-survey CK score in 2017 was 2.93 and in 2018 was 2.86, indicating a difference of 0.07. This was not a significant difference ($p=.42$).

The pre to post improvement in CK in 2017 and 2018 are shown in Figure 4.9.

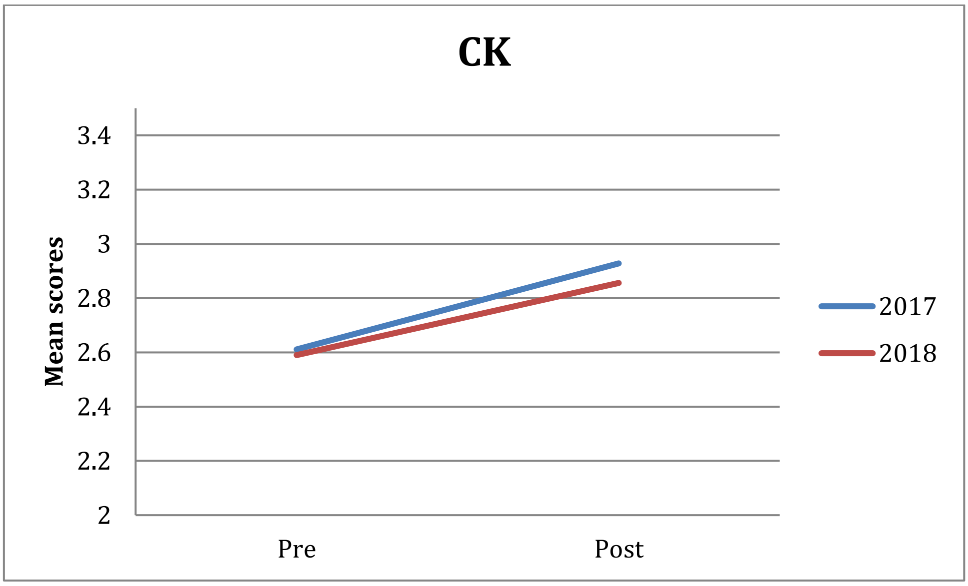

Figure 4.9: CK improvement across the cohort

4.4.1.4. PK

Pre_or_Post

The mean PK pre-test score for the cohort was 2.66, and the mean PK post-test score was 3.04, indicating an improvement of 0.38, which was a significant difference (p<0.001).

Practicum Experience

Those who entered the course with previous practicum experience reported a higher average PK score than those who had no practicum exeperience before entering the course, 3.02 versus 2.68, which indicates a difference of 0.34. This is a significant difference (p<.001).

Pre_or_Post * Year

The interaction of Pre_or_Post * Year apparently did not lead to an improvement in average PK (p=.69). However, in both years the pre- to post- PK score differences were significant while there were no significant score differences between the years. Post hoc analyses revealed more details as follows.

Comparing Pre_or_Post

The mean difference between the pre- and post- PK scores in 2017was 0.37, which was a significant difference (p<.001).

The mean difference between the pre- and post- PK scores in 2018 was 0.40, which was a significant difference (p<.001).

Comparing Year

The mean pre-survey PK score in 2017 was 2.72 and in 2018 was 2.59, indicating a difference of 0.13. This was not a significant difference (p=.186).

The mean post-survey PK score in 2017 was 3.1 and in 2018 was 3.0, indicating a difference of 0.1. This was not a significant difference (p=.268).

The pre to post improvement in PK in 2017 and 2018 are shown in Figure 4.10.

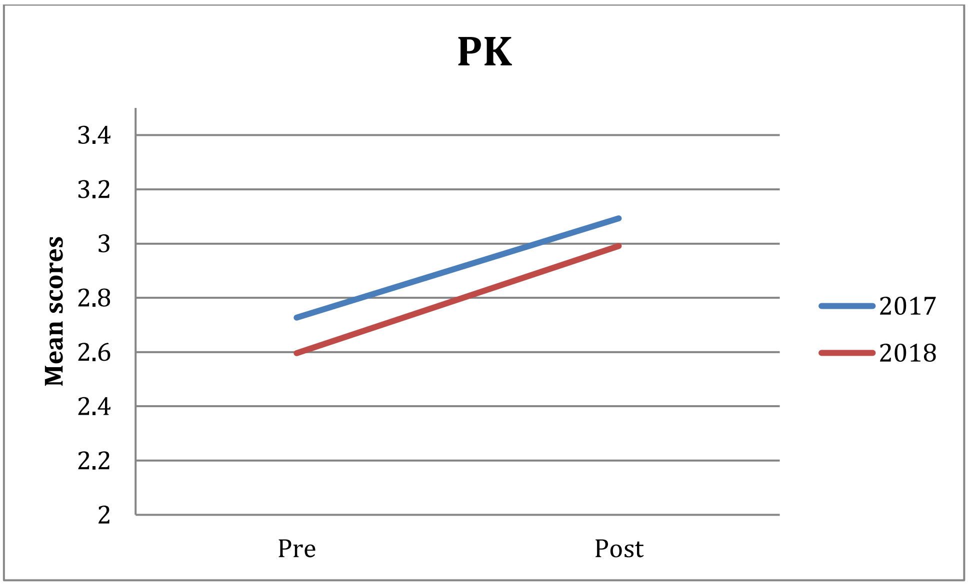

Figure 4.10: PK improvement across the cohort

4.4.1.5. PCK

Pre_or_Post

The mean PCK pre-test score for the cohort was 2.43, and the mean PK post-test score was 2.87, indicating an improvement of 0.44, which was a significant difference (p<0.001).

Practicum Experience

Those who entered the course with previous practicum experience reported a higher average PCK score than those who had no practicum exeperience before entering the course, 2.83 versus 2.47, which indicates a difference of 0.36. This is a significant difference (p<.001).

Pre_or_Post * Practicum Experience

Generally, the interaction between Pre_or_Post and Practicum Experience significantly improved participant PCK score ($p=.008$). Post hoc analyses revealed more details as follows.

Comparing Pre_or_Post

The pre-survey PCK score for the participants who had completed some practicum experience was 2.68 versus 2.18 for those who had not. This difference of 0.5 on the pre-survey PCK scores was significant ($p<.001$).

Similarly, the post-survey PCK score for the participants who had completed some practicum experience was 2.98 versus 2.76 for those who had not. This difference of 0.22 on the post-survey PCK scores was significant ($p=.003$).

Comparing Practicum Experience

In fact, students who had completed some practicum experience improved the PCK self-assessment scores between the pre- and post- surveys by 0.31 (which was a significant difference, $p<.001$), whereas students who had not completed some practicum experience improved their PCK self-assessment scores by 0.58 (also significant, $p<.001$).

That is to say, students who had not completed any practicum experience indicated, on average, a significantly lower PCK pre-course self-assessment compared to those students who had completed their practicum. The difference in the growth score was significant by the end of the unit. Apparently, students who had not completed practicum experience were able to improve at a greater rate than the students who had completed practicum so as to catch up to their final PCK self-assessment score. The improvement was shown in Figure 4.11 below.

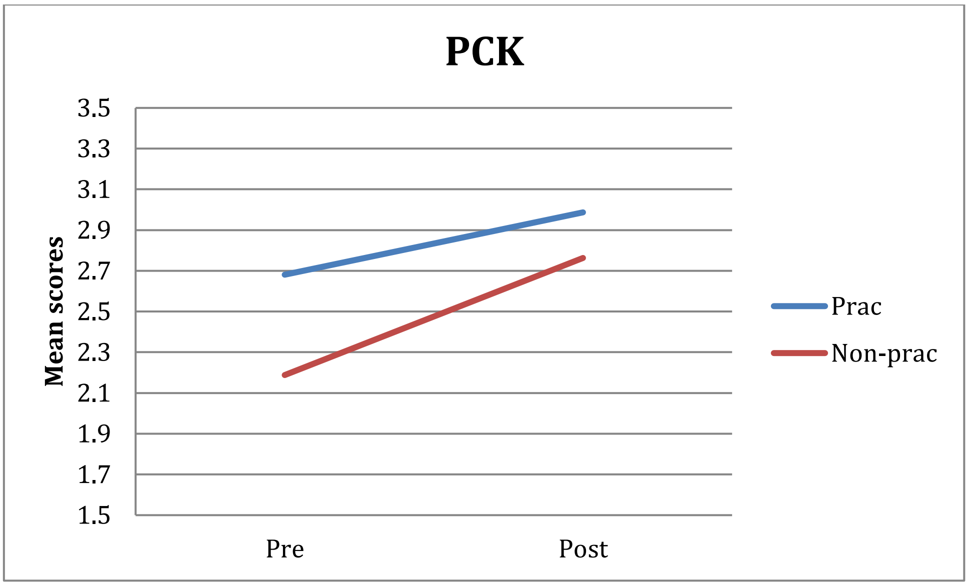

Figure 4.11: PCK improvement among Prac and Non-prac pre-service teachers across the cohort

Pre_or_Post * Year

The interaction of Pre_or_Post * Year apparently did not lead to an improvement in PCK (p=.516). However, in both years the pre- to post- PCK score differences were significant while there were no significant score differences between the years. Post hoc analyses revealed more details as follows.

Comparing Pre_or_Post

The mean difference between the pre- and post- PCK scores in 2017 was 0.41, which was a significant difference (p<.001).

The mean difference between the pre- and post- PCK scores in 2018 was 0.47, which was a significant difference (p<.001).

Comparing Year

The mean pre-survey PCK score in 2017 was 2.48 and in 2018 was 2.39, indicating a difference of 0.09. This was not a significant difference (p=.386).

The mean post-survey PCK score in 2017 was 2.89 and in 2018 was 2.86, indicating a difference of 0.03. This was not a significant difference (p=.770).

The pre to post improvement in PCK in 2017 and 2018 are shown in Figure 4.12.

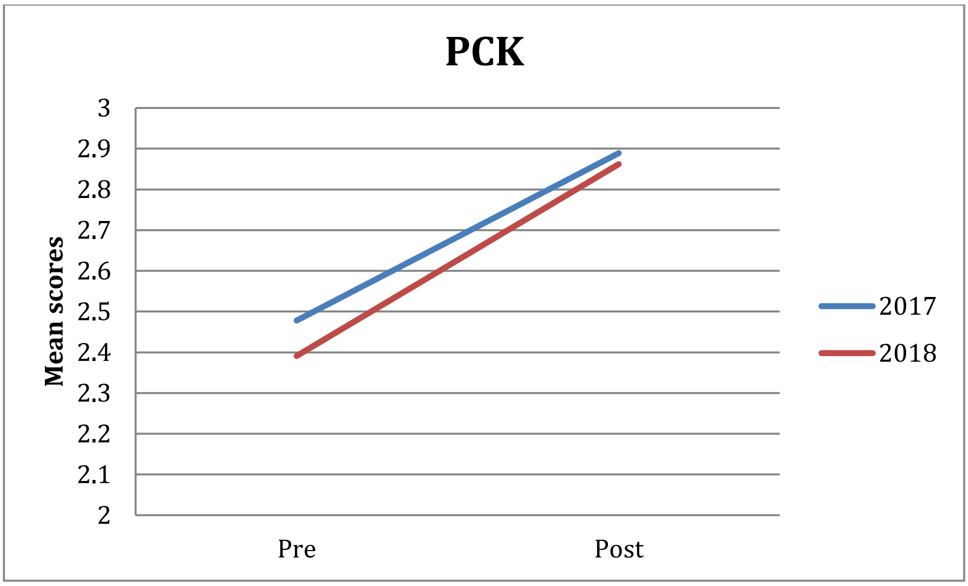

Figure 4.12: PCK improvement across the cohort

4.4.1.6. TCK

Pre_or_Post

The mean TCK pre-test score for the cohort was 2.42, and the mean TCK post-test score was 2.94, indicating an improvement of 0.52, which was a significant difference (p<0.001).

Pre_or_Post * Year

The interaction of Pre_or_Post * Year apparently did not lead to an improvement in TCK (p=.251). However, in both years the pre- to post- PCK score differences were significant while there were no significant score differences between the years. Post hoc analyses revealed more details as follows.

Comparing Pre_or_Post

The mean difference between the pre- and post- TCK scores in 2017 was 0.58, which was a significant difference (p<.001).

The mean difference between the pre- and post- TCK scores in 2018 was 0.47, which was a significant difference (p<.001).

Comparing Year

The mean pre-survey TCK score in 2017 was 2.39 and in 2018 was 2.43, indicating a difference of 0.04. This was not a significant difference (p=.735).

The mean post-survey PCK score in 2017 was 2.98 and in 2018 was 2.91, indicating a difference of 0.07. This was not a significant difference (p=.490).

The pre- to post- improvement in TCK in 2017 and 2018 are shown in Figure 4.13.

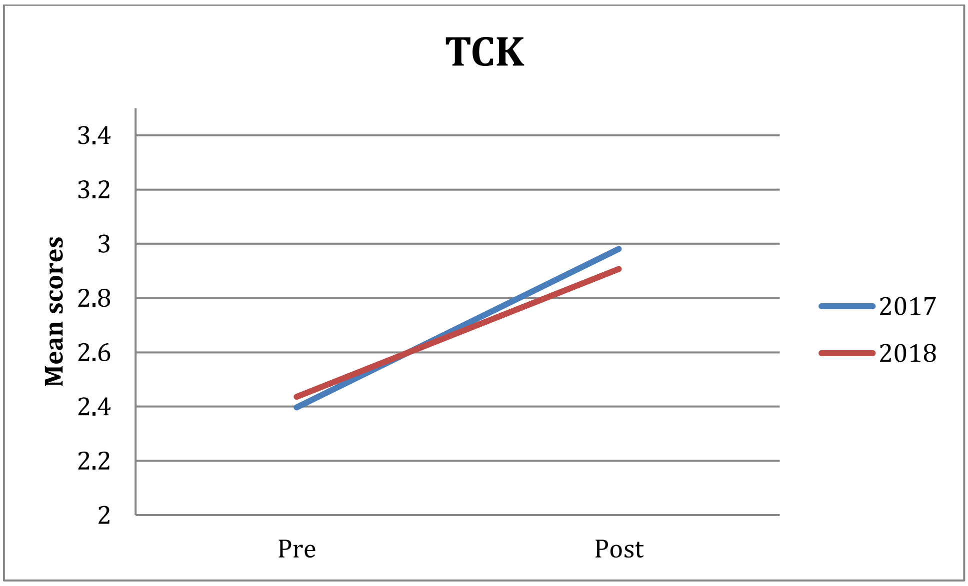

Figure 4.13: TCK improvement across the cohort

4.4.1.7. TPK

Pre_or_Post

The mean TPK pre-test score for the cohort was 2.70, and the mean TPK post-test score was 3.15, indicating an improvement of 0.45, which was a significant difference (p<0.001).

Gender

Female pre-service teachers reported a significantly higher TPK average score than male pre-service teachers, 3.0 versus 2.80, resulting in a significant difference of 0.2 (p=.007).

PST or Non-PST

Those who were Education students were, on average, more confident about TPK than those who were Planet Unit students (non-education students studying the unit) with the average TPK scores reported at 3.04 and 2.81. This difference of 0.23 is significant (p=0.007).

Pre_or_Post * Year

The interaction of Pre_or_Post*Year apparently did not lead to an improvement in TPK (p=.395). However, in both years the pre- to post- TPK score differences were significant while there were no significant score differences between the years. Post hoc analyses revealed more details as follows.

Comparing Pre_or_Post

The mean difference between the pre- and post- TPK scores in 2017 was 0.41, which was a significant difference (p<.001).

The mean difference between the pre- and post- TPK scores in 2018 was 0.48, which was a significant difference (p<.001).

Comparing Year

The mean pre-survey TPK score in 2017 was 2.79 and in 2018 was 2.62, indicating a difference of 0.17. This was a marginally significant difference (p=.066).

The mean post-survey TPK score in 2017 was 3.2 and in 2018 was 3.1, indicating a difference of 0.1. This was not a significant difference (p=.210).

The pre to post improvement in TPK in 2017 and 2018 are shown in Figure 4.14.

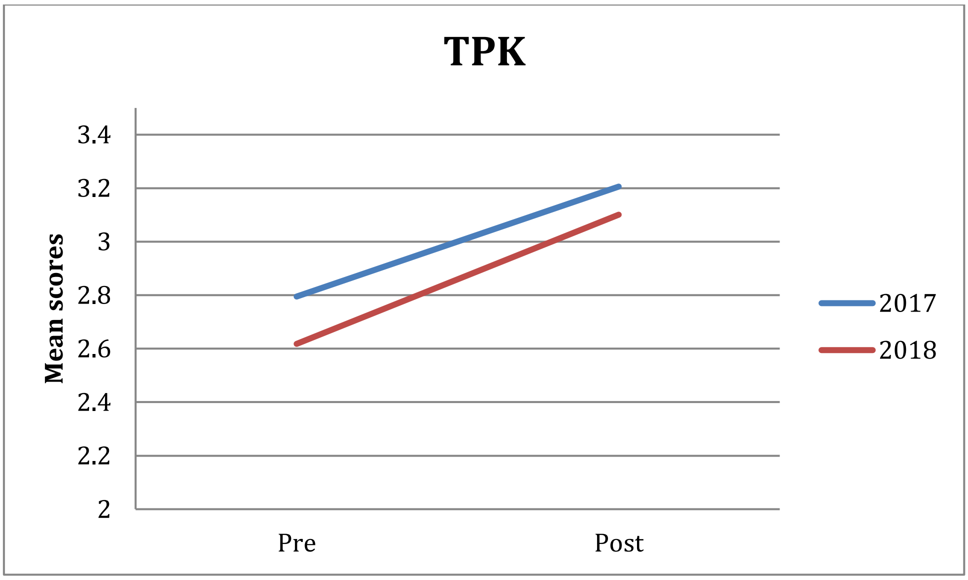

Figure 4.14: TPK improvement across the cohort

4.4.1.8. TPACK

Pre_or_Post

The mean TPACK pre-test score for the cohort was 2.41, and the mean TPACK post-test score was 2.94, indicating an improvement of 0.53, which was a significant difference ($p<0.001$).

Gender

Female participants seemed, on average, to be more confident about TPACK than male students. Their average TPACK scores were 2.80 and 2.60 respectively, making a difference of 0.2. This difference was significant ($p=.017$).

Practicum Experience

Those who completed practicum before entering the course reported an average TPACK score of 2.78 while the average TPACK score gained by those who had no practicum experience prior to the course was 2.57, showing a significant difference of .21 ($p=.004$).

Pre_or_Post * Practicum Experience

Generally, the interaction between Pre_or_Post and Practicum Experience significantly improved participant TPACK score (p=.020). Post hoc analyses revealed more details as follows.

Comparing Pre_or_Post

The pre-survey TPACK score for the participants who had completed some practicum experience was 2.57 versus 2.25 for those who had not. This difference of 0.32 on the pre-survey TPACK scores was significant (p=.001).

Similarly, the post-survey TPACK score for the participants who had completed some practicum experience was 2.99 versus 2.89 for those who had not. This difference of 0.1 on the post-survey TPACK scores was, however, not significant (p=.230).

Comparing Practicum Experience

In fact, students who had completed some practicum experience improved the TPACK self-assessment scores between the pre- and post- survey by 0.42 (which was a significant difference, p<.001), whereas students who had not completed some practicum experience improved their TPACK self-assessment scores by 0.64 (also significant, p<.001).

That is to say, students who had not completed any practicum experience indicated a significantly lower TPACK self-assessment compared to those students who had completed practicum prior to the course. However, both groups reported significantly high scores to the end of the course. Apparently pre-service teachers who had not completed practicum improved by a greater amount than students who had completed practicum, so their initial deficit was ameliorated.

The improvement is shown in Figure 4.15 below.

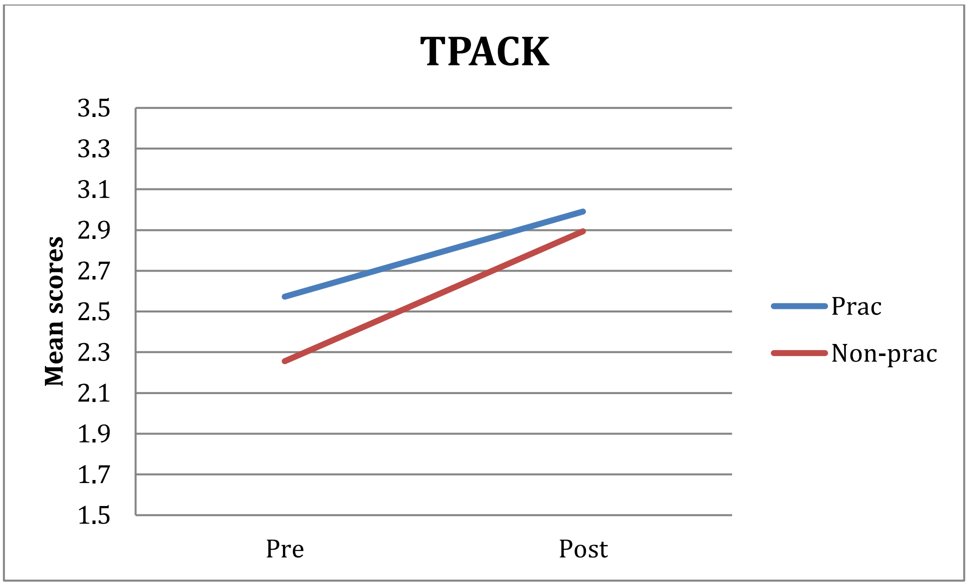

Figure 4.15: TPACK improvement among Prac and Non-prac pre-service teachers across the cohort

Pre_or_Post * Year

The interaction of Pre_or_Post * Year apparently did not lead to an improvement in TPACK (p=.716). However, in both years the pre to post TPACK score differences were significant while there were no significant score differences between the years. Post hoc analyses revealed more details as follows.

Comparing Pre_or_Post

The mean difference between the pre- and post- TPACK scores in 2017 was 0.51, which was a significant difference (p<.001).

The mean difference between the pre- and post- TPACK scores in 2018 was 0.54, which was a significant difference (p<.001).

Comparing Year

The mean pre-survey TPACK score in 2017 was 2.46 and in 2018 was 2.37, indicating a difference of 0.09. This was not a significant difference (p=.386).

The mean post-survey TPACK score in 2017 was 2.97 and in 2018 was 2.91, indicating a difference of 0.06. This was not a significant difference (p=.546).

The pre- to post- improvement in PCK in 2017 and 2018 are shown in Figure 4.16.

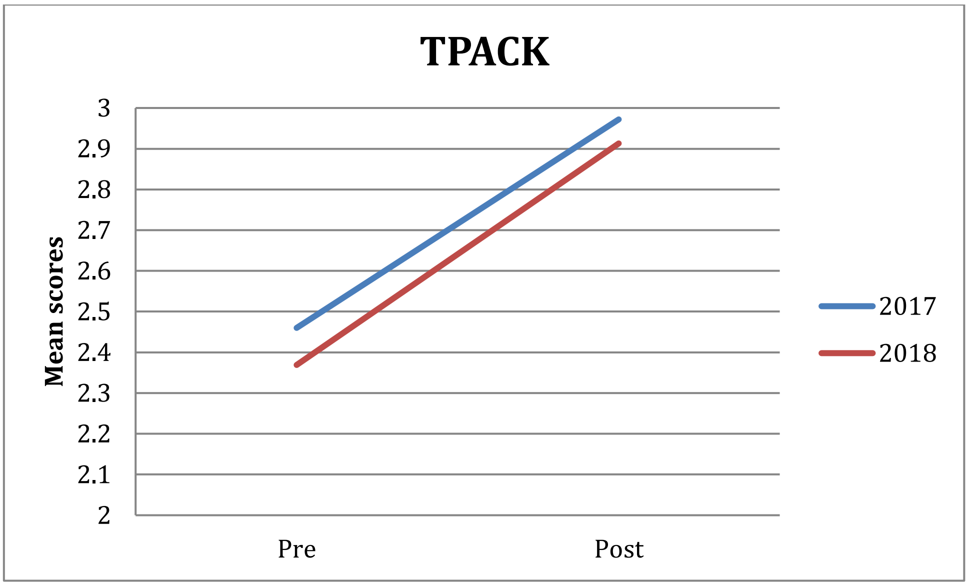

Figure 4.16: TPACK improvement across the cohort

4.4.1.9. Summary for Section 4.4.1

In summary, all the TPACK elements seemed to witness a significant improvement across the cohort in each year, as shown in Figure 4.17. CK apparently had the smallest change. This is perhaps explainable because the unit was not a subject content-focused course, being a unit undertaken by pre-service teachers across primary and secondary teaching levels, from individual subjects areas, and different stages of progress within the degree, in addition to a sample of students not studying to be teachers. Also, although there was a pre- to post-improvement in each TPACK element score by year, this was not the case between the years.

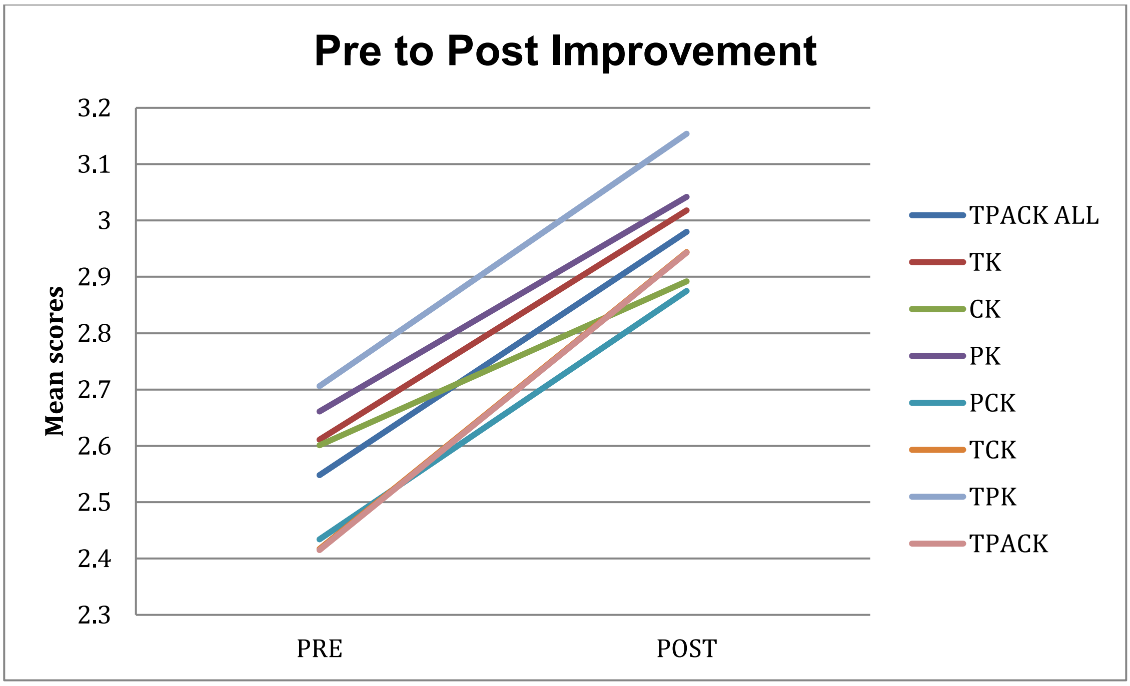

Figure 4.17: All TPACK element's pre to post improvement across the cohort

Another important point is whether or not the participants did one or more practicum placements before entering the course had an impact on participant TPACK ALL, TK, CK, PK, PCK, and TPACK self-reported scores. In most cases and except for TK, those who had some teaching practicum before entering the unit tended to report higher average scores than those who had no practicum experience prior to the unit. In contrast, as for TK, those who did not have any practicum experience before entering the unit reported higher average scores than those with some practicum experience prior to the course. This could be because Planet Unit students (e.g. computing students) may on average have stronger technological skills than pre-service teachers as a starting point. For PCK and TPACK, the average pre-survey score of practicum students was significantly lower to that of the non-practicum students; however, both groups witnessed significant growth scores by the end of the unit. This indicates that the unit had a greater positive impact on the non-practicum students for the PCK and TPACK dimensions. It also implies that the unit succeeded in lifting non-practicum students' PCK and TPACK scores to the same level as practicum students'. Interpretation and implication of these findings are further discussed in Section 5.4.1.

4.4.2. The impact of the pedagogical strategies of teacher educators upon pre-service teacher learning design processes

As stated in Section 3.11 in the Methodology chapter, a Chi-square test was run to observe if there were any significant differences between **I2** (2017) and **I3** (2018) in the coded categories such as DK, TK, CK, PK, PCK, PTK, PCK, TPACK, and Context. The Pearson Chi-Square test, Likelihood Ratio and Linear-by-Linear association as shown in Table 4.27 all indicate that there was a significant difference between the distribution of items focused upon in **I2** (2017) compared to **I3** (2018).

Table 4.27: Chi-Square tests' results

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	208.483[a]	8	.000
Likelihood Ratio	203.873	8	.000
Linear-by-Linear Association	12.424	1	.000
N of Valid Cases	10229		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 32.79.			

Table 4.28 shows whether the distribution frequencies of the units coded by DK, Context, and the seven TPACK elements were significantly different between **I2** (2017) and **I3** (2018). The distribution of such elements as CK and TK showed a significant increase from over 24% and 8.5% to over 27% and 12.4% respectively from 2017 to 2018 whereas PK, TPACK, TCK, and Context's distribution significantly declined by approximately 4%, 3%, 1%, and over 1% respectively over two iterations. Interpretations surrounding these numbers are provided in the Discussion chapter.

Table 4.28: Differences in I2 and I3 design focuses/TPACK elements

Focuses * Year Crosstabulation					
			Iteration		Total
			I2 (2017)	**I3** (2018)	
Design Focuses/ TPACK elements	DK	Count	1649_a	2804_a	4453
		% within Iteration	42.8%	44.0%	43.5%
	CK	Count	**936_a**	**1747_b**	2683
		% within Iteration	24.3%	27.4%	26.2%
	PK	Count	338_a	313_b	651
		% within Iteration	8.8%	4.9%	6.4%
	TK	Count	**326_a**	**792_b**	1118
		% within Iteration	8.5%	12.4%	10.9%
	TPACK	Count	200_a	132_b	332
		% within Iteration	5.2%	2.1%	3.2%
	TCK	Count	192_a	260_b	452
		% within Iteration	5.0%	4.1%	4.4%
	PCK	Count	111_a	225_a	336
		% within Iteration	2.9%	3.5%	3.3%
	Context	Count	72_a	45_b	117
		% within Iteration	1.9%	0.7%	1.1%
	TPK	Count	31_a	56_a	87
		% within Iteration	0.8%	0.9%	0.9%
Total		Count	3855	6374	10229
		% within Iteration	100.0%	100.0%	100.0%

Each subscript letter denotes a subset of Year categories whose column proportions do not differ significantly from each other at the .05 level.

4.4.3. Impacts of the pedagogical strategies of teacher educators upon pre-service teacher learning design artefacts

The grades that pre-service teachers received for their final learning design product submissions – or their artefacts – were graphed in order to visually compare the number of Moodle task final assignments that received Fail, Pass, Credit, Distinction, and High Distinction between 2017 and 2018. The bar chart (Figure 4.18) shows no clear differences between the final grades of the two iterations. Similarly, no substantive differences in pedagogy, technology, content, and context criteria scores on the assessment rubrics were found between **I2** and **I3**, as indicated in Figure 4.19, Figure 4.20, and Figure 4.21 respectively. Any slight variations in the mark and grade distributions could have been due to difference between the students themselves rather than due to any treatment effects. Limitations of the small sample size with respect to this component of the study are discussed in the Conclusion chapter (Section 6.5).

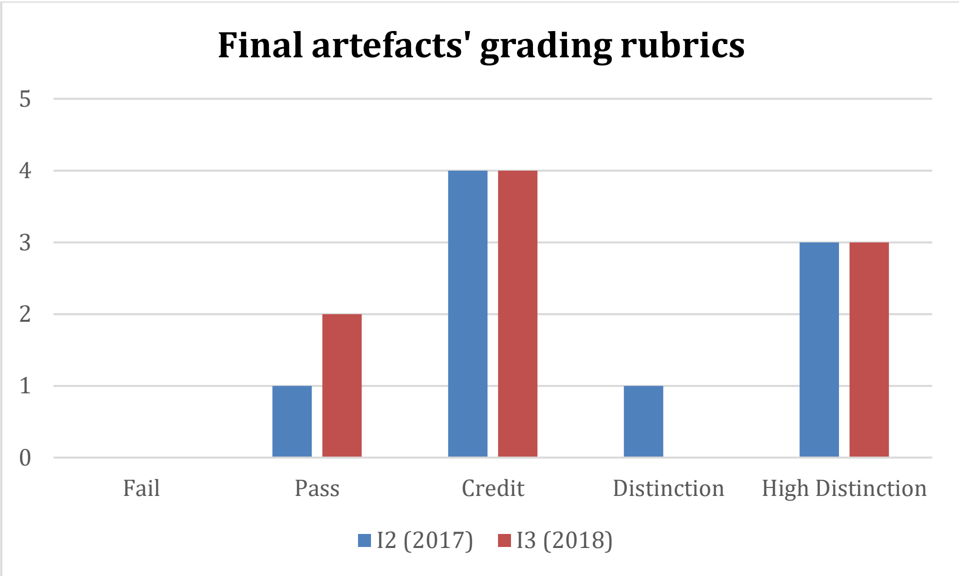

Figure 4.18: I2 vs I3 final artefacts' grading rubrics

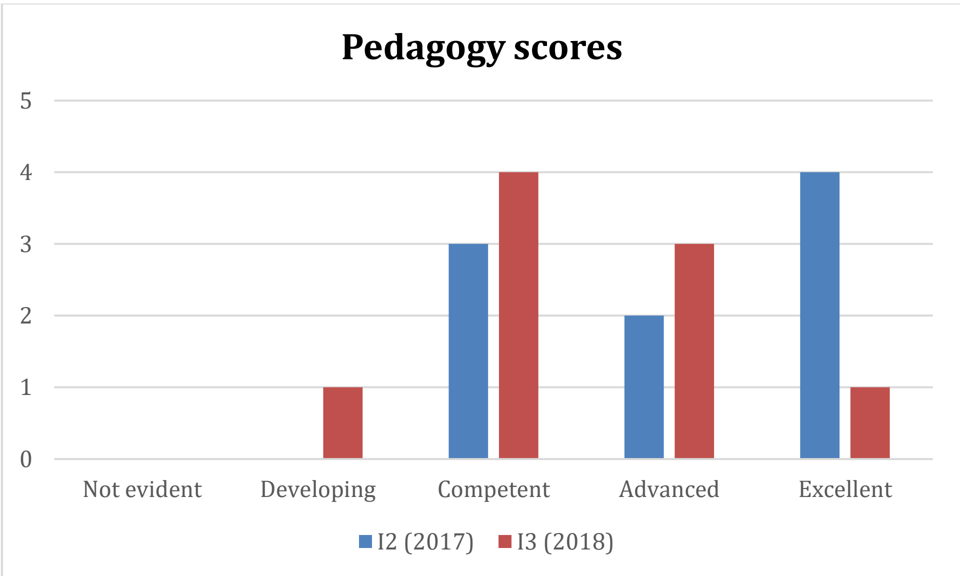

Figure 4.19: I2 vs I3 final artefacts' pedagogy scores

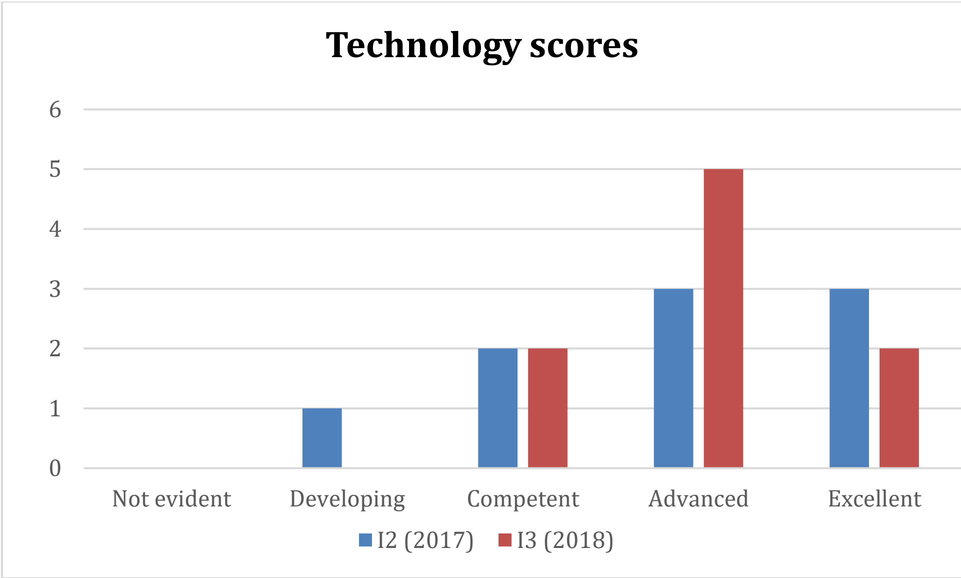

Figure 4.20: I2 vs I3 final artefacts' technology scores

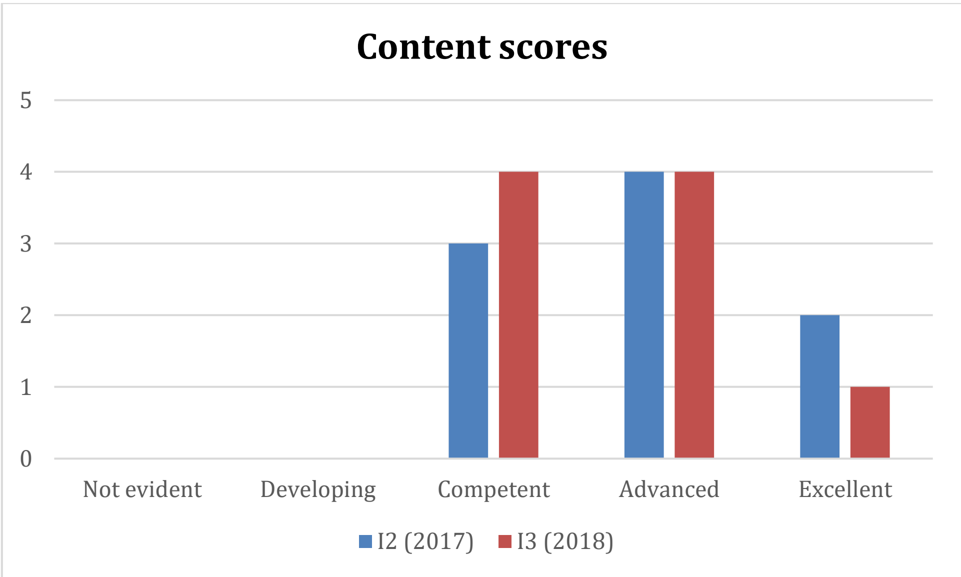

Figure 4.21: I2 vs I3 final artefacts' content scores

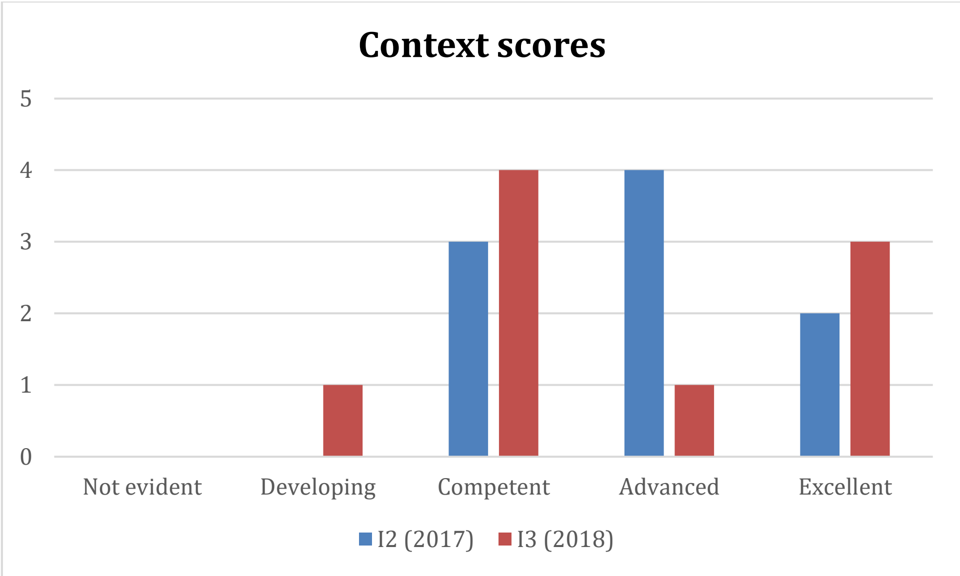

Figure 4.22: I2 vs I3 final artefacts' context scores

4.5. Summary of the Findings chapter

This chapter has unpacked the four research questions. Following are the summaries of each question's findings.

Research Question 1 explored the elements pre-service teachers focused upon during their group 'live' design activities. The results were that they discussed issues related to seven TPACK elements such as TK, PK, CK, TCK, TPK, PCK, and TPACK. Other focuses included DK, Context, and Learner Characteristics. DK dominated the pre-service teacher design conversations in both iterations (roughly below 45% of the units coded). Also, the participants attended more to single constructs like TK, PK, and CK than to the integrative constructs like TCK, TPK, PCK, and TPACK. Data of Research Question 1 also allowed the emergence of four different design approaches: content-based, top-down, learner-centred, and context-oriented. Evidence from follow-up interviews also confirmed the findings of these approaches.

Research Question 2 investigated the factors inhibiting and/or supporting pre-service teachers' collaborative learning design practices. It was found that all the inhibiting factors identified in **I1** were only temporary and eradicated in **I2** and **I3**. The supporting factors in **I2** and **I3** included tutor support, group dynamics, technological capabilities, past educational experience, and the unit's resources and activities. These findings were supported by both design conversations and post-course interviews.

Research Question 3 examined the relationships between pre-service teacher learning design practices and the characteristics of their online artefacts. The findings showed that the more the pre-service teachers referred to technology and context, the higher scores they received for technology and context for their final artefacts.

Research Question 4 explored the impact of the pedagogical strategies of teacher educators upon pre-service teacher TPACK development, learning design processes and artefacts. In terms of impact on pre-service teacher TPACK development, pre-service teachers saw a pre-to-post improvement in all TPACK elements across the cohort. The same significant increase was not observed over the iterations. In addition, practicum experience was found to be an influential factor to pre-service teacher improvement in TPACK ALL, CK, PK, PCK, and TPACK; that is, practicum-experiencers reported higher average scores than non-experiencers. Regarding impact on pre-service teachers' learning design processes, the distribution of such elements as CK and TK showed a significant increase from over 24% and 8.5% to over 27% and 12.4% respectively from 2017 to 2018 whereas PK, TPACK, TCK, and Context's distribution significantly declined by approximately 4%, 3%, 1%, and over 1% respectively over two iterations. Regarding impact on pre-service teacher learning design products, or artefacts, there were no clear differences between the final grades of the two iterations. Nor were there any discernible differences in pedagogy, technology, content, and context assignment criteria scores between **I2** and **I3**.

Interpretations and implications of these findings will be unpacked in the Discussion chapter.

Chapter 5. Discussion

This chapter discusses all the major findings by offering reasons, possible explanations, and other scholars' viewpoints surrounding the findings. Perspectives informed by Activity Theory and the TPACK framework are interwoven in the discussion where appropriate. The chapter is organised in the order of research questions and concludes with a summary of the chapter.

5.1. Elements Pre-Service Teachers Focus upon when Designing Technology-Enhanced Learning Tasks for their Potential Learners

This section offers discussions surrounding results of thematic analysis of the group design conversations and follow-up interviews. It responds to Research Question 1 (What elements do pre-service teachers focus upon when collaboratively designing technology-enhanced lessons?). The investigation into six groups of three pre-service teachers revealed ten elements they focused upon in their design conversations over **I2** and **I3**. These elements included Design Knowledge (DK), Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Knowledge (TK), Technological Pedagogical Content Knowledge (TPACK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (PCK), Context, and Learners' characteristics (LC) – in the ascending order of their distribution percentages. This section also provides critical comments on the findings of four design approaches as a result of examining design conversations and follow-up interviews.

5.1.1. Design focuses/TPACK elements

5.1.1.1. Design Knowledge (DK)

In addition to the notion that the knowledge teachers should embrace to smartly integrate technology to teaching successfully is "the Total PACKage" of TPACK (Thompson & Mishra, 2007, p. 38) with its seven knowledge elements, the study results show that there is another evident knowledge element in teacher design conversations, categorised as Design Knowledge (DK). DK happened when and where pre-service teachers discussed issues irrespective of technology, content, and pedagogy, but connected with issues related to the management of design processes such as delegating tasks among each other, creating group chats, scheduling and setting goals, and other design issues such as discussing the aesthetic aspects of the designs, and so forth. This finding matches those observed in some earlier studies (Koh & Chai, 2016; Nguyen & Bower, 2018).

Furthermore, in the current study, DK unexpectedly accounted for just below 45% of the units coded in both **I2** and **I3**, far outweighing the levels of coding of the other TPACK elements. There are possible explanations for this finding. *First*, the pre-service teachers worked together directly on mutual designs — their Moodle-based online courses — which probably led to more discussions on design related issues such as how to make the platform aesthetically better looking, more accessible, and easier to navigate for their potential young learners. *Second*, because it was a collaborative work happening over time, it was expected that they would discuss issues pertaining to arranging to meet and designating tasks among each other. The fact that DK was most frequently referenced suggests the importance for pre-service teachers as learning designers to possess knowledge other than TPACK in order to undertake the whole design process smoothly and effectively.

This finding confirms that there are more than just TPACK elements conceptually defined by Mishra and Koehler (2006) in teachers' conversations on their collaboratively designed technology-based lessons. Also, the examination of the presence of DK in pre-service teacher design conversations in this study versus its absence in other TPACK studies has confirmed the connection between the unique nature of context (i.e. a collaborative learning design tasks among pre-service teachers in this case) and the distribution of knowledge. This connection has been claimed by several other researchers (Tseng et al., 2019).

Also found in the DK category were several design patterns throughout the learning design process among the pre-service teachers (see sub-section 4.1.1.1 for more detail). According to Hoadley and Cox (2009), design patterns are a type of design knowledge and "a template solution to a common problem" (p.

27). Evidently, all the pre-service teacher teams in the current study utilised certain design patterns in seeking solutions to several problems emerging from the collaborative design process. One example was the teams sought where to store their design drafts and chose a tool that could save their design ideas and be accessible among themselves. Other patterns included assigning tasks among group members to ensure a fair group collaboration, updating each other on what was discussed in the last meeting at the beginning to make sure everyone was on the common-ground knowledge, and summarising each meeting at the end to get the main points across. Considering each group had roughly 30-40 minutes for each in-class meeting, these strategies seemed to make the whole design process a more productive and smoother one.

5.1.1.2. CK, PK, TK

Together, discussions of CK, PK, and TK accounted for 41.6% and 44.7% of the units coded in **I2** and **I3** respectively, dominating the pre-service teachers' design conversations.

With respect to CK, the participants in the present study evidently attached importance to content during their collaborative design of technology-based lessons. There was a substantial number of discussions on the issues related to CK in both **I2** and **I3**, constituting over 24% and 27% of the units coded respectively. The important role of content was confirmed by almost all the interviewees in the follow-up interviews as well. This finding was in line with that in a larger number of both studies on pre-service and in-service (kindergarten, primary, secondary, and university) teachers who attached weight to content in developing their technology-enhanced material (Graham et al., 2012; Harris & Hofer, 2011; Koh & Chai, 2016; McKenney et al., 2016), though in contrast to Churchill's study (2006) where experienced university teacher participants did not think of content as an influential factor to the learning design process. Apparently, whether content was given emphasis to during the learning design process was irrespective of participants' teaching level and experience. What made Churchill's finding about content different from that of this study could be a school versus higher education issue; that is, at school learning quite specific content items is important for younger learners.

The significance attached to content among pre-service teachers in this study was not only reflected in the frequency of CK, but also in the quality and depth of the content-related conversational exchanges. In fact, novice teachers in this study demonstrated many insights into their understanding of content. The same finding was observed in more experienced in-service teachers with the teaching experience ranging from one to 30 years who showed their profound understanding of the subject matter through reasoning and clarifying (Koh & Chai, 2016; McKenney et al., 2016). A possible explanation for this consistency may be that each teacher, pre-service or inservice, is expected to have solid foundational knowledge of the subject matter they choose as a part of their prior undergraduate studies. Plus, all the participants had undertaken the first year of education in their program, which stresses the importance of knowing the content and knowing how to teach it. Another explanation could be that the pre-service teachers all had a good grasp of the content being discussed (e.g. maths, English, geography, etc.) after years as primary schoolers, and therefore were able to show their apprehension of the subject matter as well as more experienced in-service teachers. As well, perhaps because primary education was comparatively easier than the level of content knowledge that the university students had otherwise achieved, the pre-service teachers were able to demonstrate substantial mastery of the subject matter.

In regard to PK, the pre-service teachers in both **I2** and **I3** of the study explicitly articulated pedagogy-related issues (roughly 9% and 5% of the units coded respectively), showing their knowledge of different pedagogical approaches in e-learning, teaching strategies and assessment methods. Although this finding is in contradiction with one previous finding reported in the pilot study of this study (Nguyen & Bower, 2018) and earlier research (Boschman et al., 2015), it accords with the observed success of the teacher educator interventions conducted in the current study in attempts to make pre-service teacher articulation of pedagogy explicit. On the other hand, this finding is consistent with numerous studies in the field of Learning Design (Bennett et al., 2015; Churchill, 2006; Graham et al., 2012; Postareff & Lindblom-Ylänne, 2008; Zhang et al., 2019) in a way that the participants in their studies also attended to pedagogy in designing teaching materials.

Notwithstanding that the pre-service teachers were inexperienced as educators, they showed an ability to deliberate over which pedagogical approaches would be employed in their learning activities and assessments, as well as which scholarly research would inform their discussions. This aligns with results observed in Bennett et al.'s study (2015) who reported that the teaching expertise that more experienced university teachers in their study utilised was informed by research evidence. These pedagogy-related deliberations among the pre-service teachers were unexpected and possibly suggest that the participants benefited from different pedagogical practice activities during the tutorials such as identifying pedagogical approaches underlying certain technological tools and discussing pedagogical questions in the Learning Design Guide. The Learning Design Guide was also reported as a supporting factor in the interviews by most groups in both iterations.

From an Activity Theory point of view, the relationship between three constituents of rules, subject, and tools can be seen. Both rules and tools influenced the subjects, which contributed to the final outcomes. That is, more learning activities created to encourage pre-service teachers to articular their designing thinking related to pedagogy explicitly aided by the Learning Design Guide with a section containing detailed questions on pedagogy possibly contributed to the subject pre-service teachers' more explicit and deeper articulation of pedagogy, which is part of their improvement in learning design capabilities.

In terms of TK, discussions related to technology in isolation also accounted for a substantial percentage of the units coded, 8.5% and roughly 12.5% in **I2** and **I3** respectively, making technology-related issues among the three most discussed issues in the pre-service teacher design conversations. This dominance may be due to the fact that in some conversations the team members spent a lot of time browsing the Internet together in search for the tools they needed. Also, when the group members explored the tools together, they critically compared and described different tools with similar functionalities, which is a good foundation for the next expected level: integrating technology to appropriate content and/or pedagogy. In order for an effective integration, it is important that the pre-service teachers first have a grasp of the tools. Evidently, that the unit's teacher educators gave the participants numerous opportunities to practise using technologies together in groups in the classroom contributes to more thorough understanding of the tools among the pre-service teachers, which could potentially lead to better use of the tools in designing their technology-enhanced lessons. From an Activity Theory point of view, this shows a close connection between the rules (intervention), the tools (technologies), and the object (technology-based modules).

The finding also indicates the importance of technology in shaping the participants' design decisions, which is in accord with Churchill's (2006) finding that technology was one of the areas dominating participants' design decisions. This, however, did not appear to be the case in Janssen and Lazonder's (2016) and Zhang et al.'s studies (2019). In the former, there were rarely technology-related statements among the participants, and in the latter, TK accounted for the smallest percentages of the units coded (2.3%).

5.1.1.3. TPACK, TCK, PCK, and TPK

The integrated knowledge elements of TPACK, TCK, PCK, and TPK are grouped in this sub-section because their relevant findings shared some commonalities. Their frequencies were all low (13.9% and 10.6% of the units coded in **I2** and **I3** respectively), and lower than the knowledge elements in isolation (PK, TK, CK) in both iterations.

TPACK discussions had a low frequency (approximately 5% and 2% in **I2** and **I3** respectively), which supports the evidence in Janssen and Lazonder's (2016) empirical study where the number of TPACK justifications made by teacher participants were lower than expected. On the other hand, the percentage of the units coded as TPACK in this study were smaller compared to those of other studies (Graham et al., 2012; Koh & Chai, 2016).

TPACK discussion in the current study was fairly equally distributed over the weeks in both **I2** and **I3**, which suggests the pre-service teachers' attention to integrating technology with content and pedagogy at an early stage of the training course. Moreover, there were higher quality conversations pertaining to

TPACK towards the end of the course with more sophisticated articulations as evidenced in sub-section 4.1.1.5. This indicates the success of the unit in exposing the pre-service teachers to more resources (readings), more technology practice, and more tutor supervision in attempts to increase their knowledge of integrating content, pedagogy, and technology together.

TCK discussions occurred when it came to the conversations surrounding content-based ICT tools and the use of ICT for representing and saving content. Like TPACK, TCK received not as much attention from the pre-service teachers as DK, CK, PK, and TK (constituting 5% of the units coded in **I2** and slightly over 4% of the units coded in **I3**). This finding is in keeping with other studies that investigated the distribution of TPACK among teachers—either novice or experienced—who designed their technology-enhanced modules collaboratively (Koh & Chai, 2016; Tseng et al., 2019; Zhang et al., 2019). In all of these three studies, frequencies for TCK were the lowest compared to the other TPACK elements.

PCK received less attention than other TPACK elements except for TPK in **I2** and **I3**, constituting almost 3.0% and 3.5% of the total units coded respectively. This low frequency of PCK possibly reflects pre-service teacher weakness in mapping content to the appropriate pedagogy, which, is in contrast to earlier findings in quite a huge amount of literature (Boschman et al., 2015; Koh & Chai, 2016; Zhang et al., 2019) where PCK was found to be mainly articulated by the teacher participants. This difference may be due to the fact that the teachers in the studies conducted by Boschman et al. (2015), Koh and Chai (2016), and Zhang et al. (2019) are in-service practising teachers and are therefore more ready to articulate their PCK than pre-service teachers in the current study. Koh and Chai (2016) also offered the same hypothesis in their explanation for the high frequency of PCK from the analysis of their primary teacher participants' design talk. In addition, more experienced in-service teachers predominantly considered PCK perhaps because they were more familiar with pedagogy and content while less familiar with technology. This explanation was further supported by the evidence that participating in-service teachers in the three above studies articulated much less TK during their collaborative design conversations compared to PCK.

The small distribution of PCK in pre-service teachers' design talk, is not, however, always the case. Tseng et al. (2019) found that PCK dominated pre-service teachers' collaborative design talk. Although participants in Tseng et al.'s study (2019) were inexperienced pre-service teachers, they were designing their teaching materials in a web-conferencing environment; hence having limited opportunities to integrate and discuss technologies rather than focusing on content and pedagogy (Tseng et al., 2019). In another study also on supporting pre-service teachers in designing technology-infused lesson plans, half of the participants' justifications for their design decisions referred to PCK (Janssen & Lazonder, 2016). This high frequency was explained by the researchers that the integrated support provided by the teacher educators of the training program focused on pedagogy and content only. At the first glance without looking into the implicit context, the PCK related findings of the two above studies seem to negate the hypothesis put forward in the previous paragraph that teachers' PCK distribution frequencies seem to be correlated with their readiness to enact pedagogy and content together and with their years of teaching. However, more contextual details in Tseng et al.'s study (2019) and Janssen and Lazonder's study (2016) suggest that to what extent the pre-service teachers attached weight to PCK related issues is not only connected with teachers' experience, but also with the context in which teachers design and/or teach their technology-enhanced lessons.

There was evidence that among the seven knowledge constructs in the TPACK framework, TPK was probably the most overlooked in both iterations, receiving only 0.8% of the total distribution in **I2** and 0.9% in **I3**. This finding mirrors those of the previous studies that have examined in-service teachers' considerations of TPACK in their design conversations (Koh & Chai, 2016; Tseng et al., 2019). Discussions related to the intermediary knowledge sources of TPK in these two studies were also very marginal, if not zero. Although not exploring teacher design conversations like in these two studies, Graham et al. (2012) analysed pre-service teacher justifications for their design decisions and found that TPK-oriented rationales were the most commonly provided. One point to note is TPK in Graham et al.'s study (2012) comprised of knowledge about not only why to use certain types of technology with general teaching strategies (e.g. class management, assessment, and collaboration), but also what technologies to use with certain types of learners to respond to learners' characteristics (age, learning preferences, etc.). Although some learners' characteristics in the current study were considered (and subsequently found) to be a factor influencing teacher choices of technologies, content, pedagogy, and aesthetic features for the Moodle-based courses, they were not categorised as a 'pedagogical' aspect of knowledge.

Notably, although CK, PK, and TK were among the four dominant references, their second-order constructs (PCK, TPK, TCK) and third-order constructs (TPACK) were much less articulated in both **I2** and **I3**. One possible explanation is that pre-service teachers naturally start with the first-order constructs and, over time/experience, build up knowledge of the second- and third- orders constructs.

The finding that PCK and TPACK were observed to be the least discussed while CK, TK, and PK were attached more importance to separately among pre-service teachers during their design conversations in this study is contrast to findings by Boschman et al. (2015) in their study on teachers who had an average of 30 years' teaching experience. The research team found that the participating teachers spent most of their time on discussing PCK and TPACK while scarcely mentioning CK, TK, and PK. This suggests possibly with their years of teaching experience, more experienced teacher better understood how technology, pedagogy, and subject-matter should act together and therefore showed more of their concerns toward how technology and/or pedagogy should be applied to transfer content properly while less experienced young teachers were still learning and probably revisiting their knowledge of each single domain and therefore attended more to each single knowledge domain in isolation. Another explanation might be due to the sentence level coding scheme where the chances of coding the synthetic knowledge elements (e.g. PCK and TPACK) were missed when those elements were discussed within a sentence group context.

Furthermore, it is worth mentioning the zero-sum relationships when discussing proportions; that is, a gain (%) in one area *must* result in a loss (%) in another. The proportions are about perceptions of importance; however, since not everything is equal, not everything can be equally important. In this case, it is not necessarily that the integrative elements were not important per se; it might be just that they were not considered as necessary to discuss as the other individual areas for this group of pre-service teachers at this time.

5.1.1.4. Context (C)

Context was scarcely mentioned in **I1** and therefore a number of decisions were made in the 2017 and 2018 offerings in attempts to have context more extensively considered. In the former iteration, a default context of mixed-ability class was given to encourage differentiated learning design and, in the latter, two websites to real sample schools were added as a contextual foundation in an attempt to make students more deeply consider context and thus refer to it more in their design conversations. However, context discussion distributions were low-expected in both iterations 2 and 3 (the units coded constituting only 1.9% for **I2** and 0.7% for **I3**).

The two core questions regarding context asked in the Learning Design Guide were *What is the context?* and *What are the best ways to promote student motivation and engagement within that context?* Basically, almost all the teams answered the first question by deciding on or re-mentioning the default class context with mixed-abilities learners. The second question was not as easily resolved in one brief discussion in one single week, the answers to which were, in fact, found implicit in every weekly discussion when the pre-service teachers talked what learning activities to create, what technologies to use, and what aesthetic aspects to add to the Moodle course interface, and so on. That is to say, context was often considered implicitly when talking about how to best facilitate and motivate their potential learners' learning within the "mixed-ability" context, but often not mentioned explicitly. This possibly explains why school and class characteristics tended to be discussed as an overarching context early in the design process and not frequently mentioned again throughout the weeks.

Although the two real-life schools' websites were provided in **I3** with the expectation of more discussions on context compared to **I2**, the occurrences of context discussions in **I3** were even lower. Nevertheless, this addition of real-life context in **I3** did subtend some evident benefits. *First*, pre-service teacher participants had a real context as a prompt to reflect on their past experience as a student or—in cases where they had undertaken one—as a practicum teacher so that they could understand more about a similar school curriculum or learners' background. From that, the participants were observed to adjust the syllabus and learning activities for their Moodle modules. *Second*, as shown in their in-class design conversations, some pre-service teacher participants in **I3** accessed the websites, looked for the school report in order to have real information about potential learners' background and school facilities to base their technology-enhanced lesson designs upon, which could be only assumptions to the student participants in **I2**.

The responses to the context-related questions in the Learning Design Guide could suggest that perhaps specifying the context in more detail in **I3** actually meant the pre-service teachers did not need to discuss it as much as in **I2** because it had been decided for them, which leaves open to the question what might have happened if the two real-life specific schools had not been added. Recommendations concerning whether or not to provide pre-service teachers with a context for their learning design tasks will be further discussed in the Conclusion chapter.

5.1.1.5. Learners' characteristics

There was evidence that learners — the school children in the contexts provided — and their characteristics were considered in the majority of pre-service teachers' group discussions over the Moodle weeks. Potential learners in these schools were taken into consideration in relation to their choices of content, technology, and pedagogy – which are also three core TPACK elements – in the learning design process. In this case, learners' characteristics could be considered a specific contextual factor from the perspective of TPACK framework. This is in line with how Tseng et al. (2019) conceptualised learners' background that their pre-service teacher participants considered while enacting TPACK. Also related to the use of TPACK among pre-service teachers, learners' characteristics in Graham et al.'s study (2012) were categorised as a pedagogical factors when considered together with technology and content.

The consideration of learners' characteristics in the learning design activities is apparently observed in different study settings. Like the pre-service teachers in this study, more experienced in-service teachers also attended to their learner characteristics in their learning design activities. They considered learners' limitations, strengths, capacities, and feedback to base on and build the lessons (Bennett et al., 2015; Churchill, 2006).

The pre-service teachers in the current study also took into account their potential primary school children's preferences when they needed to make decisions on the aesthetic aspects of their Moodle designs. This finding accords with that in Nguyen and Bower's (2018) study, which was also the pilot study of the current study. This consistency further confirms that attending to and empathising with potential users' needs in design is among the factors that characterise pre-service teachers' group design conversations on their technology-enhanced online courses.

5.1.2. Design approaches

Similar to the findings of the pilot study (**I1**), the teams in both iterations 2 and 3 adopted the following approaches in their learning design process: top-down, content-based, and learner-centred. In addition, there was an emergent design approach which was context-oriented. These four approaches are related to each other in several ways.

A top-down approach to designing in the current study is one that flows from an overarching outline, learning outcomes, topics and/or content points of the module to more specific subtle considerations like learning tasks, tools, feedback, and time management to fit in with the overall scheme, whereas a content-focused approach is one where most learning activities and assessment tasks are developed and sequenced around certain learning outcomes or content-area focuses. These two approaches are related to each other in a way that regardless of whether each group commenced their design with a learning-outcome or content-area focus, their following processes took a top-down approach. These findings mirror those of earlier studies on both pre-service teachers (Nguyen & Bower, 2018) and in-service university teachers (Bennett et al., 2015).

A learner-focused approach to designing technology-based lessons relies on learners' age, interests, capabilities, preferences, and background as a starting point for developing learning activities, considering Moodle designs, choosing technology, selecting content, and choosing pedagogy. In other words, the considerations of Moodle design, technology, content, and pedagogy choices seem to have made the designing activity more learner-focused. A close connection between learning activities, technology, and content selection and the learner-focused approach was also identified in Harris and Hofer's study (2011) and Nguyen and Bower's study (2018).

In addition, the learner-focused approach is connected with the content-focused approach in a way that the participant teachers first considered the content to be taught and then discussed what would be done to engage the potential learners to that content (Bennett et al., 2016b; Harris & Hofer, 2011; Nguyen & Bower, 2018). This is also in line with the result of the present study; it was found that, the pre-service teachers approached to designing the same learning activities by selecting a content point first and then working surrounding that content point by deciding on what and how to do to engage the audiences, or young learners.

Furthermore, it was found by several researchers that products from the student-focused approach are modifiable and adaptable while the content-focused approach is more like teacher-focused than learner-centred; that is, teachers' planned lessons are based on their own interests and are less adaptable (Postareff & Lindblom-Ylänne, 2008). This teacher-focused tendency was not observed in the current study. On the contrary, regardless of whether it was a top-down or content-based approach, learners' interests, preferences, and age were frequently taken into account, both affectively and intellectually.

The emergent context-oriented approach to designing involved pre-service teachers' considerations of the whole cohort of learners' characteristics, curricula, and school facilities. These considerations were not found in the pre-service teachers' design conversations as well as follow-up interviews in the pilot study (Nguyen & Bower, 2018). The emergence of this approach implies the success of the teacher educators' pedagogical strategies the intervention in terms of context (a brief description of a default context in **I2** and **I3** in the Moodle task requirements and an addition of links to two real-life specific school websites in **I3**). With these treatments, the pre-service teachers went from having no discussion on context to not only discussing context, but also basing on context to shape their design decisions. The learner-centred approach perhaps is not broad enough to encapsulate the design approach and, therefore, it is important to consider broader context, which the pre-service teachers did.

5.1.3. Summary of Section 5.1

In summary, the two iterations exhibited a degree of consistency with relation to Research Question 1 (What elements do pre-service teachers focus upon when collaboratively designing technology-enhanced lessons?). These findings were related to how frequently the participants referred to each design focus over the Moodle weeks in their design conversations, how they focused upon more isolated knowledge elements than the integrated ones, how they attended to context and their potential learners' characteristics, and the design approaches they adopted. One possible explanation for these consistencies and similarities between **I2** and **I3** is that all the major interventions applied to the whole cohort by teacher educators were the same in both iterations. This homogeneity might have also confirmed the effectiveness of teacher educators' repetitive pedagogical strategies in the two consecutive years.

5.2. Factors Supporting and Hindering the Design Process

This section responds to Research Question 2 (What factors support and/or hinder the collaborative design of pre-service teacher technology-enhanced lessons?). Unlike in **I1** where technological capabilities, peer support, tutor support were found to be as both enablers and inhibitors to the design process, in **I2** and **I3** all these three factors were reported as supporting factors only. In addition, two more approaches emerged from the data. All the factors were identified from both design conversations and follow-up interviews. Discussions surrounding these findings particularly through the Activity Theory lens are detailed in the below sections.

5.2.1. Did hinderances exist?

As reported in Section 4.2.1 of the Findings chapter, the pre-service teachers were observed to have a few questions about technologies posed to their peers and tutors at some points during their in-class design conversations. It was also observed that they solved the problems on the spot within their groups or with tutors' assistance. Evidently, these difficulties were only momentary. Possibly this is why none of the participant interviewees vocalised any hindrances in the post-course follow-up interviews.

Findings show that the case study participants did not have any problems pertaining to the collaboration within their group as well as with the tutors. They indeed encountered occasional technological barriers such as a frozen computer screen, slow internet connection, and not knowing where to get a certain document during the design process. In all cases, the teams were able to solve these issues either among themselves or with the help of the tutors. This suggests over time the pre-service teachers understood the complexity of design problems in terms of what Boschman et al. (2015) called practical concerns. Evidently, the more available and more advanced technology is, the more problems encountered in classroom design. However, the design teams in the current study could solve the problems in a quick and efficient manner. This could be explained by the pre-service teachers' constant exposure and access to technology throughout the course that served to build up their experience and confidence in dealing with technical problems. Their confidence in fixing each other technological assistance demonstrates the value of giving students more time to practice using technologies in the classroom.

From an Activity Theory point of view, this also confirms the importance of community. The interactions between students within a group and between students and tutors obviously led to students' strength at using technologies and hence lifting student technological capabilities to a higher level. More discussions on the role of community will be detailed in the next sections on supporting factors.

5.2.2. Technological capabilities

An impressive finding was that the pre-service teachers showed no fear of a wide variety of tools introduced to them throughout the course, but enjoyably looked for various technologies together and confidently used technologies throughout. This is in contrast with numerous earlier studies (Ertmer, 1999; Ertmer et al., 2012; Kopcha, 2012; Teo, 2009). Several factors could explain this observation. *First*, it was perhaps the unit's intentional strategy of scaffolding technology inputs and practice in every session that led to students' constant access and exposure to technology and increased their confidence. *Second*, students had been able to access technology everywhere, for example, outside the classroom as well, and, therefore, have acquired greater familiarity with technology, which might have been a solid foundation for their technology-related lessons. *Third*, the collaborative group work seemed to help them not only overcome small technological problems but also understand the usages of various technologies shared by other team members. *Fourth*, the participants' strong confidence about technology was possibly due to tutors' assistance. As evidenced in both design conversations and interviews, tutors were an instant source of help when the participants had questions related to technology while designing in the classroom. Tutors were also reported in the post-course interviews to provide clear technological explanations, feedback, and demonstrations.

Although the last two explanations are discussed in more detail in the following sub-sections about the roles of peers and tutors, a quick elaboration on how they should be viewed from an Activity Theory lens can be provided here: the interaction among people in the community (among peers and between students and tutor) apparently helps raise community members' confidence about using tools. This confidence about using tools is supposed to mediate the products (object) and final outcomes.

One more finding about technological capability that is worth discussing was some participants in the current study were aware of higher standards for technology integration that involved not simply using technology for the sake of technology, as evidenced in the interviews. This finding is in accordance with a qualitative study on collaborative design among seven experienced secondary school teachers (Harris & Hofer, 2011). The finding indicates the pre-service teachers' critical and sensible understanding about one of the underpinning philosophies of using technology in the classroom that technology should not be used because one is asked to use it without educational reason. That is, teachers need to make sure the activity in which their potential learners are using technology is engaging and meets the syllabus outcomes and content in a way that it encourages learning rather than having learners, for example, type up their narrative because it 'ticks the box' of using technology in the classroom.

5.2.3. Tutor support

Unlike in the pilot study where tutors were identified as both helpful and unhelpful to the design process, in this study tutors were seen as overwhelmingly supportive in the design process. It was evident that the participants showed no hesitance in asking tutors for help, especially with technological problems. This shows their trust and beliefs in the tutor's expertise and that they could tap into the tutor's depth of knowledge. It also implies how the tutor was successful in creating a friendly and interaction-encouraging environment or community (from an Activity Theory point of view) for the best possible collaboration. This corresponds well to the recommendation on further enhancing a tutor's role in collaborative design made in the pilot study preceding this current study (Nguyen & Bower, 2018).

Tutors in the current study were found to support students in a way that students would not be passive learners but rather more independent. This approach accords with the ideas of Alemdag et al. (2019), who attach importance to fostering the active learning among the novice designers. Furthermore, tutors in the current study used the in-class design sessions to provide students with timely and proper feedback. This is not the case in Tondeur et al.'s study (2020) where only few participants reported that they received feedback from mentors.

Moreover, the modeling role of tutors and their provision of hands-on experience for students were acknowledged in the present study. Recent literature has emphasised human tutors' roles in scaffolding and developing teacher design thinking competence in a collaborative environment (Wu et al., 2019). On the other hand, recent literature has also reported that in some cases teacher educators did not appear to be skilled enough to provide clear examples, and that this impacts upon pre-service teacher learning (Tondeur et al., 2020).

In conclusion, in the current study, tutors were evidently not only able to demonstrate technology, but also teach students how to integrate technology properly with content and pedagogy, encouraging students to be active learners, and creating interactive and motivating learning/designing environment.

5.2.4. Group dynamics

Positive group interactions among the participants that supported the design process in numerous ways were evidenced via both design conversations and follow-up interviews in the last two iterations. This is different from that of Nguyen and Bower (2018), where group interaction was found to be a both challenging and enabling factor to the design process. This finding of the current study also indicates the unit's successful efforts in fostering and encouraging peers' role in a collaborative design process. These efforts included dedicating 25 minutes in **I2** and 40 minutes in **I3** to Moodle group discussions; encouraging the participants to discuss in groups outside the classroom via chat function inside their Moodle modules, or via other chat tools like Messenger and Skype; and coming up with a shared outline of their whole Moodle course before working on their individual Moodle module.

The participating pre-service teachers reported that they were given plenty of opportunities and time to collaborate with their group members and other groups as well as learn a great deal from partners. These findings are in contrast with those of Tondeur and his colleagues (2020), based on their mix-methods study exploring the effectiveness of the strategies used to prepare pre-service teachers for TPACK. One of the strategies was collaboration with peers. Interviews with participants who were, at the time of being interviewed, already beginning teachers, revealed that they were not provided with sufficient time and chances to share ideas and discuss with peers and had to work individually though they wanted to do group assignments to learn from each other. In this study in **I2**, and even more so in **I3**, participants were given extensive in-class time over several weeks to collaborate with their peers.

From an Activity Theory perspective the mutual support in the tasks that require collective efforts is a reflection of the benefits of community where collaborative and interactive spirit can contribute to a successful outcome. Also, the group member evidently provided technological support for each other; that is, the more knowledgeable ones showing the less able ones how to use tools. This engagement in the activity collectively not only increases the potential of acting/designing but also broadens a zone of proximal development for individual learning and development (Engeström, 1987).

Another important observation was the way that the teams proactively sought to equally divide the different tasks and individual lessons among team members. Somehow the participants structured their design process by specifying the "who" rather than the "how" of designing. This, in some cases, is a vital design considerations since "the root of success or failure in a particular design process is a particular configuration of roles or a particular division of labour" (Hoadley & Cox, 2009, p. 25). Through an Activity Theory lens, division of labour is of significance in participatory design because it highlights each individual's tasks and raises personal awareness of their own values, contribution, and responsibility toward the whole community, leading to a more productive design process.

5.2.5. Past educational experience

The pre-service teachers were found to share with each other their learning and teaching experience in the past including stories about their past schools, courses, assignments, tutoring and practicum experience. This sharing facilitated their design process in a way that they could learn from mistakes as well from success in the past. Most importantly, they could share with their group all these experiences so other group members could benefit without having to acquire the pedagogical insights from first-hand activity. Group members sharing memories about their schools, past courses, and assignments possibly added extra meaning to the supporting spirit. Past experience, from an Activity Theory point of view, is an inner conceptual tool shared within a community in a collaborative design activity. This tool, once shared, not only helped group members broaden each other's zone of proximal development (Engeström, 1987), but also facilitated the groups' activity of designing their technology-enhanced lessons (object) on their way to achieve the ultimate outcome.

Past experience in this case could be a tool that is somewhat out of the control of rules set by teacher educators. It is not directly related to teacher educators' pedagogical strategies, but it is closely connected with community and object.

5.2.6. The unit's resources and activities

The pre-service teacher participants reported that the resources and activities provided during the program facilitated their learning design practices. These resources consisted of the Learning Design Guide document, readings (textbook), lectures, peer feedback activity, technology demonstrations, and Moodle examples. With respect to examples and demonstrations of technology, unlike the participants in this study who were content due to comprehensively equipped and supported, participants in a recent study claimed that they received hardly any examples of how to use technology in teaching and learning in their pre-service teacher education program (Tondeur et al., 2020).

The emergence of this finding suggests that teacher educators' pedagogical strategies pertaining to the provision of resources and activities were recognised and appreciated by the participating pre-service teachers. These strategies included greater emphasis on the readings before and after each tutorial as well as more intensive use of the Learning Design Guide. This finding was not present in **I1**.

From an Activity Theory viewpoint, the unit's resources and activities are tools mediated by rules which are also pedagogical interventions in this study. These constituents interact with each other as well as with the subject and object. For example, under the influence of rule (requirement of focused and relevant reading), the subject (pre-service teachers) spent more time reading the textbook (tool), which was reported to provide the pre-service teachers with practical and scholarly knowledge that informed their design of the online artefacts (object). Similarly, the relationship between multi constituents within the model such as rules, subject, tools, community, object, and outcome could be observed. For instance, thanks to the demonstrations of technologies (rule) provided by the tutor (community), the pre-service teachers (subject) knew how to use technologies (tools) to create their learning design artefacts (object) and sharpen their technological skills (outcome).

5.3. Relationship between Pre-Service Teacher Learning Design Practices and the Characteristics of their Online Artefacts

In reviewing the literature, no data was found on the association between teacher learning design practices and the characteristics of their online artefacts. In order to unpack this relationship (Research Question 3), relevant correlational statistical tests were run based on the percentages of PK, TK, CK, and Context distributions among the group members in both iterations and the scores out of 5 each group member received for each of the above elements for their final Moodle tasks.

The results showed that there was a non-significant positive correlation between the frequency of PK and CK discussions and the scores gained for the corresponding elements for the final artefacts. This finding suggests it is not always the case that the more the pre-service teachers articulate pedagogy and content, the better pedagogy and content are reflected in their final products, though the higher proportions of the distributions may indicate the participants' comprehension of the pedagogy related issues.

On the other hand, the results also showed that there was a small significant connection between the occurrences of TK, and Context in the design talks and the average scores gained for those elements for the final product. Apparently, the increased discussions around the two concepts seem to translate into the quality of what the student teachers produced in their final artefacts. However, with a small sample size, caution must be applied, as these findings might not be transferable to a larger population.

Time spent considering technology, as a single dimension, where pre-service teachers explored different technology possibilities, appears to have actually improved Technology performance. That is to say, educators should encourage the exploration of technology, even when it may not be initially related to pedagogy and content, because it is an essential part of the design process that in this study led to observable improvements in the quality of technology application in the final assignment.

The higher score Context gained in proportion with the frequency of context related discussion indicates the importance of considering context in designing technology-enhanced lessons collaboratively. This corroborates the importance attached to context by a team of researchers who found a huge number of TPACK studies not considering context an inseparable concept in the technology integration (Rosenberg & Koehler, 2015) and by another team who studied context carefully before consulting tools for learning design (Bennett et al., 2011). This finding further substantiates the presence of the context-oriented approach to designing, clearly evidenced in both design conversations and post-course interviews, which implies that an emphasis towards conversations focused on context can improve the quality of artefacts with respect to context.

5.4. The Impacts (if any) of the Pedagogical Strategies of Teacher Educators upon Pre-Service Teachers' TPACK Development, Learning Design Processes, and Online Artefacts

This section is composed of three parts which respond to the three sub-questions of Research Question 4 (What are the impacts (if any) of the pedagogical strategies of teacher educators upon pre-service teachers' (1) knowledge development, (2) learning design processes, and (3) learning design artefacts?). Possible explanations and reasons for the answers to each sub-question are presented as follows.

5.4.1. Impacts on pre-service teacher TPACK development

In order to find out the impacts of the pedagogical strategies of teacher educators on pre-service teacher TPACK competencies, the Linear Mixed Model (LMM) was used to analyse the statistical data from both iterations' pre- and post- TPACK surveys. Analyses of data using the final minimal model showed that the factors of Pre_or_Post, Practicum Experience, Gender, and PST_or_Non_PST as well as the interaction between Pre_or_Post and Practicum Experience had a significant impact on the improvement of the participant TPACK while the interaction between Pre_or_Post and Year exerted no influence. Elaboration is provided in the following sub-sections.

5.4.1.1. Was there a pre-to-post improvement across the cohort?

As specified above, an LMM was used to fit the data including TPACK ALL, TK, CK, PK, PCK, TCK, TPK, and TPACK as dependent variables and Pre_or_Post, Year, Practicum Experience, Gender, and PST_or_Non_PST as independent variables or categorical factors. The findings show that all the TPACK elements improved significantly across the cohort between pre- and post- time points in each iteration. Generally, this pre-to-post improvement is consistent with that in earlier studies (Graham et al., 2012; Papanikolaou et al., 2017).

Out of the eight elements, TPACK and TCK had the biggest significant differences between pre and post, with the mean scores being 0.53 and 0.52 respectively. This is quite unexpected for TCK because discussions on TCK related issues barely occurred in the design conversations according to the qualitative findings. However, although discussions on the TCK and TPACK related issues were not extensive, there were possibly chances that the participants deliberated about TPACK and even TCK beyond the sentence level (i.e. the knowledge areas were fragmented across sentence boundaries by the protocols of the coding process). The outstanding improvement in TCK and TPACK between the start and the completion of the training course was also observed in other earlier studies (Graham et al., 2012; Papanikolaou et al., 2017).

A smaller increase was observed for CK (0.30) compared to the other dependent variables (e.g. 0.41 for TK, 0.44 for PCK, 0.52 for TCK, and 0.53 for TPACK). This is explainable because the unit was not a subject content-focused course, being a unit undertaken by pre-service teachers across primary and secondary teaching levels, individual subjects areas, different stages of progress within the degree, in addition to a sample of students not studying to be teachers.

*5.4.1.2. Was there an improvement between **I2** and **I3**?*

Although there was a pre-to-post improvement in each TPACK element score by year, there was no significant difference between the two years with respect to improvements in any of the TPACK elements. Although this result was somewhat disappointing, it could be explained by the fact that the major interventions were essentially the same in both iterations of the present study (see Section 3.1.2 a full list of major interventions). It appears that the **I3** treatments had impact on the relevant aspects of the pre-service teachers' design practices. For instance, the prescription of two real-life school websites as design contexts might have provided a context-oriented approach to designing, but did not have an impact on **I3** knowledge elements as measured by TPACK. In summary, the average TPACK mean scores of the two **I2** and **I3** cohorts were similar, which implies the two cohorts underwent similar changes in their TPACK development, potentially due to the fact that the treatments in the two iterations were not substantially different.

5.4.1.3 Role of practicum experience

Three demographic variables of practicum experience, gender, and PST_or_Non_PST were found to have impact on TPACK development. For example, TPACK scores related to gender and PST_or_Non_PST was both found in TPK, to practicum experience was found in TPACK ALL, TK, CK, PK, PCK, and TPACK (see Section 4.4.1 for more detail). This sub-section only focuses on discussing how PCK and TPACK scores changed across the cohort over the iteration in relation to the interaction between two variables of Pre_or_Post and Practicum Experience within the LMM. PCK and TPACK pre-to-post changes are selected to further discuss due to their relevance to TPACK improvement over time as well as to teacher educators' pedagogical strategies.

Students who had not completed any practicum experience indicated, on average, a significantly lower PCK and TPACK pre-course self-assessment compared to those students who had completed their practicum (2.18 vs 2.68 for PCK). The difference in the growth score was significant by the end of the unit (0.58 vs 0.31 for PCK, 0.64 vs 0.42 for TPACK). Apparently pre-service teachers who had not completed practicum improved by a greater amount than students who had completed practicum for both PCK and TPACK, so their initial deficit was ameliorated. This indicates that the unit had a greater positive impact on the non-practicum students for the PCK and TPACK dimensions. It also implies that the unit's vital role in lifting non-practicum students' PCK and TPACK scores to the same level as those of practicum students by the end of the course. At the same time, another possible explanation is that the practicum students shared their teaching experience with non-practicum students, as evidenced in design conversations and interviews.

5.4.2. Impacts on pre-service teacher learning design processes

In order to examine if there are impacts of teacher educators' pedagogical strategies on pre-service teacher learning design process, a Chi-square test was run to observe if there were any significant differences between **I2** and **I3** in the frequency distributions of the coded categories such as DK, TK, CK, PK, PCK, PTK, PCK, TPACK, and Context. The results showed that although the frequencies percentage of each design focus appeared similar between two iterations, there was a significant respective increase by just over 3% and almost 4% in the distribution of CK and TK from **I2** (2017) to **I3** (2018). There was also a significant respective decline by nearly 4%, just over 3%, just below 1%, and 1.2% in the frequency distributions of PK, TCK, TPACK, and Context between two iterations.

The evidence that there were more design focuses (four) experiencing a significant decline in the frequency distributions than those (two) undergoing a significant increase in the frequency distributions between **I2** and **I3** may be due to the fact that the **I3** case study cohort were generally a less mature cohort with more participants who were younger, less experienced in practicum, and had completed less credit points. This immaturity might also explain why the **I3** groups tended to discuss more TPACK elements in isolation such as CK and PK compared to their counterparts while mentioning less integrative knowledge elements such as TPACK and TCK.

However, the **I3** cohort were somewhat more confident about using technology in general while less confident with respect to using Moodle to design learning tasks compared to the **I2** cohort when they first entered the unit. This was a possible reason for why the **I3** groups articulated more technology in isolation (TK) and less technology in integration with pedagogy and content (TCK and TPACK). In addition, the fact that more participants in the **I3** cohort doing no practicum teaching and being less strong at using technology to create Moodle learning tasks might explain why the decline in their PK and TPACK frequencies between **I2** and **I3** was deemed as significant.

Several extra treatments were prescribed in **I3** with the expectation that the frequencies of the coded categories were higher. These treatments included a bigger amount of time assigned to the in-class conversations, one extra Moodle week, and Learning Design Studio where students could spend more time with peers in their groups and with tutors. One possible interpretation from these above statistics is more time allocated to the pre-service teachers' design conversations perhaps does not guarantee a higher proportional occurrences of design focuses. Instead, the associations between **I2** and **I3** design focuses' frequencies were apparently influenced by such variables as the case study participants' age, experience, and technological skills.

In terms of Context, both **I2** and **I3** participants worked with a prescribed default context which a mixed ability typical learner cohort. **I3** participants received an extra contextual treatment which was the addition of two websites of two real-life schools upon which the participants designed their technology-enhanced modules. A significant decline in the Context distribution frequencies might mean that younger participants in **I3** with fewer credit points and less experience in practicum teaching may not have considered context as much as those in **I2** who had been exposed to the real-world teaching. The decline also implies that the presence of the links to the two websites possibly restricted the **I3** participants to the information found on the website only (e.g. school facilities, potential learner cohort) without considering other contextual factors such as their possible colleagues and school policies, especially when the **I3** cohort generally comprised generally more immature groups. More insights into context can be found in Section 6.2.3 in the Conclusion chapter.

5.4.3. Impacts on pre-service teacher learning design artefacts

There were no clear differences in the final grades (Fail, Pass, Credit, Distinction, and High Distinction) as well as in pedagogy, technology, content, and context criteria scores on the assessment rubrics between **I2** and **I3**. This might indicate that teacher educators' pedagogical strategies did not have substantive impact on the pre-service teachers' learning design products. However, this finding must be interpreted with caution due to small sample size (data analysed for this section were collected from 18 case study pre-service teachers in both iterations).

5.5. Summary of the Discussion Chapter

This chapter has offered discussions surrounding all the qualitative and quantitative findings. Possible explanations, reasons, and interpretation were provided with respect to (1) the extent to which design focuses were differently distributed over the weeks between two iterations, (2) the possible connection between design approaches, (3) the enablers to the learning design process and how they interacted with each other from the Activity Theory perspective, (4) the relationship between pre-service teachers' learning design practices and online artefacts, and (5) the possible impact of teacher educators' pedagogical strategies on pre-preservice teachers' knowledge, design processes, and design products. The findings were also compared and related to other findings in the literature.

Some findings could be related across the two sets of qualitative and quantitative data. For example, context was found to be a design consideration in design conversations as well as an essential design foundation from the interviews. Context scores in the final artefacts were significantly and positively correlated with its distribution frequency in design conversations. Another example was quantitative LMM analyses showed that practicum experience had an impact on PCK and TPACK scores across the cohort while design conversation and interview data evidenced that stories about and experiences in practicum teaching were shared between practicum and non-practicum participants. These two examples and other findings that were related in a similar way will be further deliberated in the next chapter, the Conclusion chapter.

Chapter 6. Conclusion

This study set out to gain insight into pre-service teachers' learning design practices and to understand how teacher educators' pedagogical interventions impact upon pre-service teachers' learning design capabilities while they undertake group design activities to create technology-enhanced modules. A mixed-methods approach was adopted to achieve these goals. More specifically, a thematic analysis of over 80 group design conversations and 15 follow-up interviews in 2 years revealed the knowledge elements that the participants focused upon while designing collaboratively, the design approaches they adopted, and the factors that affected their design experiences. In addition, statistical tests were run to unpack the correlation between pre-service teachers' learning design practices and the characteristics of their technology-enhanced modules. The study also explored the impacts of the educators' pedagogical strategies on pre-service teachers' TPACK development (via 200 pre-course and 200 post-course surveys analysed in the Linear Mixed Model), their design processes, and their design products.

The findings with relation to pre-service teacher practices in the unit provide newfound insights into the pre-service teacher education processes. In turn, these insights infer several recommendations for pre-service teacher educators and programs, which are presented below. All the related conclusions, implications, recommendations, contributions, as well as limitations to the study are discussed in the sections that follow.

6. 1. Insight into Learning Design Process and Practices

One of the purposes of the study was to examine *the issues that pre-service teachers focus upon when they create their technology-enhanced modules collaboratively*. Thematic analysis of their design conversations revealed that the design conversations among pre-service teachers are not just characterised by the seven knowledge elements as conceptually defined in the TPACK framework developed Mishra and Koehler (2006). Design Knowledge (DK) turned out to be a dominant reference in the pre-service teacher design conversations in both **I2** and **I3** in this study (close to 45% in both iterations). Several design patterns —

for instance, different steps involved in the design process — emerged from the DK data as well. The investigation of pre-service teacher design focuses also enabled surfaced four *design approaches*: content-focused, top-down, learner-focused, and context-oriented. This four approaches were consistently supported with the follow-up interviews' thematic analysis results.

One striking finding to emerge from the study related to the above purpose was that in both **I2** and **I3**, the single knowledge elements in the TPACK framework such as CK, PK, and TK dominated the pre-service teacher design conversations while the integrated ones such as TPACK, TPK, TCK and PCK were less frequently articulated. Similarly, discussions pertaining to Context were minimal in both iterations. Irrespective of the smaller percentages, quality conversations regarding CK, PK, TK, and Context were identified. These conversations showed the participating pre-service teachers' capabilities, for example, to select appropriate content for the potential learners, reflect on the scholarly pedagogical expertise, compare and contrast between tools, and be aware of the prescribed context.

Another aim of this study was to explore the *factors that affect the pre-service teachers' collaborative design of their technology-based modules*. This was examined as a consequence of the evidence in the pilot study that the pre-service teachers' design activities were both discouraged and motivated by their technological capabilities, group dynamics and tutor support. With more interventions implemented by the teacher educators in the current study, the challenges identified from the design conversations were temporarily experienced and solved readily with help offered by peers and tutors. This is contrast to findings from the pilot study, where problems seemed to last and were reported at the end-of-course interviews. The interviewees in both iterations in this study mentioned no difficulties related to their technological abilities, or the cooperation among team members or between students and tutors. The follow-up interviews revealed the same three factors – technological capabilities, group dynamics, and tutor support – only as facilitating factors. In addition, two more enabling factors were identified from the follow-up interviews, which were previous educational experience and the unit's resources and activities.

Also pertaining to the design process, *the discernible relationship between technology-enhanced modules that pre-service teachers created collaboratively and how frequently they discussed technology, pedagogy, content and context related issues* was examined via correlational statistics tests. This examination was intended to fill a gap in the literature since there has been no empirical research to date exploring this relationship. There was no correlation between the frequency of PK and the final product score for pedagogy; nor was there a correlation between the frequency of CK and the final product score for content. However, there was a positive and significant correlation between how often TK and Context were referred to during the design conversations with their final product scores for technology and contextualisation. These results need to be interpreted with caution due to the small sample size of 18 participants.

Pre-service teachers' learning design practices could be viewed from the way their practices (knowledge, processes, products) were influenced by teacher educators' pedagogical strategies, which was another overarching goal of the present study. Many Linear Mixed Model (LMM) tests, Chi-square tests, and other statistical tests were run to gauge the impacts of the pedagogical strategies of teacher educators upon pre-service teacher TPACK knowledge, learning design processes and artefacts respectively. The following three paragraphs will briefly summarise the respective improvements in pre-service teachers' learning design capabilities after the interventions.

With reference to the *impact on pre-service teachers' TPACK development* examined via LMM tests, all the eight TPACK variables including TPACK ALL (an average of the other seven knowledge elements' average scores), TK, CK, PK, PCK, TCK, TPK, and TPACK underwent a significant pre-to-post improvement across the cohort, in which the post-scores for TCK and TPACK increased the most. Surprisingly, there were nonsignificant differences across all those knowledge elements between **I2** and **I3**, indicating that the changes in teacher educators did not have measurable different impact on **I3** compared to **I2** even though there was a significant increase in all elements within each of the iterations.

As a result of an attempt to minimise the LMM to fit the data, many effects of as well as two-way and three-way interactions between the available demographic factors (e.g. Pre_or_Post, Year, Age, Gender, Practicum Experience, and PST_or_Non_PST) were excluded out of the model. The LMM statistics tests also revealed the influences of several demographic factors on TPACK scores. Whereas the pre-service teachers' improvement in PCK and TPACK capabilities was found to be influenced by their practicum experience, that in TPK by whether they were male or female and whether they were pre-service teacher or non-pre-service teachers. These findings indicated the impact of teacher educators' pedagogical strategies which, for example, apparently assisted non-practicum experiencers in reaching similar post-course PCK and TPACK scores to practicum experiencers' although the experiencers had higher pre-course PCK and TPACK scores.

Apparently, the changes in teacher educators' pedagogical strategies in **I3** (2018) (real-life context, more time for Moodle group discussions and Moodle week, Learning Design Studio) did not have a comprehensive *impact on pre-service teachers' learning design processes*. Out of the eight design focuses investigated (DK, TK, CK, PK, PCK, TCK, TPK, TPACK, and Context), only distribution frequencies for CK and TK increased significantly from **I2** (2017) to **I3** (2018) while those for PK, TPACK, TCK, and Context significantly declined over two iterations. There was not also a clear *impact on pre-service teachers' final learning design products* (i.e. their artefacts). No substantive differences in the final grades (Fail, Pass, Credit, Distinction, and High Distinction) as well as in pedagogy, technology, content, and context were found between **I2** and **I3**.

From the above findings related to the participating pre-service teacher design process, the following conclusions can be highlighted. *First*, both the case study and the TPACK surveyed cohorts seemed to be homogenous due to many similarities in both qualitative and quantitative findings between them between two iterations. This homogeneity may be due to the fact that the same major interventions were applied in both iterations. This reason may also explain why there were not many changes from **I2** to **I3** in TPACK development as well as in design focuses frequencies. The changes from **I1** to **I2** appeared to have resolved many of the original issues identified in **I1**.

Second, the distribution frequencies of design focuses, or knowledge elements, are possibly affected by the settings in which the design activity happens. In other words, the extent to which pre-service teachers focus on specific knowledge dimensions in their design conversations is arguably shaped by the classroom context and learning tasks that students undertake. For example, if the education program devotes a huge amount of time to having students practise using tools in the classroom, then the higher frequency of technology is expected. Another example is if the task requires learning designers to work collaboratively on a learning design over a period of time, then greater occurrences of the design knowledge are expected, which was what happened to DK in this study.

Third, context evidently played a vital role in learning design processes. Context was not mentioned in Nguyen's pilot study (2016) and has been claimed to be ignored and not to be operationalised in a huge amount of research on TPACK (Rosenberg & Koehler, 2015). In the present study, the qualitative data analysis showed that context – an explicit component in the intervention that took place – was explicitly considered during the design conversations. Although its frequency was not as high as most of the other design focuses, a context-oriented approach to designing was identified in the follow-up interviews where the pre-service teachers based their design upon contextual factors such as class cohort's background and school facilities. Furthermore, the statistical analysis revealed that the more the participating pre-service teachers took into account context in their design process, the higher scores they gained for the context criteria in the final artefact marking rubrics.

Fourth, the pre-service teacher learning design practices appear to have been influenced and supported by both internal and external factors. The former included the knowledge and experience they had up to the point of the designing activity that was happening. In this study, pre-service teachers employed knowledge of design-related issues; knowledge of technology, pedagogy, and content; knowledge of integrating these three elements together; and knowledge of their potential learners and context. These knowledge elements were continuously scaffolded for them by teacher educators throughout the learning process. They also added their own experience to shape their design decisions.

Among the past stories in the design conversations, practicum experience emerged as a dominant factor. The LMM quantitative analysis also showed that practicum experience was a significant factor leading to pre-service teachers' improvement in most of TPACK areas (TPACK ALL — an average of average, TK, CK, PK, TPK, TPACK) over iteration. The external factors were composed of the enabling dynamics among group members, among groups, and with tutors. They also consisted of the unit's resources and activities.

Perhaps, the most influential external factor, also an overarching one, was teacher educators' pedagogical strategies. Interestingly, it appears that some emergent qualitative findings were associated with teacher educators' pedagogical strategies. The context-oriented design approach identified from both design conversations and post-course interviews may be the result of the guiding context treatment available in the task specifications. Similarly, the facilitating factor of resources and activities within the course may have resulted from the approach to having students read relevant scholarly documents intensively. These qualitative enhancements may reflect the effectiveness of the treatments to a great extent.

From an Activity Theory perspective, this external factor of teacher educators' interventions belonged to the category of rules that controlled the whole designing activity. The internal factors (knowledge and experience) were conceptual tools. Such factors as technologies, readings, lectures, learning activities were concrete tools. Other external factors like group dynamics and tutor supports were the community constituent. Within the Activity Theory Model, these factors, together with the subjects (pre-service teachers), objects (the online artefacts), and division of labour (how tutors, students, and group members were aware of and completed their roles) interacted with each other to ultimately reach an outcome which was to develop pre-service teachers' learning design capabilities.

6. 2. Practical Recommendations

Returning to the overarching research question posed at the beginning of this study (How can the learning design capabilities of pre-service teachers be effectively developed?), findings from the study enable recommendations to be subtended for how pre-service teacher educators can effectively improve pre-service teachers' learning design capabilities.

6. 2. 1. Design Knowledge (DK)

The prevalence of DK in pre-service teachers' conversations highlights the need for teacher educators to understand how students collaborate in the design process. According to the relevant findings, DK should be defined as teachers' knowledge of the design process irrespective of TK, CK, PK, PCK, TCK, TPK, and TPACK, which refers to but not limits to teachers' discussions on the aesthetic aspects of their artefacts and their design process managing strategies with regards to setting goals, making schedules, delegating tasks among group members, establishing common-ground awareness, organising where to store design ideas and drafts, and discussing copyrights and referencing.

DK in this study is also composed of understanding of when and where to action the above DK sub-elements in the learning design process. Being aware of and adhering to effective design patterns may enable teachers to improve the efficiency and quality of their learning design processes. For instance, team members who do not know each other before being grouped could commence by sharing their learning and teaching context to attempt to come up with a design topic of common interest. At the start of each design meeting, reminding each other of what was (not) completed in the previous meeting may help the team understand their milestones and know what to discuss next to achieve more goals. At the end of each group discussion, a summary of the points discussed and goals set for the next meeting might develop some senses of achievements and increase the team's awareness of their ongoing commitment to team work. While designing, it would be more beneficial if tasks were equally distributed, and design ideas or drafts safely stored.

As a result, DK is recommended to be introduced in the teacher education programs, especially ones with the focus on ICT training, where teachers are required to work on a learning design in teams. Knowing how to effectively design in teams is also something that could be directly relevant and helpful to pre-service teachers once they embark in the teaching profession. As part of DK, *design patterns* could be written up by teacher educators who would drive pre-service teachers' attention to these patterns during the courses. There is also a good chance for DK to be explored in self-reported D-TPACK surveys, which has never happened in the literature to date. As well, pre-service teacher-employed DK (and TPACK) could be fostered and supported via metacognitive prompts, reflection, tutoring, modelling and collaboration (Chai et al., 2019; Kramarski & Michalsky, 2010b).

To this end, the operationalised definition of learning design of this study that was mentioned in the Literature Review chapter should be re-visited. It was referred to as a process of planning and structuring technology-enhanced learning activities informed by an understanding of pedagogy, technology potential, content, and other contextual factors. Adding DK to the definition, learning design encompasses a process of planning and structuring technology-enhanced learning activities informed by understandings of not only pedagogy, technology potential, content, and other contextual factors, but also design related issues.

6. 2. 2. Integrated knowledge elements: TPK, PCK, TCK, and TPACK

The evidence of the participating pre-service teachers dominantly referring to separate TPACK elements (TK, PK, CK) while much less frequently discussing integrated knowledge elements (TPK, PCK, TCK, TPACK) during their design conversations possibly suggests that the pre-service teachers did not have a good, concrete understanding of TPK, PCK, TCK and TPACK as they evidently did of TK, PK, and CK. This implies that there should be strategies to encourage them to articulate more of these integrated TPACK constructs based on their available TK PK and CK competencies.

It could be clearer to students if there are concrete examples of second- and third-order TPACK constructs to be explicitly taught and discussed in class as a whole class. In an introductory educational technology unit such as the one that was the focus of this study, it would be quite presumptuous to assume that pre-service teachers can abstract their own examples of these constructs from a highly conceptual model.

In order for the pre-service teachers to further enhance their understanding of the integrated TPACK constructs and to bring together what they know more about as individual constructs, one possible strategy is to ask more specific questions when pre-service teachers are required to practise technologies together. The questions should encourage students to map the technological affordances of the tools they are working on to content and/or appropriate pedagogy. Alternately, another possible activity could be a collaborative research exercise where pre-service teachers find high quality examples of TPK- PCK- TCK- and TPACK-suited technologies and critique them. Those technologies are educational technology tools that have pedagogical considerations either built into their design or stemming from their use in the classroom.

6. 2. 3. Context

Marginal discussions on context in both **I2** and **I3** and significantly decreased occurrences of context in **I3** compared to **I2** may have meant that participants did not need to conjecture as much about potential classes and schools once the context were described – though briefly – and available. Instead of extending the discussions, participants might have thought they had achieved sufficient contextual information to design upon. This cause-effect explanation implies a possibly unnecessary introduction to a default context in both iterations as well as two real-life school contexts in **I3**. Although the default context was typical and the schools were real, the participants were not designing for the real world or for the context they were actually immersing in as practising teachers, which could have limited their insights into the contextual specifications. Hence, there is a need for prescribing a near-real-world context that is close to pre-service teachers' learning and teaching background. A recommended context would be either a school where pre-service teachers used to or are going to do practicum or a school they attended. The former would be more advisable because then pre-service teachers could also consider other contextual factors such as other teachers with whom they were or would be teaching.

On the other hand, the prescribed contexts apparently provoked a context-oriented approach to designing as shown in both design conversations and follow-up interviews. In addition, it was also found that discussion of context related to the quality of learning design products in terms of context. To the extent of this last point, teacher educators could provide further prompts in class to have pre-service teachers continually and more deeply articulate context-connected issues in their design conversations. There are also potentially other approaches that may result in similarly beneficial contextual discussions, for instance, by asking pre-service teachers to select and explain their own context, preferably the categories of school as suggested in the first paragraph of this section.

Hence, it may enhance pre-service teachers' context knowledge if there were different specific steps involved to scaffold pre-service teachers with knowledge of context weeks before they create their learning designs. *First*, like technology, pedagogy and content, context arguably deserves dedicated considerations in teacher training programs. Explicitly teaching pre-service teachers how to adjust design to cater to context may enable them to better tailor designs to the needs of their potential learners. For example, knowing how to integrate technology with content and pedagogy in an appropriate way is an initial step. The next step could be to consider whether the tools employed would work well with the school facilities. A technology-enhanced learning activity that requires the use of mobile devices might not work with schools that are not equipped with tablets such as iPad. Therefore, context and its roles could be introduced to students after they have learned more about technology, pedagogy, and content, three core constructs of the TPACK framework, as well as their interactions with each other to create higher order knowledge elements.

Second, specific inputs are encouraged to be frequently scaffolded. For instance, research evidence on the roles of context in learning design and in the TPACK framework should be provided via lectures and further readings. Tutorials are the time when students' understanding of context is reinforced via tutors' recaps, practice activities, and quizzes. Furthermore, context specifications could be established either by each group of pre-service teacher learning designers based on the knowledge they have gained via lectures and tutorials. School websites of their own selected schools could be used for a practice activity where students are asked to analyse the schools' situations based on the above specifications. This practice with authentic websites may also prepare pre-service teachers for their real teaching in the future because this is what they need to do in real-life teaching; that is, researching thoroughly the context before designing.

In brief, teacher educators' context interventions in both iterations did possibly not lead to more discussions on context in terms of frequencies. However, the context interventions impacted in a way that they enabled pre-service teachers to have more quality conversations on context that translated to their final assignment's context scores as well as to an obvious context-based approach to designing. Students' own chosen schools and more intensive exposure to context inputs might make them more aware of the importance of context in designing and thus considering it while designing.

6. 3. Supporting the Collaborative Design Activity

Five factors (technological capabilities, group dynamics, tutor support, students' past educational experience, and the units' resources and activities) were identified in both design conversations and follow-up interviews as enablers to collaborative designing. Through the Activity Theory lens, these factors were engaged in the collaborative design activity and interacted with each other as well as with other constituents such as the subject (pre-service teachers) and the object (learning design artefacts). Based on how the engagement and interactions were observed, recommendations for the collaborative learning design activity are proposed below.

One of the interventions, or rules (encouraging the active role of tutors), apparently took effect with the evident reports from students that tutors (part of the community) not only offered their intellectual support, but also their emotional support. The tutors were also reported to model technologies and responded instantly both in the classroom and online (e.g. via email). The Learning Design Studio prescription (rule) in **I3** that required more active involvement of tutors in the design activity could have partly contributed to these findings. Hence, it would be helpful if teacher educators maintain these strategies so that pre-service teachers could receive optimal support throughout the learning design process.

Another intervention (rule) was students' reading more focused and relevant materials compared to **I1**. This was to assist students understand the research pertaining to technology-enhanced learning design. Findings showed that the pre-service teachers found readings and lectures (tools) very practical and enlightening. Thus, the same strategy is encouraged to broaden pre-service teacher research-based learning design expertise. This can be based on more recent literature, added to the list each year, as evidence and the field progresses. Fun weekly or fortnightly quiz activities related to the literature could be encouraged to maintain study inspiration and check their understanding at the same time.

One more treatment (rule) was that more learning activities were created to encourage pre-service teachers to articulate their design thinking explicitly. One of the activities was pre-service teachers being exposed more extensively to the Learning Design Guide. The participants reported that one factor that contributed to the success of their learning design task was how their group could refer to the Learning Design Guide (tool) again and again during designing in teams. Also, possibly due to numerous technological practice activities (rules), the pre-service teachers' technological capabilities (tool) were reported to improve in the post-course interviews as one of the supporting factors and found to significantly improve over iterations via TPACK survey analysis. These findings suggest a continuing application of these strategies to educating pre-service teachers in the area of collaborative learning design. Several minor modifications could be made to the Learning Design Guide in the Context section, for example, pre-service teachers choosing their own schools and more prompts for contextual discussions, due to the relevant findings as discussed in Section 6.2.3.

Finally, the collaboration between group members (community) were observed not only in design conversations but also in end-of-course interviews. The participants were found to support each other emotionally and intellectually. They helped each other solve problems, shared skills and experience (tools), and shared tasks and responsibilities (division of labour). Pre-service teachers could have the same efficient and manageable design process if the same grouping techniques (students were grouped based on their preferred partner, design topics, and confidence about using technology) were employed. Other techniques could be applied, for example, grouping practicum and non-practicum students together in collaborative designs so the ones knowing more could share knowledge and experience with the ones knowing less.

This last point was further confirmed by a quantitative finding of this study that for PCK and TPACK, the average pre-survey score of practicum students was significantly lower to that of the non-practicum students; however, both groups of pre-service teachers witnessed significant growth scores by the end of the unit. This indicates that the unit succeeded in lifting non-practicum students' PCK and TPACK scores to the same level as those of practicum students. Also, there was qualitative evidence in design conversations that the case study practicum pre-service teachers reflected on their teaching experience and shared it with non-practicum group members.

Hence, in the Learning Design Guide, there could be a section where pre-service teachers were encouraged to reflect on their past experiences and share them with their peers. Another recommendation is there could be a class activity where students discuss past experiences in groups and then share their stories on the online forum. After that, different Moodle groups could be encouraged to continue to do so throughout the design process.

6.4. Theoretical Recommendations

6.4.1. A proposed framework of D-TPACK

The dominating presence of DK in the pre-service teacher design conversations as opposed to other TPACK and Context elements leads to this proposal of a framework that includes TPACK plus DK together with Context as an overarching element. The proposed framework could be named *the D-TPACK framework*, meaning the Design Knowledge plus TPACK framework. Like context, DK in this framework could play complementary and contextualising role to the technology-enhanced lesson designing practices. Such a framework could provide deeper and broader understandings of how teachers approach technology-based lesson design, which are needed to address limitations of the TPACK framework (Boschman et al., 2015).

The difference between knowledge and design is that the former is considered static and conceptual while the latter, pragmatic and fluid (Bower, 2017). Thus, thinking of learning design purely in terms of the TPACK framework obscures how much practical procedural design thinking needs to occur during the real-world practice of technology-enhanced learning design. In a study conducted using a survey instrument that incorporated the adapted TPACK framework with Teacher as Designer elements, Chai and Koh (2017) found that pre-service teachers were ready to accept their roles as designers with the beliefs that teachers should be entrusted with designing their own lessons, be responsible for the quality of the design packages, and get hold of design expertise. Also, This finding indicates the importance of teacher education programs engaging teachers as designers, providing them with design knowledge and practice among other essential knowledge elements such as TPACK elements. *The D-TPACK framework* which proposes the conjunction of both TPACK and Design Knowledge could be an ideal solution.

The D-TPACK framework can be visualised as below.

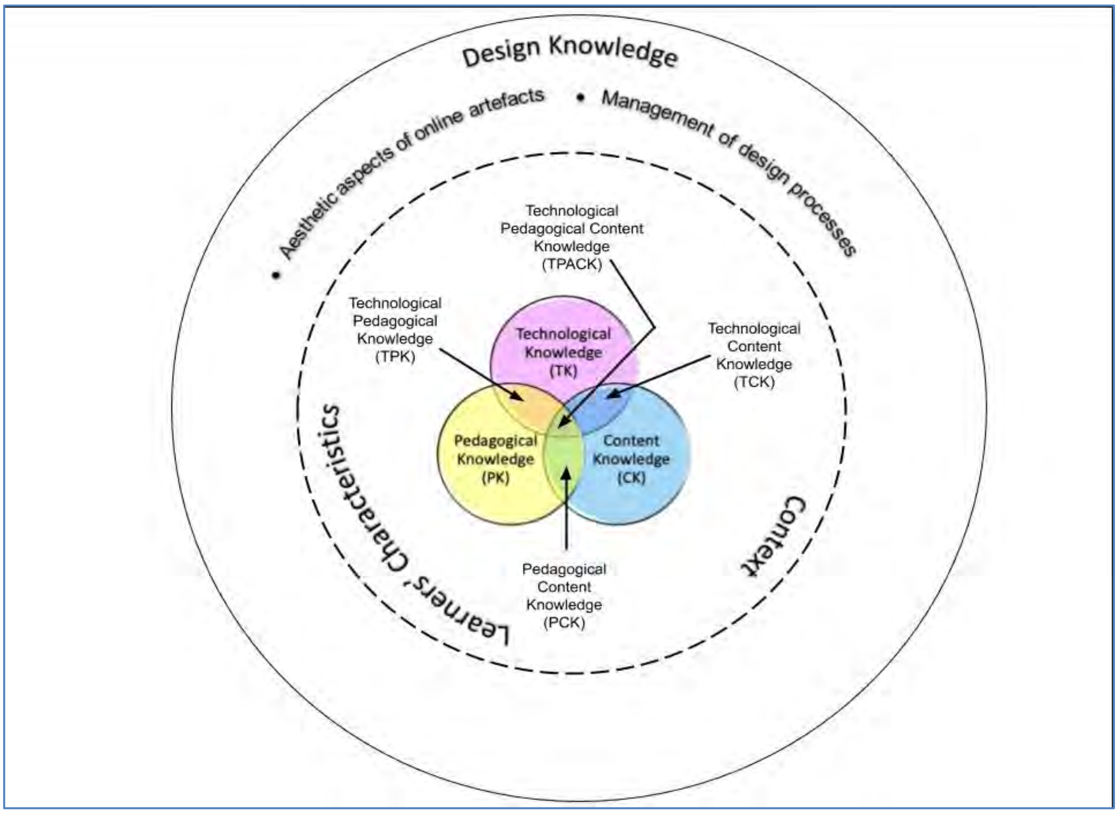

Figure 6.1. The D-TPACK Framework

As can be seen, the D-TPACK framework indicates that there are plenty of knowledge elements involved in a collaborative learning design process. In this process, not only is teachers' TPACK applied, but also their knowledge of context and learners' characteristics is. Beyond that, there is another layer of knowledge that helps understand the process where teachers go through their design processes, which is the understanding of online artefacts' aesthetic aspects as well as of the design process management. This overarching knowledge is depicted by the outer layer of the model.

As mentioned in the literature review, teaching, or designing, is a complex process with numerous 'wicked problems'. It is teachers' responsibilities to design solutions to these problems by utilising all available expert knowledge. This proposed framework is especially recommended in the setting of collaborative design where teachers work in groups to design their technology-enhanced modules together. This setting offers them opportunities to discuss all the design-related issues above in addition to the context and TPACK related issues.

6.4.2. Use of Activity Theory in Learning Design

Activity Theory has arguably been suitable for describing design processes holistically in this study, even though it has been borrowed from a more general research field. All the constituents such as the tools (either technological tools like the Moodle platform and other apps or conceptual tools like the Learning Design Guide), rules (teacher educators' pedagogical strategies), and community (peers and tutors) interacted well with each other and engaged the subjects (pre-service teachers) to work collaboratively to create objects (shared final products) and finally improve their learning design capabilities (outcome).

While different factors were involved in the activity of designing, a great deal of two-way, three-way as well as four-way relationships could be observed. Examples are the relationship between rule and subject (how the prescribed context helped provoke a context-oriented design approach among pre-service teachers as young designers), between subject and community (how each group member interacted with other peers, or each group collaborated with other groups or the tutor), between subject, tools, and object (pre-service teachers utilised Learning Design Guide to create Moodle modules), between rule, subject, tool, and object (the treatment of having pre-service teachers exposed more to practising Moodle and other technologies led to final artefacts with significant technology scores) and so on.

The Activity Theory theoretical framework complemented the conceptual framework in this study. Activity Theory was used to describe the learning design process holistically while the TPACK framework was used to look more deeply into the nature of pre-service teachers' design conversations and distil out the design inner characteristics. Based on the literature review of this thesis, Activity Theory is rarely used in studies of teacher learning design practices. Therefore, Activity Theory is recommended as a suitable theoretical framework in learning design studies that investigate collaborative design processes.

6.4.3. Proposed design principles

The following design principles are proposed based on the findings from this current study that were viewed through the lenses of the conceptual framework (TPACK) as well as the theoretical framework (Activity Theory) as discussed so far in this Conclusion chapter. They are proposed to help (pre-service) teachers engage productively and smoothly in collaborative learning design practices.

- *Pre-service teachers should be provided with as many opportunities as possible to articulate their TPACK.* Without understanding content, technology, and pedagogy and how these three core elements are related to each other, pre-service teachers may make sub-optimal design decisions, for example, selecting the wrong tools for the intended pedagogical approaches. More specific recommendations for implementation can be found in Section 6.2.2.
- *Where pre-service teachers create their learning design on an online platform, the application of DK to the design process should be promoted.* This includes guiding them to make aesthetic considerations and manage their learning design processes collaboratively. Refer to Section 6.2.1 for more detailed guidelines.
- *Engaging design necessitates an extensive focus upon potential learners' characteristics.* Designing also involves considering whom to design for in

addition to the what, the why, and the how. The characteristics to consider are learners' age, preferences, learning styles, prior knowledge, and language and cultural background. This aligns with recommendations from McKenney et al. (2015) and Tseng et al. (2019).

- *Learning design should comprehensively focus on all contextual factors.* These factors consist of curricula, school facilities, classrooms, the whole big learner cohort's background, and other teachers. This accords with findings from many recent studies (Bennett et al., 2011, 2016b; Boyle & Ravenscroft, 2012; Rosenberg & Koehler, 2015). Suggested ways of raising pre-service teachers' awareness of considering context in their design activity can be found Section 6.2.3.
- *Strategically manage group work processes.* Group dynamics can heavily influence the success of collaborative design processes and minimise hindrances, so explicit guidance about how to communicate effectively, accommodate differences, distribute workload and assume responsibility can be provided and supplemented with ongoing monitoring to support learning design processes. More experienced and more confident teacher designers should be grouped with less experienced and less confident ones in order to create a sharing and communicative designing environment. This is also supported by Tondeur et al. (2020).
- *The role and importance of tutors and facilitators should be a foremost consideration.* Tutors in this study has shown to be critical in providing technological guidance, providing mental, emotional, and intellectual support, developing pedagogical understanding and monitoring group work processes. To this extent, the role that the tutor takes should be a matter of deliberate reflection and extensive design. This recommendation concurs with other studies (Kali et al., 2011; Papanikolaou et al., 2017; Svihla et al., 2015; Tondeur et al., 2020; J. Voogt et al., 2011).

6.5. Limitations of the Study

The case study qualitative data presented in this thesis has illustrated the nature of pre-service teachers' learning design processes as well as issues that impact upon their performance. However, as noted in the methodology, this case study enquired into activities of two specific cohorts of student participants in a particular course at a particular university, so the findings cannot necessarily be directly generalised to other students in courses — whether similar or otherwise — or in-service teachers in their construction of ICT-based learning designs. Similarly, although the number of the quantitative TPACK surveys in this study were deemed big enough to run statistical tests in the SPSS software, the generalisability of the related findings was limited due to the controlled nature of the sampling population, which was selected from a specific course at a specific university.

Although the first iteration of the current study attempted to solve the problems identified and implemented most of the recommendations made in **I1** or in the pilot study, there were absolute inconsistencies between coding for the pilot study case study and the current case study. **I1** design conversations were not sentence-coded while **I2** and **I3** ones were. Therefore, some of the relevant findings could not be systematically compared across the three iterations.

The small qualitative sample size (18 pre-service teachers in both iterations) does not seem to support well the interpretation of the results regarding the learning design process versus product analysis. As well, it leads to the inability to compare the frequencies of knowledge distribution with the final learning design products as well as knowledge with process. With a small sample size, caution must be applied to interpret the related findings, as these findings might not be transferable to a larger population.

6.6. Recommendations for Further Research

This study has established many fruitful areas for further research. This section takes into considerations the thematical and methodological aspects to make suggestions.

Thematically, the following research topics are worthy of further investigation in future study. First, further research could examine how the application of the proposed D-TPACK framework contributes to understanding of pre-service teachers' learning design practices. This could also entail the development of an integrated D-TPACK-based design approach. As a result, it would be interesting to investigate the improvement in pre-service teachers' DK in addition to other TPACK elements. This research could be also carried out with in-service teachers as participants.

A question raised by this study is: What if context was taught in more detail in a separate section to further draw pre-service teachers' attention to the role of context in designing technology-enhanced lessons? Further work could be done to see whether there is an increase in pre-service teachers' context references' frequencies when such a section is added to a teacher training program. Accordingly, the correlational relationship between context distribution and pre-service teachers' learning design performances could be examined to further validate the role of context.

Encouraging cognitive engagement (hence discussions) with the context was shown to correlate with better performance on the context indicator, so that it could be that not setting a context and making students discuss and define their own leads to greater consideration of context and hence better performance. However, qualitative data indicated benefits to both approaches. Nevertheless, sample sizes were small, so further research would be required to substantiate which approaches to promoting contextual considerations are most effective.

Methodologically, it is recommended that further research be undertaken in the following areas. First, other coding units besides sentence level coding could be explored for the studies that investigate the nature of teacher design conversations via thematic/content/discourse analysis using the TPACK elements as themes. Although coding using sentences as unit of analysis is fine grained, some meanings can be lost when the whole idea (e.g. discussions on synthesised knowledge elements like TPK, TCK, PCK and TPACK) is expressed in a cluster of sentences. Therefore, a more structured approach to analysing discourses to more accurately capture semantics such as topic exchanges or discourse episodes could be adopted.

Second, future work could examine more than just the categorisation of the focuses of design conversations. That is, the quality of that conversation somehow needs to be analysed in order to capture a more nuanced and direct relationship between design conversations and design artefacts.

Furthermore, this study is among the first learning design studies measuring and comparing TPACK in different interventions using LMM. Further research could use LMM to analyse quantitative data, particularly those surveys containing multiple variables observed over years, in order to better account for the intervening variables that may affect outcomes.

Future research exploring teacher learning design practices over a long period of time could consider using a Design-based research (DBR) approach. With this approach, problems arising from teaching as well as designing would have enough time to be observed and solved. Similarly, there would be sufficient time for the related interventions to be implemented and take effects. A three- or four-year PhD candidature would be appropriate to conduct a DBR study. With a carefully and methodically written plan and support at different levels, challenges such as being time consuming and exhaustive, and receiving support could be minimised.

As well, for a better validation of findings regarding pre-service teachers' learning design processes, data from the tutors could be collected if possible. This would allow multi-dimensional insight into pre-service learning design practices. Tutors in this study would have been interviewed if the related ethics application had been approved.

Collaborative design of technology-enhanced modules among in-service teachers could be examined in a similar way. A real-life teaching and learning environment together with authentic learning design products that would be directly applied to classroom could lead to different results in terms of design focuses, design approaches, and supporting and inhibiting factors. This could in turn lead to interesting findings about differences between experienced and novice teachers, and hence the sorts of strategies that teacher educators may need to apply.

Finally, more extensive investigations of the relationship between knowledge, processes and artefacts could be conducted using larger sample sizes. The small sample for the process versus product analysis in the current study made it difficult to reliably compare knowledge with product and knowledge with process. A larger sample size would allow generalisability and transferability of the findings to a bigger population.

6.7. Contributions of the Study

The current study has contributed to the learning design research field in several ways. First, a key strength of this study is that it examined the pre-service teachers' actual learning design process via a thematic analysis of nearly 50 group 'live' design conversations. This analysis, together with another thematic analysis of 15 follow-up interviews revealed deep insight into the pre-service teachers' learning design practices and hence adds more knowledge to the existing field of Learning Design. These contributions were over an extended timeframe and captured much, if not all, of the design conversations of the groups to characterise their nature using a deductive and exhaustive coding process. This in itself is a unique contribution to the field.

Furthermore, the study further established and clarifies the connection between the TPACK framework and Learning Design, especially with relation to collaborative design practices. This was reflected, for instance, through the identification of DK that dominantly characterised the pre-service teacher design conversations. The occurrence of DK not only confirms the importance of DK with relation to the TPACK framework while teachers are enacting it for their technology-based lesson planning, but also adds to the existing knowledge of the design process the design patterns that could be replicated in other teacher education programs.

Last, this research has empirically validated the relationship between key teacher education strategies and the performance of pre-service teachers as well as relationships between learning design process and products. It is the first study to have empirically investigated such connections in a rigorous and systematic way. This validation can inspire the confidence that ICT-enhanced learning design initiatives and how they may effectively support the improvement of pre-service teacher learning outcomes.

6.8. Concluding Remarks

Exploring teachers' learning design practices is never an easy task. It is important for teacher educators to adopt an evidential approach to building teacher education curricula as well as developing pre-service teacher technology-enhanced learning design skills. Although it is a mutual research interest among Learning Design scholars and academics, from which numerous practical implications and recommendations have been made to ultimately improve learning environment for learners, challenges remains to create high-quality learning designs that impact on learners in a meaningful way. Addressing those challenges should be the joint efforts among tutors, researchers, teacher educators, and institution leaders. At the end of the day,

> there is a continual need to rethink our preparation practices in the teacher education field and propose new strategies that better prepare teachers to effectively integrate technology into their teaching (Schmidt et al., 2009, p. 126).

It is intended that this study has helped to advance both teacher education practices and the research approaches that can be used to study them.

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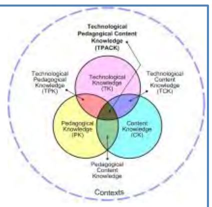
Appendix 1: Learning Design Guide



'Pedagogy First' Learning Design Guide

1. Module Aims

Goals/Objectives/Outcomes
What it is students need to learn? Define as precisely as possible.

2. Module Foundations

Overarching pedagogy/pedagogies
What overarching pedagogical approach/approaches may be suitable?
Content
What sort of content is being addressed and what sort of thinking skills are being developed?
Context
What is the context and what are the best ways to promote student motivation and engagement within that context?

3. Module Activities

Brainstorm Possible Lesson Activities	
What are some initial ideas about the sorts of activities that could be used to help students to develop the required knowledge, skills and attitudes?	*(leave this column blank initially)*

How might the activities above be sequenced to promote effective learning? Order them.

4. Technologies

Brainstorming possible technologies
What technologies, based on their affordances, can be used to facilitate and support pedagogies, interactions, and content representation?

Now map these into the second column of the Module Activities Table

Having thought about the pedagogical and learning objectives, do the available technologies inspire any new ideas for types of tasks? If so, make amendments in the Module Activities Table.

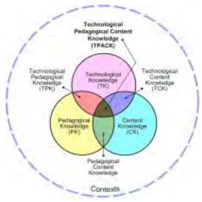
5. Assessment

Appropriate assessment tasks
How will students be assessed as having met or progressed towards the learning outcomes?

6. Fine tuning

- Has the student cohort and learning context been fully considered?
- How can the presentation and sequencing of the tasks be optimized to promote student learning? (for instance, efficiency of words for task instructions, using the most effective form of representation to share knowledge and skills, using modalities together in cognitively efficient ways, using increments appropriate for the ability level)
- How have learning supports (scaffolding) been provided within tasks and overall to assist learning? (links to further information, feedback, hints, suggestions, prompts, clear instructions about group work processes etc)
- Does the lesson operate at the desired levels of thinking (for instance lower order thinking as opposed to higher order thinking)?
- Is the length of the lesson too long or short (place yourself in the mind of the learner)?
- Is there alignment between my learning objectives, tasks, and assessment ("Constructive Alignment", Biggs & Tang, 2011)?
- Is there alignment between the different levels of pedagogy (the overarching pedagogical perspective, pedagogical approaches and pedagogical strategies)?

Does the design promote accessibility through multiple modes of engagement, representation, expression and action?



'Pedagogy First' Learning Design Guide (Notes)

This guide has been created to support teachers in the design of technology-enabled lessons. It is not a prescription, but rather a logical sequence of critical elements and questions to help structure the learning design process. It is based around the Technology Pedagogy And Content Knowledge model of teacher practice, but asserts that Pedagogy and Content thinking should precede the consideration of Technology.

1. Goals/Objectives/Outcomes

These are usually defined by a syllabus or curriculum.

2. Lesson Foundations

Overarching pedagogy/pedagogies

Which overarching pedagogy might be appropriate and why, for instance:

- Behaviourist – suitable for recall of facts, such as spelling, multiplication tables, language memorisation
- Cognitivist – useful for situations where direct instruction is being designed in order to promote efficient formation of understanding
- Constructivist – suitable for logical domains, deductive reasoning, systems thinking, for instance in STEM subjects (Science Technology Engineering and Mathematics)
- Socio-constructivist – appropriate where knowledge is to be negotiated, is subjective, or where peer exchange, debate and guidance will enhance understanding of material and development of skills
- Connectivist – suitable for complex and rapidly changing domains, where learning from and with people helps to remain up to date or quickly form new understanding

Note that proposed applications above are only suggestions – each pedagogy can be applied in a range of different contexts. As well, more than one pedagogy may be applied during a module. At this stage it may also be possible to draw upon pedagogical patterns, such as "Think-Pair-Share" or "Predict-Observe-Explain" to structure the lesson. At a more granular level also consider which pedagogical approaches and strategies might be used.

Content

Aspects to consider are:

- The nature of the knowledge type/s being represented (factual, conceptual, procedural, metacognitive)
- The nature of the cognitive processes being developed (from lower order recall, understand, apply, to higher order analyze, evaluate, create)
- What sort of modalities are appropriate for representational purposes (for instance, factual knowledge: text, image; procedural knowledge: video, sometimes audio; conceptual knowledge: images, diagrams)

Context

Pay careful attention to the prospective learning environment, the level of student abilities and their learning dispositions. Also think about what may motivate the cohort of students. Possible approaches to motivating students include:

- Authentic contexts and tasks
- Role plays

Gamification

3. Brainstorm Possible Lesson Activities

Possible lesson activities include:

- Activating prerequisite knowledge so that students recall the required facts, concepts and skills
- Providing instructional information and resources
- Interactive tasks (students share their ideas with peers, with teacher)
- Investigative tasks
- Practice tasks
- Debates
- Creative tasks
- Group work tasks
- Formative assessment to check student progress
- Summative assessment to evaluate overall learning

Also consider:

- Does the lesson cater to student diversity (differentiate the curriculum)?

4. Technologies

Possibilities include:

- Wikis
- Discussion boards
- Multiple choice questions
- Written responses e.g. in a text area
- File sharing
- Videos
- Mindmapping
- An almost infinite range of Web 2.0 technologies and apps
- Social networking
- Mobile learning
- Virtual worlds
- Many more

When mapping technologies to the learning activities, consider the affordances of the technologies, and how they relate to the affordance requirements of the activities in terms of concept representation and interaction. Consider:

- What sort of information can the technology represent (for instance, factual knowledge: text, image; procedural knowledge: video, sometimes audio; conceptual knowledge: images, diagrams)
- What sort of discourse and collaboration do they enable (for instance, one directional broadcast, discussion, individual construction, co-construction)

It is important to revisit the possible activities in light of the available technologies – sometimes technologies inspire creative activity ideas. However, the approach adopted in this Learning Design guide is that consideration of the pedagogical elements needs to have proceeded the technological elements so that fundamental learning requirements are met.

5. Assessment

Points to consider include:

- The level required (conditions, behavior, performance)
- Authentic assessment – completing tasks that students will find relevant and realistic
- Formative versus summative assessment

- The technology selected enables students to appropriately represent their level of understanding (for instance, multiple choice for lower order thinking skills and factual knowledge, versus more open ended and creative tasks for higher order thinking and conceptual knowledge).

6. Fine tuning

It is important to continually reflect upon and fine tune a learning design. Designing lessons is as much art as science, and in this respect it cannot be purely linear. Seek feedback from a several people in order to support the refinement process.

Appendix 2: EDUC261 Timetable- S1 2016

Week Commencing	**Lectures**	**Tutorial Content**
Week 1 (29/02/16)	Introduction to ICT in Education (Technology as an educational imperative, Effective technology integration and the TPACK Model)	Intro to unit & technologies (LMS, wiki) Introduction to contemporary technologies (LAMS sequence)
Week 2 (07/03/16)	Pedagogies of Online Learning	Introduction to shared resources Critiquing learning objects Evaluating LAMS sequences Advanced online searching & copyright
Week 3 (14/03/16)	Technology Affordances and Their Effects	Authoring LAMS sequences Pedagogical implications of LAMS tools NSW syllabuses/BOS & technology **(Wiki task due)**
Week 4 (21/03/16)	Knowledge, Thinking and Technology	Overview of lesson planning Further authoring in LAMS
Week 5 (28/03/16)	Designing for Learning	Workshopping and constructively evaluating each other's LAMS sequences
Week 6 (04/04/16)	Designing for Learning using Web 2.0 (blogs, wikis and more)	Introduction to Web 2.0 tools Web 2.0 design activities
Mid Semester Break – Monday 11th April to Friday 22nd April **(LAMS task due at beginning of break)**		
Week 7 (25/04/16)	*No lecture (Education students on practicum)*	*No face-to-face tutorial*
Week 8 (02/05/16)	*No lecture (Education students on practicum)*	*No face-to-face tutorial*
Week 9 (09/05/16)	Learning in Social Networking Environments	Introduction to Learning Management System authoring (Moodle)
Week 10 (16/05/16)	Enhancing Learning using Mobile Technologies	Exploring mobile potentials
Week 11 (23/05/16)	Virtual Worlds in Education	Virtual world activity Moodle module group work
Week 12 (30/05/16)	Implications of Technology in Learning (Social, Assessment, Research, Future)	Reflections and evaluations Group debriefing Exam overview
Week 13 (06/06/16)	Unit review	**In class examination**

Appendix 3: EDUC261 Timetable- S1 2017

Week Commencing	Lectures	Tutorial Content
Week 1 (26/02/18)	Introduction to ICT in Education Technology as an educational imperative The Technology Pedagogy and Content Model and its implications	Intro to unit and technology platforms Initial analysis of technologies & their educational implications Introduction to Task 1 Quiz Questions
Week 2 (05/03/18)	Pedagogies of Technology-Enhanced Learning	Analysing pedagogies of technology-enhanced learning Evaluating Moodle modules
Week 3 (12/03/18)	Technology Affordances and Multimedia Learning Effects	Introduction to Learning Management System authoring (Moodle)
Week 4 (19/03/18)	Representing and Sharing Content Using Technology	Learning objects Sharing and reuse of content (copyright & Creative Commons) Assessment using technology
Week 5 (26/03/18)	Design Thinking and Learning Design	Introduction to the design of technology enhanced learning (learning design and lesson planning) Overview of Task 2 Moodle Module
Week 6 (02/04/18)	Design of Web 2.0 Enhanced Learning (blogs, wikis and more)	Designing activities using Web 2.0 tools Moodle Module group work
Week 7 (09/04/18)	Designing for Learning using Social Networking	Using social networking for learning Moodle Module group work
Mid Semester Break – Monday 16th April to Friday 27th April		
Week 8 (30/04/18)	*No lecture (Education students on practicum)*	*No face-to-face tutorial*
Week 9 (07/05/18)	*No lecture (Education students on practicum)*	*No face-to-face tutorial*
Week 10 (14/05/18)	*No lecture (Education students on practicum)*	*No face-to-face tutorial*
Week 11 (21/05/18)	Design of Mobile Learning	Exploring mobile potentials Moodle module group work
Week 12 (28/05/18)	Designing for Learning using Virtual Worlds	Virtual world activities Moodle module group work
Week 13 (04/06/18)	Abstracting Technology-Enhanced Learning Design Principles Conclusions and Future Directions	Peer feedback on Moodle modules Reflections and evaluations Group debriefing General review

Appendix 4: Pre-Moodle Survey

Dear students,

Please take a few minutes to complete this brief survey before you start the Moodle module. Your careful responses will help us to provide you with the best group work experience. Thank you so much for your cooperation.

1. Which tutorial class are you in?

   Monday 4p.m.

   Tuesday 9a.m.

   Tuesday 11a.m.

   Tuesday 2p.m.

   Wednesday 9a.m.

   Wednesday 11a.m.

   Wednesday 1p.m.

   Friday 12p.m.

2. What degree program are you enrolled in and what is your major? (*e.g. BA in Education (Primary)*)

   ____

3. How many credit points have you completed on your degree program?

   ____

4. What is your age range?

   18-20

   21-25

   26-30

   31-35

   36-40

   41-45

   46-50

   51-55

   56-60

   60+

5. Please rate your agreement with the following statements.

SA = Strongly Agree, A = Agree, MA = Mildly Agree, N = Neutral, MD = Mildly Disagree, D = Disagree, SD = Strongly Disagree

	SA	A	MA	N	MA	D	SD
I am a confident user of technology generally.							
I am confident using technology to design learning tasks.							
I am confident using Moodle to design learning tasks.							
I consider myself to be a learning designer.							

6. For the Moodle assignment task, you are required to design a course in groups of three on a certain subject area. Which syllabus area(s) are you interested in focusing upon? (*e.g. English for secondary school children*)

____

7. Are there any people in your tutorial class that you would prefer to be grouped with? (*If yes, provide names*)

____

8. Are there any people in your tutorial group with whom you would prefer NOT to be grouped? (*If yes, provide names*)

____

9. At some points during the course, would you be willing to let your discussions in group be recorded and used for an educational study?

If you answer yes, then you will be sent further information before you consent. Please note that if you end up being recorded then your identity will not be revealed to anyone outside the research team and participation in this study will not affect your progression in this unit in any way.

Yes

No

10. After the end of semester, would you be willing to be part of an interview relating to the design of your group's Moodle course?

If you answer yes, then you will be sent further information before you consent, and please note interviews will take place after results of the Moodle task have been released. Students who end up participating in the group recording and interview will receive a shopping voucher.

Yes

No

Appendix 5: Participant Information and Consent Form

Dear students,

You are receiving this email because previously you indicated that you would be willing to participate in a study investigating relationships between pre-service teacher learning design practices and their design products. The study aims to examine what underlies pre-service teacher learning design decisions and how this influences the quality of the learning design products they create. This may be of benefit to you in order to help you reflect upon your own design thinking. The outcomes of the research may also be immensely helpful to other students and educators around the world.

If you decide to participate, you will be completing the EDUC261 Moodle design task in exactly the same way as your peers who choose not to participate. The only difference is your in-class design conversations with your Moodle team will be audio-recorded and your Moodle designs will be examined. You may also choose to share notes and links to online resources used for the design process and participate in a post-semester interview. Your identity will not be shared with anyone outside the research team and you may choose to withdraw from the study at any time. Participation in this study is entirely voluntary: you are not obliged to participate and if you decide to participate, you are free to withdraw at any time without having to give a reason and without consequence. Participation in this study will not influence your performance in EDUC261 or any other subject in any way. Further details about the study are provided below.

People who decide to participate in all aspects of the study will also be given a $30Coop Book Shop voucher each.

Please indicate below whether or not you are willing to participate in the study.

1. Would you be willing to let your discussions in group be recorded and used for an educational study? *

- Yes
- No

2. Would you be willing to share notes and links to online resources used for the design process (e.g. links to Google Docs, referenced websites and Word documents)? *

- Yes
- No

3. Would you be willing to be part of an interview relating to the design of your group's Moodle course? (If your answer to the above question is No, you are not expected to respond to this question)

- Yes
- No

Participant Information

As a student in EDUC261 you are invited to participate in a project investigating relationships between pre-service teacher learning design practices and their design products. In other words, it aims to examine what underlies their learning design decisions or what they think about while they are designing. This may be of benefit to you in order to help you reflect upon your own design thinking. The outcomes of the research may also be immensely helpful to other students and educators around the world. People who decide to participate in all aspects of the study will also be given a $30 Coop Book Shop voucher each.

If you decide to participate, you will be completing the EDUC261 Moodle design task inexactly the same way as your peers who choose not to participate. The only difference is your in-class design conversations with your Moodle team will be audio-recorded. Your notes and links to online resources used for the design as well as some of your online activities, for example forum discussions and other contributions to the Moodle Learning Management System, will be also collected as data. After the course is finished and the final results have been released, you will be invited to a 15-20 minute interview relating to your Moodle assignment design. These interviews will be again audio-recorded and transcribed to be used as data.

Any information or personal details gathered in the course of the study are confidential, except as required by law. No individual will be identified in any publication of the results.

The only people who will have access to the data are Assoc. Prof. Matt Bower and his student, Ms. Giang Nguyen, who is his associate investigator. A summary of the results of the study can be made available to you on request by contacting A/Prof Matt Bower via phone (+61 2 98508626) or email (matt.bower@mq.edu.au).

The ethical aspects of this study have been approved by the Macquarie University Human Research Ethics Committee. If you have any complaints or reservations about any ethical aspect of your participation in this research, you may contact the Committee through the Director, Research Ethics & Integrity (telephone (02) 9850 7854; email ethics@mq.edu.au). Any complaint you make will be treated in confidence and investigated, and you will be informed of the outcome.

Note: By ticking "Yes" to the three questions above and clicking "View and submit", you mean you have read and understood the information above and agree to participate in this research, knowing that you can withdraw from further participation in the research at any time without consequence.

Thank you so much for your cooperation!

A/Prof Matt Bower

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Appendix 6: TPACK Survey

This survey has been prescribed as a learning task in order to help students better understand the components of the Technology Pedagogy and Content Knowledge (TPACK) framework, as well as issues surrounding its measurement. The survey will only take about 5 minutes to complete, but we encourage you to think carefully about your responses because we will be examining your TPACK development over the course of the semester. Some questions may not make entire sense at this stage of the unit, and if you are really unsure about the meaning of any questions then you can answer "neutral" (N).

Towards the end of the survey you will be provided with the option of allowing your responses to be anonymously used for research purposes. Whether or not you choose to allow your responses to be anonymously used for research purposes will in no way affect your grades in this unit or your progress at Macquarie, and you can withdraw your data at any time in the future by emailing the convenor. At the end of the survey you will also have the opportunity to see the results of all students who have completed the survey, which provides you with an interesting point of contrast.

So if you are ready, please begin!

DEMOGRAPHIC INFORMATION

1. Gender

    Female

    Male

2. Age range

    18-20

    21-25

    26-30

    31-35

    36-40

    41-45

    46-50

    51-55

    56-60

    60+

3. Which tutorial class are you in?

    Monday 4p.m.

    Tuesday 9a.m.

Tuesday 11a.m.

Tuesday 2p.m.

Wednesday 9a.m.

Wednesday 11a.m.

Wednesday 1p.m.

Friday 12p.m.

4. What degree program are you enrolled in? (*e.g. BA in Education (Primary)*)

____

5. Are you enrolling in EDUC261 as your Planet Unit?

Yes

No

6. How many credit points have you completed on your degree program?

____

7. Have you completed any practicum teaching experience?

Yes

No

STUDENT TEACHING

Technology is a broad concept that can mean a lot of different things. For the purpose of this questionnaire, technology is referring to digital technology/technologies - that is, the digital tools we use such as computers, laptops, iPods, handhelds, interactive whiteboards, software programs, etc. Please answer all of the questions, and if you are uncertain of or neutral about your response, you may always select “Neither agree nor disagree.”

Technology Knowledge (TK)

Strongly Disagree = SD Disagree = D Neither Agree/Disagree = N Agree = A Strongly Agree = SA

1. I know how to solve my own technical problems. SD D N A SA

2. I can learn technology easily. SD D N A SA

3. I keep up with important new technologies. SD D N A SA

4. I frequently play around with the technology. SD D N A SA

5. I know about a lot of different technologies. SD D N A SA

6. I have the technical skills I need to use technology. SD D N A SA

7. I have had sufficient opportunities to work with different technologies. SD D N A SA

Content Knowledge (CK)

Strongly Disagree = SD Disagree = D Neither Agree/Disagree = N Agree = A Strongly Agree = SA

Mathematics

8. I have sufficient knowledge about mathematics. SD D N A SA

9. I can use a mathematical way of thinking. SD D N A SA

10. I have various ways and strategies of developing my understanding of mathematics. SD D N A SA

Social Studies

11. I have sufficient knowledge about social studies. SD D N A SA

12. I can use a historical way of thinking. SD D N A SA

13. I have various ways and strategies of developing my understanding of social studies. SD D N A SA

Science

14. I have sufficient knowledge about science. SD D N A SA

15. I can use a scientific way of thinking. SD D N A SA

16. I have various ways and strategies of developing my understanding of science. SD D N A SA

Literacy

17. I have sufficient knowledge about literacy. SD D N A SA

18. I can use a literary way of thinking. SD D N A SA

19. I have various ways and strategies of developing my understanding of literacy. SD D N A SA

Pedagogical Knowledge (PK)

Strongly Disagree = SD Disagree = D Neither Agree/Disagree = N Agree = A Strongly Agree = SA

20. I know how to assess student performance in a classroom. SD D N A SA

21. I can adapt my teaching based upon what students currently understand or do not understand. SD D N A SA

22. I can adapt my teaching style to different learners. SD D N A SA

23. I can assess student learning in multiple ways. SD D N A SA

24. I can use a wide range of teaching approaches in a classroom setting. SD D N A SA

25. I am familiar with common student understandings and misconceptions. SD D N A SA

26. I know how to organize and maintain classroom management. SD D N A SA

Pedagogical Content Knowledge (PCK)

Strongly Disagree = SD Disagree = D Neither Agree/Disagree = N Agree = A Strongly Agree = SA

27. I can select effective teaching approaches to guide student thinking and learning in mathematics. SD D N A SA

28. I can select effective teaching approaches to guide student thinking and learning in literacy. SD D N A SA

29. I can select effective teaching approaches to guide student thinking and learning in science. SD D N A SA

30. I can select effective teaching approaches to guide student thinking and learning in social studies. SD D N A SA

Technological Content Knowledge (PCK)

Strongly Disagree = SD Disagree = D Neither Agree/Disagree = N Agree = A Strongly Agree = SA

31. I know about technologies that I can use for understanding and doing mathematics. SD D N A SA

32. I know about technologies that I can use for understanding and doing literacy. SD D N A SA

33. I know about technologies that I can use for understanding and doing science. SD D N A SA

34. I know about technologies that I can use for understanding and doing social studies. SD D N A SA

Technological Pedagogical Knowledge (TPK)

Strongly Disagree = SD Disagree = D Neither Agree/Disagree = N Agree = A Strongly Agree = SA

35. I can choose technologies that enhance the teaching approaches for a lesson. SD D N A SA

36. I can choose technologies that enhance students' learning for a lesson. SD D N A SA

37. My teacher education program has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom. SD D N A SA

38. I am thinking critically about how to use technology inky classroom. SD D N A SA

39. I can adapt the use of the technologies that I am learning about to different teaching activities. SD D N A SA

Technological Pedagogical Content Knowledge (TPACK)

Strongly Disagree = SD Disagree = D Neither Agree/Disagree = N Agree = A Strongly Agree = SA

40. I can teach lessons that appropriately combine mathematics, technologies, and teaching approaches. SD D N A SA

41. I can teach lessons that appropriately combine literacy, technologies, and teaching approaches. SD D N A SA

42. I can teach lessons that appropriately combine science, technologies, and teaching approaches. SD D N A SA

43. I can teach lessons that appropriately combine social studies, technologies, and teaching approaches. SD D N A SA

44. I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn. SD D N A SA

45. I can use strategies that combine content, technologies, and teaching approaches that I learned about in my coursework in my classroom. SD D N A SA

46. I can provide leadership in helping others to coordinate the use of content, technologies, and teaching approaches at my school and/or district. SD D N A SA

47. I can choose technologies that enhance the content for a lesson. SD D N A SA

RESEARCH

The research team might use the data from this teaching and learning exercise for research. The responses used will be anonymous and data will be pooled. No one will be identified in any publications arising from the research. Your decision to agree/not agree for the research team to use the data will not affect your grades or other aspects of your progress. If you wish to withdraw your response from being used anonymously for research purposes then please email matt.bower@mq.edu.au. All research will be approved by an ethics committee. Please tick the box below if you consent to your responses being used for future research.

- Yes
- No

Appendix 7: Interview Questions

1. What did you design in the final EDUC261 Moodle-based course? What is your favourite part of the lessons you designed? What made you design it in that way?

2. How did you go about designing your module across the five weeks?

3. What do you think were the best parts of your Moodle course? What were the things that you think contributed to the successful elements of your Moodle course?

4. What were the main difficulties that you experienced when completing the Moodle design task?

5. When your group was collaborating, what were the main things that you were focusing upon?

6. EDUC261 focused quite a bit on pedagogy. What do you really think about pedagogical theory? Is it just something that you need to talk about in your justifications or is it really useful? Did you use any pedagogical approaches and strategies in your module, and if so, what were they?

7. At what stage or stages (from Moodle Week 1 to Week 5) in the design process did you focus on pedagogy? Why did you choose that time or those times to focus upon pedagogy?

8. What do you believe are the important factors to consider when creating learning designs

9. What is your view now of how people learn most effectively? How has this changed throughout the semester and if so, what has caused those changes?

10. How has your thinking developed over the semester / what are the main things that you have learnt? What contributed most to your learning? What were the major factors that led to changes that you have experienced over semester? What was helpful? What was not helpful?

11. How would you rate your confidence in **using technology generally? Using technology to design learning tasks? Using Moodle to design learning tasks?** [Out of the 7 scales: Strongly Agree, Agree, Mildly Agree, Neutral, Mildly Disagree, Disagree and Strongly Disagree]

Appendix 8: Ethics Approval of this thesis has been removed as it may contain sensitive/confidential content

Appendix 9: Transcript of One Design Conversation (Group 2-Week 1-Iteration 2)

First few minutes: Self-introduction + Tutor instruction. Each member of the group used a laptop connected to the internet during this in-class discussion.

They were possibly looking at this link while discussing https://syllabus.nesa.nsw.edu.au/stage-2-outcomes/

Jaden: 02:21 Are you keen on English or Maths? What are you keen for?

Layla: I think so, but I also don't mind.

Paige: I am good with all of them.

Jaden: I am okay with anything as well.

Layla: Yeh, I don't know.

Layla: Do we just pick any year group?

Paige: So what have you guys done?

Layla: I always do like Stage 2. This is just as for my assignments, but I also don't mind.

Jaden: I don't mind.

Paige: Yeah, I think Stage 2 yeah. 02:45 I haven't taught Stage 2 yet, so probably it's a time for compiling some resources now.

Jaden: 02:51 Plus for EDUC371, there's the whole phonics stuff and we can probably incorporate some of that to.

Paige: So much Kindergarten to Year 2 stuff in that subject. Okay. So Stage 2 English?

Layla: English is good.

Paige: You can integrate other stuff. It's a lot easier. And it would probably work better with the Moodle format.

Layla: 'Cause you can have that many potential answers and stuff or like the little quizzes. I think English is good.

Paige: Yeah, that's very.

[*The group is probably looking at some website for search for the Stage and outcomes*]

Paige: 03:44 That's the mistake. That's not what I want.

Jaden: Sorry. It's touch screen.

Paige: Okay. English. Stage 2 [*speaking and browsing a website at the same time*]. Outcome ... [*not clear*]. Oh right. Nice.

Jaden: One of the subjects from what I remember.

Paige: It's changed now.

Jaden: Oh my god. It keeps changing.

Paige: It's hard because English has so many outcomes.

Jaden: That's good. They give us flexibility. I'm trying to stay positive. [*Chuckling*]

Paige: 04:29 Well, "using digital techno"

Jaden: "publishing texts using digital [technologies]" Yeah

Layla: Should we do that comprehension?

Paige: Digital literacy? And they could do like critical looking at online advertising.

Layla: Or how different texts are written for different audiences for different purposes.

Paige: But on the internet.

Layla: Yeah.

Paige: Hard to say.

Jaden: Or we have to incorporate our tasks into Moodle, right, which is like...?

Layla: Yeah.

Paige: ... like quizzes, essays, responses.

Layla: Yeah, right.

Jaden: True.

Paige: 05:23 You could do like, I don't know, fake news. The kids would like fake news.

Jaden: Oh yeah! That's a good idea.

Layla: Yeah.

Paige: How to navigate the world with fake news.

Jaden: These are solid ideas you are coming up with.

Layla: [*Chuckling*] The foundation.

Paige: Yeh, at the moment [*laughs*].

Jaden: Do you hear that?

Paige: Well, I came up with a solid idea [*some laughing*]. Umm I am just trying to think if there is a way to incorporate all the communication modes. Is there a bit in Moodle where you can speak and record something? I think there is.

Jaden: I think there is.

Layla: Really?

Paige: Because I think I did it when I did Japanese. There was a thingy. Oh I can't even remember how to get on it. There was a thingy every week we had to do.

Layla: Was that a speaking lesson?

Paige: A Japanese. Yes it was a speaking unit.

Jaden: Oh, that's awesome.

Paige: We had to record ourselves.

Jaden: I remember doing those units I did with [*proper name of a lecturer*]. Is that his name? I think it's probably 388 or something like that. And we had to, well external students, had to record a video and submit it on there or something through iLearn.

Paige: 06:58 Ahh I just can't remember how to get onto the Moodley thingy.

Layla: Oh, I always forget this as well.

Paige: [*Showing her laptop screen to the whole group*] We had this thing in Japanese class called *Shadowing* where we had to listen to a passage and talk at the same time.

Layla: It sounds hard.

Jaden: It sounds ridiculous.

Paige: It was. The tutor was doing this research about how it was really good for language acquisition, but everyone we talked to hated it. We'll decide if this is an idea.

Layla: That would be so confusing.

Jaden: And even in your native language like English, it's really hard.

Paige: It was really difficult. Imagine Japanese every week it got faster.

Layla: That sounds really traumatic.

Paige: And you even didn't know what it meant. I wasn't registering it like "Oh I know what they are talking about." I was like I just need to make the sound the same.

Jaden: 07:58 It's like you are fluent at it but you're not actually comprehending what it is.

Paige: We had to do that on iLearn, which is the point I was talking about. I am just trying to think what it was called. It was a special thingy, but I forget what it's called.

Layla: Theatre?

Paige: A what?

Jaden: I don't think so. It doesn't sound right.

Paige: There was something like sound board or something.

Jaden: Maybe we can ask um…

Paige: 'Cause I am just thinking with English, it's really good to get them to do like a speaking thingy and a writing thingy and a reading thingy. And maybe they could make an info graph or something I don't know.

Layla: All the different modes and stuff.

(*Tutor is clarifying outcome requirements.*)

Paige: 09:14 And how long would the module have to go for?

Jaden: Yeah, that's a good question.

Layla: Two 50 minute lessons each.

Paige: So it's not really a unit.

Layla: Yeah, I wonder if it's meant to be really spread out? Or how much is it meant to cover?

Paige: Yeah, I don't know.

Layla: I guess it's just up to us, maybe.

Paige: We could attach it to a current event or something.

Layla: Yeah, like two lessons a week or like all in one week.

Paige: No, it wouldn't be all in one week.

Layla: No.

Paige: It would be two a week. It sounds funny. It's really techy. It's like the fun lesson.

Layla: The fun easy lesson.

Paige: Yeah, that makes sense.

Jaden: In school do they aim to do one hour of tech a week or is it two hours of tech a week?

Paige: At my last one it was an hour.

Jaden: 'Cause I know like every morning you're meant to do two hours of literacy. For us we can incorporate literacy with…

Paige: Yeah, literacy kinda comes through this from reading.

Jaden: So we can probably just do it in two consecutive sections, not consecutive but two consecutive days or something like that.

Paige: We've got to think of it in the scope of the program. 10:54

Jaden: True.

Paige: So if we could incorporate this with something like geography to interpersonal relationships kind of a way, relationship to place blah blah blah. It's too late for this.
[*laughing]*
Paige: I am just trying to think of ... yeah 'cause they are all integration, integration, integration.
Layla: Should we add another subject?
Paige: Yeah, I think so.
Layla: Geography could be good.
Paige: I think Geography maybe.
Layla: Yeah, Geography. Maths and Science is a bit harder. Doesn't really link in as well.
Jaden: So not English anymore? We'll do Geography?
Layla: Mainly English.
Paige: We'll do English as a focus but integrate it with other subjects.
Layla: 'Cause then we can have actual interesting topics and put current stuff or something.
Paige: So English is like skills.
Layla: Yeah.
Jaden: 11:48 Yeh, so like the literacy pieces we can use can be like geography-based ish.
Paige: Yeah if we are talking about fake news, I don't know, I think that would be a fun topic to do. I am trying to make it as fun as possible.
Jaden: It's good. It's teaching them life skills.
Paige: Yeah, life skills about critically evaluating.
Layla: We can put some BTN in there.
Paige: Yeah, I love BTN
Layla: I love BTN.
Paige: When I was in primary school and we watched BTN. We had to do PMI (Plus Minus Interesting). They could do something like that but on the internet as a blog post or forum thingy.
Layla: Using technology.
Layla: I think blog...
Jaden: You know I'm surprised BTN is a good thing.
Layla: Yeh and they love it.

Paige: It's awesome.

Layla: They're obsessed.

Jaden: My prac teacher two years ago played it every week, I think. Or like in free time she was like "Ah BTN".

Paige: "Let's watch BTN; it's educational." [*Jaden laughing]*. I wish we had BTN in our free time. Our free time was Kid Picks.

Layla: 13:03 What is Kid's Picks?

Paige: It is a really janky program on the computer with when we had floppy disks. They all tried to save our art things on their floppy disks.

Layla: I remember in Year 1 we'd go into this computer room and get to go on the magic school bus. That was a kind of game or something and it was the most amazing thing. Or even Kindy when everyone was like 'Oh my goodness!'

Paige: [*Possibly looking at the link above, opening the Geography outcomes*] I hate how this is formatted though.

Jaden: It used to be so much better.

Paige: All at the one time. And then hold on. Look at these, guys, "...people, places, ..."

Layla: The interactions.

Paige: "...management of places and environments". And yeah "communicates geographical information using..."

Jaden: "using geographical tools and inquiry"

Paige: That would be good. They can do things like surveys. And that would tie maths in too.

Layla: Yeh.

Jaden: Maps and scales.

Paige: Scales, data collector.

Jaden: 14:11 They can throw maps onto the thing.

Layla: Data collection is always good. Interpreting the data.

14:20 [*Tutor is directing everyone to the Learning Design Guide and what to do with it in the whole design process.*]

Paige: 19:43 I think we can get them on this thingy.

Layla: Okie.

Paige: Stage 2. 26 pages. How many outcomes? If it is Geography and English, how many outcomes are going to be the limit?

Layla: Did he say how many people usually do or no? What's normal?

Paige: I don't know. Do you think like it's three weeks?

Jaden: Because a lot of the outcomes overlap anyway in little ways, you can link them together easily. You can just do one outcome. And I'm like... I don't know.

Jaden: Uh dammit.

Layla: This one would be good.

Paige: Definitely touch on this one for sure.

Layla: And this is the one we were going to do.

Paige: I think this one.

Layla: So we can literally do two, maybe three.

Paige: We have one or two that are like the focus ones. The other ones are like incidentally attached on in terms of the modes and things like that.

Layla: So we can do those two and add others if we feel the need.

Paige: 21:22 If we find anything.

Jaden: And you know for the ah...

Layla: One or two? Two.

Paige: How's that guy? Sorta, maybe? I think that other one that we were looking. But if we change our minds, we can change our minds [*singing*]. So this guy.

Layla: Yeh [*yawns*].

Paige: So do you want to get the document? And then you can scribe that.

Layla: Is the Moodle page like a Google Docs thingy? Like if someone edits it, then we can all tell they've edited it?

Paige: Yeah, I think so. We all have access to it, and we can all edit it.

Layla: Yep, okay.

Paige: 22:20 But I mean we sure probably have a communication about who is doing what using Facebook.

Jaden: Okay.

Layla: Okay.

22:32 [*Tutor is warning the students not to copy EDUC261 format.*]

Jaden: 24:04 What approaches should we use/ focus on? Constructivism?

Paige: I think it's hard because it would have bits that are Constructivist. But then there are a lot of opportunities for social stuff.

Jaden: Could be a lot of different things.

Layla: I think we should try and add social stuff.

Paige: And then we could even do something Connectivist. Because if you do Connectivism by like talking to some journals or something and I don't know, connect to the wider world.

Jaden: I think we should decide. Well we can touch on that or talk about the perspectives or whatever after we actually make our thing.

Paige: Yeah, once we start getting into it. But let's say Social Constructivism because I feel like that encompasses Constructivism.

Layla: Yeah, Social is good.

Jaden: 25:04 Yep. And definitely not Behaviourism.

[Three were saying the three below at the same time.]

Jaden: Or we could. It could be squeezed. There should be like the main thing.

Layla: ... And that would be right. Behaviourism.

Paige: Well I mean...

Layla: 25:17 Make sure it's mainly not. We can have bits of it.

Paige: Like if there is a point system. I know the kiddos love points.

Jaden: So this will be our overarching.

Paige: Yeah, I think a balanced approach would be fine, but I think the main one should be Social Constructivism [*singing*].

Jaden: And maybe a bit of Connectivism. Constructivism.

Paige: I think if we can get a bit of Connectivism in there, we'll look really good.

Layla: So good.

Paige: Just a little bit. [*Laughing]*

25:49 [*Some silence when waiting for the tutor to approach*]

Jaden: 26:04 [*was taking note on the Learning Design Guide*] "... maybe littered throughout the Moodle."

Paige: We will sort that out later. We'll look at the geography thingy as well. [*mumbling and typing on the Learning Design Guide*] Geography. Stage 2.

Jaden: "What sort of content...?"

Jaden: What aspects of the geography are we going to touch on though? Here it says, "What sort of content is being addressed and what sort of skills are being developed?" What was this? One of the dot points we were talking about earlier mentioned some geographical...geography skills.

Layla: The second one might be good. Not that one though. Yeah, yeah. [*Layla and Paige looking for the point together*]

Paige: They are the same outcomes. They are just different sorts of content

Jaden: Different topics.

Jaden: 27:09 What does it say here? Can you scroll up a little bit? "Using geographical tools for acquiring..." [*typing up the information*]. What's the code for it? G...

Paige: We can do a very peoply kind of based. We can do things like people's perceptions of places. And other bases like...

Layla: And we can do issues to like protecting different places or plants.

Paige: Yeah, sustainability type of things, heritage sites.

Layla: I think I did an assignment on that one.

Paige: This is good because my 455 one is more science than geography is. So this is good. I am doing more geography too. Rounded out.

Jaden: 28:05 So I typed here "using geographical tools for enquiry, such as scales, maps, diagrams" and what else?

Paige: Surveys.

Jaden: Surveys, that's it. [*continuing typing*]

Paige: 'Cause you could go out. You could make a survey using something like SurveyMonkey, give it to the public, your parents, your friends, your sports coach, asking for some opinions about "What's a cool place in our school zone that we could heritage site?"

Layla: What's your favourite in the community?

Paige: And then they can make little...

Jaden: What is the context? What are the best ways to promote student motivation and engagement within that context?

Paige: He said our context was like mixed abilities, mixed socio-economic statuses.

Layla: Wait, what was the question?

Jaden: Mixed ability, mixed social… [*typing*]

Paige: What's our context? Do we have .... [*not clear]*

Jaden: 29:12 So we need to "Differentiated learning is required to cater to different needs."

Paige: So yeh, from people with learning difficulties and disabilities, EALD students and gifted students.

Jaden: Okay, so mixed abilities.

Paige: All of them.

Jaden: Students with learning difficulties and students who excel academically as well who are working beyond students? [*taking more notes*]

Paige: That lesson thing where you can sort of differentiate what pages they go up to. That would be a really good thing to do.

Jaden: Working toward EALD? LT?

Paige: EALD.

Paige: 30:26 And how are we going to make them pumped up? Because we are engaging with the community and real issues.

Jaden: Is that the context bit?

Paige: Yeh.

Jaden: "Differentiated learning..." "Engagement with the community. School and community work together to ensure student needs are met."

Paige: They can be like ACTivists. The kids are activists.

Jaden: The kids are acti.. What?

Layla: Activists.

Paige: Activists 'cause he said they should be explorers or designers or something. Ours are going to be activists.

Jaden: So that goes in the Pedagogy or the Context?

Layla: I think it's like the scope of learning.

Paige: In the context 'cause that's how he said you get the kiddos engaged.

Jaden: So the students are activists.

Paige: The students are activists.

Jaden: But what that makes it sounds like they are fighting for human rights or something like that.

Paige: They are fighting for the right of the land.

Layla: They are fighting for the heritage listing

Paige: They going to try and get places.

Layla: ... of their community.

Jaden: Students are activists.

Paige: It's gonna be awesome. Stay tuned. It will probably completely change in a couple of weeks.

Jaden: 31:44 Oh we are getting through this pretty fast.

Paige: We haven't fought yet [*laughing*] I think.

Jaden: I'll just save this then um. Should we make this into like a Google Document so we all can edit it?

Layla: Could do Facebook and Google Docs?

Jaden: I don't know how to do it. I don't know how to set it up.

Paige: Yeh, I did this in my first year.

Jaden: Yeah, it's been a while. Do you know how to do it?

Layla: I also don't know how to do it. I might, but I'd have to.

Paige: Facebook and Google Docs. Why isn't there a Facebook Docs?

Layla: I know. We could make like a Facebook page.

Paige: Now they've included like reacting to people's messages on chats, but I don't understand why.

Layla: Ah, that makes me stressed. All the little faces next to the messages.

Jaden: Yeh, good.

Layla: Yeh.

Paige: Yeh.

Jaden: I'll just show you.

Layla: No, we're talking about Facebook and figuring out how to communicate with each other.

[*Tutor approaching and asking how the group was doing. He also showed the group how to communicate with each other on Moodle. Then he turned to show the whole class.*]

Paige: 33:21 Attention. Newsflash. I edited something.

Layla: Something's been added. You get like 10 emails or something.

Jaden: 35:33 Let's catch up on what we've done so far.

Layla: Okie.

Paige: Awesome!

Layla: Yay, do we take these off?

Paige: I am not sure, but we are all good.

35:52 *Recording ends.*

Appendix 10: Transcripts of One Interview (Marley – Group 1 – Iteration 3)

5306 words

Interviewer: Good morning Marley. Thank you for coming. This is the first question. What did you design in your final Moodle-based course and what is your favourite part of the lessons that you designed?

Marley: 00:21 So the favourite thing that we designed was looking at social economic status of different countries so that the students could compare and contrast their country to another country and they used that knowledge to then explore world heritage sites and then design and pick a country or a location that they thought should become a world heritage site and so they would look at things that were involved in economics and social status and see how that could relate to world heritage sites and what's the importance of them and things like that. I think my favourite part was actually in my lesson so Lesson 3. I think it was Lesson 3 where students had to create a Facebook profile for a country.

Interviewer: Oh! Nice.

Marley: So it would kind of give a snapshot to what a country looked like so they would include the population, the location. The GP is their education levels there. They'd also be able to include a picture of a map of where it's located. So those kinds of things I thought it was really fun.

Interviewer: Yeh it sounds really fun. So that is your favourite part of the lesson that you designed. So what made you design it in that way?

Marley: Um.. I chose to do a Facebook profile because I thought it was very relatable for Stage 3 students even though technically individuals aren't meant to be on Facebook until 13. The chances are they're going to exposed to it from their parents and their siblings. Social media is a very large part of a society these days like it's how we connect. So I think that by incorporating something that is relevant to them, it gives them high motivation and it's actively engaging with them as they're going to be interested in it. They want to make a fake profile for Facebook those kinds of things. I thought it would be a great way to, a different way to teach them information that's good for them to know.

Interviewer: That's interesting. So how did you guys go about designing your module across 5 or 6 weeks? Think about like first week, second week, blah blah blah and what you focused on each week while you guys were collaborating and stuff?

Marley: So for the first two ish kind of weeks we were mainly drilling down on what outcomes we wanted to meet, what content we wanted to cover, and how they were going to link with each other. We kind of drafted up a few ideas of what could be included in the Moodle module. We also explored what could be used in a Moodle module. Um, we discussed different resources that we knew could be included in the Moodle module. So the first 2 weeks were mainly just building a foundation of our understanding of the assignment and making sure we had a clear goal of what we wanted to meet. In the following weeks we began to actually set out our lessons and no lesson was created individually. The core idea of each lesson was built as a group so that we knew there would be flow and consistency throughout our Moodle module. And then from there we designated lesson to each person, and we would work on it from there. We would bring it back the next week and we would reflect on what we had built, whether or not we felt like it was in tune with what we were going for, and if there was something that we needed to add or those kinds of things. And then the final week was just final touch ups, making sure all the links worked, making sure that we had done appropriate copy right. Then making sure that there weren't really any spelling mistakes or grammatical errors and things like that.

Interviewer: 04:35 Yeh that sounds interesting. So, while you are designing, what do you believe are the important factors to consider when creating learning designs?

Marley: Um I think it's really important to make sure that the content you are putting into online modules doesn't actually waver from the curriculum because it is very easy to get lost in what you are doing. It is really fun making online modules for students so I think it's very important that we use each other as an anchor to come back to what the content originally was so there were times where we'd come up with an idea and we'd be like that'd be great but how is it linking. We'd always make sure the curriculum went back into the content that we were meaning to teach the students. So I think it's really important that you create fun and engaging activities but making sure that they are actually aligned to the curriculum.

Interviewer: So did you have this belief before you actually entered 261?

Marley: Um, I believe I did a little bit but I think this kind of more solidified my understanding of that, the importance of that and showing how easy it is to actually waver from the content that you were initially aiming to teach.

Interviewer: And how has this belief changed as a result of this module?

Marley: I think it's strengthened. I can definitely see different areas where I didn't fully understand that concept before coming into 261 but 261 has shown me that you definitely need to keep coming back and questioning the curriculum and making sure that the activity that you are doing is linking in with it.

Interviewer: So what caused the changes to your belief if you haven't answered this?

Marley: I think it's the process of designing the module. That whole process, knowing that there are certain outcomes in that assignment that we need to meet, and knowing that one of those outcomes is making sure that it aligns with the curriculum and making sure that your learning intentions meet up. So I think that the whole designing of the actual module is what reassured that and showed me the importance of aligning the tasks.

Interviewer: 07:09 Ok yeh, so EDUC261 focused quite a bit on pedagogy as well. What do you think about pedagogy and pedagogical strategies?

Marley: For me I find that there is no one pedagogical strategy that I use. I know that I really enjoy implementing Constructivism, Social Constructivism, those kind of areas of pedagogy. I find that students engage better with those types of learning. So for my module I had a mixture of Social Constructivism and Constructivism in the tasks.

Interviewer: Ok so is pedagogy just something that you need to talk about in your justification or is it really useful in your opinion?

Marley: I think it's useful for teaching but also at the same time it depends on the students. I believe that students respond differently to different pedagogies. And so I think that you need to make sure that you're catering for your students and so I think pedagogy gives you a way to take a step back, look at what your students are doing, see how they are responding, take their responses, and apply them to the pedagogies that you use in the classroom to strengthen their understanding.

Interviewer: Were there any pedagogical approaches and strategies you used in your modules and what were they?

Marley: So um, Social Constructivism for the Facebook profiles because they were required to use internet resources to construct their understanding of countries. In my final task which was a form of jigsaw learning, they each went back and did something different. Then they brought it back together and they each used their individual understanding to build a whole concept behind their choice for a world heritage site. That's kind of where the two main pedagogies were formed in my assignment.

Interviewer: Yeh so when you chose these pedagogies, did you also think about your learners or content or technologies?

Marley: Um, I think I more, I think the pedagogy more came naturally to me like I um like whilst I was thinking about it for me it more just happened that way and came out that way. But I do believe that when you have access to such a wide resource and there are so many things you can do, Constructivism and Social constructivism are very common when you use technology.

Interviewer: Can you clarify a little bit? When you have access to such a wide variety of resources and then you mention pedagogy so what do you mean resources like technologies?

Marley: 10:35 Yes. So Internet has got an abundance of resources on there and I used just a couple a very minuscule amount in my assignment but I gave them multiple websites that they could use to find particular information. So yeh they had to use multiple resources such as the internet to find their understanding about particular countries, profile shows that Social Constructivism is linking the information that they read on the Internet and applying it to their understanding of their economic profile. So there were 2 different resources. You've got the Fakebook profile which is an online application and then you've got the website such as World Fact Book or I think there was a Central Intelligence page as well.

Interviewer: So did they share information with their peers?

Marley: So pretty certain they did as a group. Yes, they built the Facebook profile as a group so each student was given a worksheet and within their groups they each had to find different bits of information. Because it is quite hard to find certain bits of information on websites, so it was also building their ability to research on websites. One student would be tasked to find population. One student would be tasked on finding location and those sorts of things. And then they put that information back on a shared Google Docs. And then they then go 'This is all the information that we have. Let's take that information and apply it to our Facebook profile'.

Interviewer: 12:36 That's nice and what stage or stages from Moodle week 1 to week 6 in the design process did you and your group focus on discussing pedagogy?

Marley: Um, I don't know if we exclusively discussed pedagogy by itself but we did discuss pedagogy as a group like 'Oh ok this task is bringing in this pedagogy here and this task is bringing in another pedagogy here.' and then we did try to make sure that pedagogy was kind of not uniform but there were bits of each pedagogy throughout. Not each individual one sorry, so there would be bits of Constructivism in each little lesson or a little bit of Social Constructivism here or there, just so that the tasks weren't completely different. They did have some sort of core idea that would bring them back together.

Interviewer: Oh ok. And could you somehow explain why you guys chose that week or that stage to focus on discussing pedagogy?

Marley: So it would have been at the beginning when we were drafting our ideas when we would have spoken about it. I think it's because pedagogy is part of the foundations of how you teach and what you teach so I think that would've impacted what we'd have chosen to put into our Moodle module. So thinking back if we did speak about pedagogy, that's when we would've spoken about it. I can't remember exactly but when we spoke about it, it would've been there and then possibly at the end when we're tweaking things, we're like 'Ok. Let's bring that back to this sort of pedagogy or that kind of thing.'

Interviewer: Ok, yeh and what do you think were the best parts of your Moodle course?

Marley: Umm, well I really enjoyed working collaboratively with other student teachers because it gives you another perspective and it gives you like 'You've got a massive'. We each had different and incredible ideas, so it just exposes you to other ways of thinking. I also really enjoyed just in general the tutorials that we engaged with the tutor were incredible. Rather than just being like 'Ok so this is my stuff. This is what it looked like, we actually went in and explored it ourselves and had first-hand experience with the applications which I think is really important. As a teacher if somebody goes 'Oh this application is great!', you're not really going to divulge into it unless someone actually shows you and engages you with the application. So I think that was really good the fact that we actually got to engage with the resources that we were learning about.

Interviewer: Yeh, so what do you think were the things that contributed to the successful elements of your Moodle course or your designing process in general?

Marley: Um, we did discuss with the tutor certain ideas to see if we were on the right track, so having that support there was really beneficial because he had such a wide bank of knowledge that by asking him like we were able to clarify our understanding better.

Interviewer: 16:28 Yeh so from what you have told me I could see that you have the peer support. You had tutor support and it seems also you had different resources and technologies as kind of support as well or in other words your technological abilities seem improved.

Marley: Definitely.

Interviewer: And can you think of other factors in the units that could have supported your design process as well beside these 3 factors?

Marley: Um, I think that having the example modules really helped us cos it was kind of hard to visualise what our end product would look like until we actually got a chance to see other Moodle modules and it kind of flicked a switch in us like ‘Oh ok so this is the kind of thing that we should be like aiming towards’. It should be like how it's set out and taking little bits of inspiration from each of the other Moodles. That was really beneficial.

Interviewer: Yeh.

Marley: And I also think it would've been beneficial for me as an individual to have taken better notes at the end of each week of what I was thinking about like the time for implementing certain features of my Moodle modules. When it came to writing my justification, I found it a bit difficult to recall why I had selected certain things and I'd go back through my lecture notes and I'd go ‘Ok well, yes, that links here. Yes, that links there. And I'd bring that into my justification.

Interviewer: Yeh, so I think you guys also worked like a lot based on the document called like Learning Design Guide.

Marley: I think so.

Interviewer: Yeh so you guys answered pre-designed questions there along the process.

Marley: Yeh I think so.

Interviewer: 18:49 Yeh.

Marley: Thinking back I recall thinking as though the Moodle the actual module, the online section. I think it would've been nicer if it was worth a bit more than the justification because I feel like with the Moodle module showing what we're capable of doing, we're showing how it links in. And I think that's really beneficial. I found that in my justification I found it difficult to express what I was doing and why I was doing it in words. So I felt as though my justification didn't fully reflect what I had done in my Moodle module.

Interviewer: Yeh? Was the learning design guide helpful at all during the whole process?

Marley: So, if I can remember what it looks like.

Interviewer: It's a document that gave you different questions so you guys answered about the outcome, context, pedagogy, content.

Marley: Yeh it was a good scaffold for us to use and I think we used to more for designing our Moodle module. Personally, I used it more when actually designing my Moodle module and I think I just must have scribbled on paper because I didn't have any notes on my computer with it. So I think it might have been nice, better for me, to have made notes on my computer and at the end of each tutorial being like ok this is why I have chosen this section for my Moodle module and this is why I've chosen this kind of thing.

Interviewer: Ok that's nice so you have just said that the Learning Design Guide might have been more beneficial for designing your Moodle modules, right? So you can you elaborate more on that?

Marley: I think it just gave us a bit more of direction of checking with our module and making sure it's feeding our content and outcomes and things like that. I think that it gave us a bit more direction with designing our Moodle module if that makes sense.

Interviewer: Yes. I just mentioned context in the learning design process, so how important do you think context in is designing an online course?

Marley: 21:22 I think context was actually deeply embedded particularly for my lessons because they do a country profile for their country. So whichever country they're in, they could relate it to. I think I said in my justification that the idea was that if you had students from different countries in your classroom if they're comfortable with it we explore their countries, their home countries so if I had a classroom and in my classroom I had students from the United States, students from Japan, students from Europe, we'd back those individual countries as well and bring them together so we could compare their home country to the country that they're in now. I think that was linked into my lessons. It was Carlingford West that was the primary school that we they had a significant percentage of students that were English as a second language. So we had applications put onto our websites to help support that. We made sure that students knew that they could access translation tools if they needed to and that there was always a teacher to help them further if they needed to. I think that impacted how we designed our lessons. Like I said, using the countries where they're from, making it more relevant to them so that they engage better.

Interviewer: 23:25 Yeh that's nice. So back to the question about the supporting factors. What else do you think helped you during the Moodle task?

Marley: I found that often the content that we covered in the lectures was then further covered in tutorials which I thought was fantastic. It gave us a better understanding, rather than just giving you a little bit of a snippet in the lectures. By having that with our tutor, he then expanded on it and made sure that he gave us opportunities to ask questions. We didn't feel overwhelmed. We didn't feel as though we couldn't ask questions. It was a very comfortable environment and the teacher gave us the opportunity to ask questions both in tutorials and lectures. I think it was really beneficial as well having that online element of the lectures. A couple of times I couldn't physically get into uni on time to make the lecture and so I was able to pretty much tune in with everyone else online at the same time which I thought was very beneficial. And the readings were good as well. The book that the convenor used as the required reading was great. I actually used that book in other assignments for different units as well because it has such valid information in it that was applicable to more than just one area. So for me that was very beneficial.

Interviewer: 25:17 Was it too much? Is the reading too much in your opinion?

Marley: Um, it is a lot of content. I don't know if it's necessarily a lot. It did take a lot of time and as a student who studies full time and pretty much works full time, it was hard. At times I did fall behind and at times I'd just be skimming through reading because I didn't have time to read them in depth. But the content's all there and the content is great. For people of different circumstances, it might be fine, but for me I found it was quite a lot. But the information was all really valid, so it's kind of hard to say it was too much when all the information was important to read.

Interviewer: So what were the main difficulties that you experienced when completing your Moodle design task?

Marley: Um, my Moodle group we didn't get to meet outside tutorials as much as we wanted to because of distance factors and work factors and other commitments and stuff like that. But we did get ample amount of time during our tutorials.

Interviewer: Ok so time constraint was the main challenge?

Marley: We got plenty of time, but it was more the difficulty of meeting up with your group members and... because our timetables often wouldn't fit with each other.

Interviewer: 27:04 I see.

Marley: So which is where the constraint comes in.

Interviewer: Yeh so what do you believe are the important factors to consider when creating learning designs?

Marley: Um I think it's important to consider your outcomes, your content... And your students. I think making sure that it's relevant for your students I think is important.

Interviewer: Did you have this belief before you started in EDUC261? And how might your beliefs have changed as a result of designing your modules?

Marley: I think that my belief has changed in the sense that technology isn't as much of a nuisance in the classroom as it's first depicted to be. I think it can be extremely beneficial. You just need to know how to incorporate it properly that it's not going to become a distraction, that it's not going to become a hassle to use in the classroom and making sure that the technology that you do incorporate in your lessons is age appropriate, is student appropriate, that kind of thing. So that's how my understanding has changed. Like before coming into this, I didn't use as much technology in my lessons but since then, going on placements, starting 261 I've definitely increased my use of technology in the classroom and how I perceive it as an asset rather than a nuisance.

Interviewer: So what caused the changes then to your belief in your opinion?

Marley: I think it was the lectures and the tutorials. The fact that it was such an open discussion on where we find our benefits, where we think there's negativity and discussing them and talking about them and being like 'Hey if we think that this is a problem? How can we counteract that?' and taking the ideas from not just the tutor but all the other students and using each other to bounce off each other and come up with ideas of how we can deter certain factors that can disrupt the class really I think is beneficial for us to use.

Interviewer: 29:34 Can you elaborate a little bit on the student? Like you also mentioned that one of the important factors to consider is students?

Marley: I think not only student ability, but student interests as well. If we have a class where they know that their community is changing, their school is going to have something in particular built or there is a particular event going on nearby, and if you can incorporate that into your lessons and using that to support your technology, I think that's really beneficial. For example, if they were getting a new playground, they could use, I'm don't know what kind of app but some sort of app to...

Interviewer: Yeh.

Marley: ...show what sort of thing they'd like their equipment to look like. And then they could take that and use that in mathematics to show 'Well, this is one square. This equipment is going to take up this amount of space that kind of thing'. So student interest and student community to can be the basis of what you're teaching and how you're teaching it. And in terms of student ability, you're not going to make them write an entire essay on the Word document if they haven't used Word often or if they can't touch type yet. You'd have to obviously build that skill up first before you could actually implement that kind of task. So making sure that the task that your setting is meeting the technological abilities of your students and making sure that you have differentiated tasks so if there are students who aren't as technologically advanced there is an option for them to complete the same content, but in a way that is accessible for them.

Interviewer: 31:25 That is very nice elaboration. Can you also elaborate a little bit on the important factors that you mention like outcome? Why do you think it's an important factor to consider?

Marley: I think if you're just going to be putting on videos and stuff like that randomly, it might be teaching students things, but it might not be relevant to their stage. You're not going to put on a video about long division for a kindergarten class or a Grade 1 class or a Grade 2 class. You're going to be finding videos that are engaging for them at a level that they can understand that meets the content and the outcomes that they are researching and are learning about. So just making sure that you're not going off on a tangent and things like that.

Interviewer: Oh yeh, what is your view now on how people, on how your potential learner learn effectively?

Marley: Sorry can you expand on that?

Interviewer: Yeh what is your view now about your potential learner learns most effectively and how has it changed throughout the semester?

Marley: So do you mean my potential as a teacher to integrate?

Interviewer: Yeh like as a small case you know?

Marley: Oh yeh, sorry. Yeh it's...

Interviewer: You can combine with number 9 as well. How has your thinking developed over the semester?

Marley: I think, it's kind of in sync with my developed understanding of incorporating technology. That for some students, technology is a really great resource for them and provides a more engaging way of learning. But then you will also have students who don't necessarily take as well to technology as others. I think it is that idea that you need to make sure your lessons underpin on your students so that they can learn most effectively. I think I've always known the idea that you should cater your lessons to students' abilities and the way that they learn and that kind of thing, but it's just kind of emphasised it more with technology that you can use it as a tool to help students. For example, if you have a student with a visual impairment, one way you can do it in the classroom without having technology is you can move where they sit. But another way that you can do it so they can sit anywhere in the classroom is you can use an iPad as a magnifying glass, as a camera and you could be screening the whiteboard onto the iPad so that they can be looking at what's in front of them and not have to worry about where they're sitting in the classroom. They've got the content right there and the teacher right there. They can here and they can see more effectively.

Interviewer: Yeh ok.

Marley: So I think my thinking has developed over the semester to incorporate better technology. I've definitely learnt the skills and I've changed in a way in my mindset of incorporating technology in the classroom. That has definitely developed and strengthened to be a more positive outcome for implementing technology for the main things that I have learnt. I think it's accessing different resources and how to implement technology in the classroom in a way that it's not going to become a distraction, but it's going to be an asset to my teaching.

Interviewer: What were the major factors that have led to changes that you have experienced?

Marley: The major factors that have led to changes that I have experienced I think are the lectures and the interactions and the tutorials with the lecturer/tutor.

Interviewer: 35:42 How about the reading as you mentioned above?

Marley: And the readings, but I think more the lectures and the tutorials because for me, reading and learning from what I've read is a little more difficult than engaging with the lesson. Reading for me isn't as engaging as a lecture or a tutorial where I can interact with the information, I can interact with the tutor and discuss where my understand may not be fully there yet. Or if I've got a question here or there, I can ask the tutor and straight away I can get a response. If I'm not fully understanding what he's saying, I can say 'Well I'm not quite sure. Is my understanding meeting it or not?' Whereas with the readings, while they do show valid information, if I had a certain question about it I'd have to wait until the tutorial or the lecture to talk to the tutor about it.

Interviewer: I see.

Marley: It's harder to decode than it is in the lecture or tutorial.

Interviewer: I know what you mean. Yes, even if you make conversation silently with the author, it doesn't help much.

Marley: Exactly, exactly.

Interviewer: So by now how would you rate your confidence in using technology generally? Using technology to design learning tasks? And using Moodle to design learning tasks? Out of the 7 scales here.

Marley: Umm, I would say using technology in general I would say Strong. I strongly agree that my confidence has improved significantly. I'm a lot more confident with it. Using technology to design learning tasks? Again, Strongly Agree. Using Moodle to design a learning task? I'd say Agree to Mildly Agree because I'm still like there wasn't things where I was like there are certain features that I was still struggling to use whereas I was designing my areas of the Moodle module. But that was only going to improve with practice and using the Moodle site a lot more. So it's nothing to do with what we've done on tutorials. It's just a matter of using it more often and getting more used to it and more comfortable with it and exploring it some more.

Interviewer: Ok, yeh so last question. Would you consider yourself a learning designer now?

Marley: I think so.

Interviewer: Yeh. That's good. Why?

Marley: I am confident with designing lessons. I think I'm just that little bit more confident now in using technology when I design so I definitely, I think everybody is a learning designer? But I think that I've definitely improved my skills. I think everybody has the basics to become a learning designer but through this course I've definitely improved those skills and I've definitely seen myself improve with how I'm designing lessons and how I'm incorporating certain things. Not just with technology but also without technology and things like that. Oh, that's interesting. Thank you very much. Now I can...

39:16 *Recording ends.*

Appendix 11: Inter-Coder Reliability Results – Iteration 2

Iteration 2 Node	Kappa	Kappa x weighting	Agreement (%)	A and B (%)	Not A and Not B (%)	Disagreement (%)	A and Not B (%)	B and Not A (%)	% Agree	Weighting (by person A codings)	% Agree x weighting
CK	0.8196	21.4161	92.54	25.26	67.28	7.46	0.87	6.59	0.772005	26.13	20.17249
Context	1.0000	0.0000	100	0	100	0	0	0		0.00	0
DK	0.8763	7.8516	98.09	7.46	90.63	1.91	1.5	0.41	0.796158	8.96	7.133575
PCK	0.5117	0.6806	98.3	0.92	97.39	1.7	0.41	1.28	0.351145	1.33	0.467023
PK	0.8356	3.1920	98.95	2.77	96.18	1.05	1.05	0	0.725131	3.82	2.77
TCK	0.6555	3.7429	95.16	5.14	90.03	4.84	0.57	4.26	0.51503	5.71	2.940822
TK	1.0000	0.0000	100	0	100	0	0	0		0.00	0
TPACK	0.8434	14.1944	96	12.98	83.02	4	3.85	0.15	0.764429	16.83	12.86534
TPK	1.0000	0.0000	100	0	100	0	0	0		0.00	0
	0.81828							Sum		62.7800	
Average	**0.8380**							Average	**0.653983**		
Weighted average	**0.8135979**							Weighted average	**0.73828**		

Appendix 12: Inter-Coder Reliability Results – Iteration 3

Iteration 3 Node	**Kappa**	**Kappa x weighting**	**Agreement (%)**	**A and B (%)**	**Not A and Not B (%)**	**Disagreement (%)**	**A and Not B (%)**	**B and Not A (%)**	**% Agree**	**Weighting (by person A codings)**	**% Agree x weighting**
CK	0.8953	8.048747	98.39	7.59	90.79	1.61	1.4	0.21	0.825	8.9900	7.41675
Context	0.6007	1.249456	98.78	0.94	97.84	1.22	1.14	0.08	0.435185	2.0800	0.905185
DK	0.8711	22.247894	94.96	24.08	70.89	5.04	1.46	3.57	0.826923	25.5400	21.11962
PCK	0.8951	5.200531	98.95	4.76	94.18	1.05	1.05	0	0.819277	5.8100	4.76
PK	0.9892	2.02786	99.96	2.02	97.94	0.04	0.03	0.02	0.980583	2.0500	2.010194
TCK	0.8394	2.879142	99.05	2.56	96.49	0.95	0.87	0.07	0.729345	3.4300	2.501652
TK	0.7711	7.101831	96.41	6.77	89.64	3.59	2.44	1.14	0.653475	9.2100	6.018504
TPACK	0.8135	3.034355	98.42	3.65	94.77	1.58	0.08	1.51	0.697897	3.7300	2.603155
TPK	0.9847	1.102864	99.97	1.1	98.86	0.03	0.02	0.01	0.973451	1.1200	1.090265
	0.8820							Sum		61.9600	
Average	**0.8511222**							Average	**0.771237**		
Weighted average	**0.8536585**							Weighted average	**0.781558**		

Appendix 13: Moodle Assessment Rubric

EDUC261 TASK 2 – MOODLE MODULE ASSESSMENT RUBRIC

MACQUARIE University SYDNEY·AUSTRALIA

	Not Evident	Developing	Competent	Advanced	Excellent
Pedagogy *Infuses pedagogical reasoning throughout the learning design*	Not evident	There is some evidence of pedagogical reasoning in the module and justification, but at times it is superficial, incomplete or inappropriate	There is evidence of appropriate pedagogical reasoning in the module and justification	There is substantial and convincing evidence of effective pedagogical reasoning in the module and justification	There is sustained and integrative pedagogical reasoning throughout the module and justification that displays critical insight and creativity
Technology *Uses technology appropriately and creatively to support learning*	Not evident	Some tools have been used in order to support learning, but they are limited in terms of their variety and appropriateness	The module and justification clearly evidence the appropriate use of a variety of tools to support learning	The module and justification clearly evidence the use of a wide variety of tools to support effective learning	The module and justification clearly evidence the insightful and creative use of a wide variety of tools to support effective learning
Content *Represents content in a way that supports learning*	Not evident	Efforts have been made to represent the content of the module, but the content is inaccurate, incomplete, or ineffectively represented in several places	The module and justification make it clear that content has been accurately and appropriately represented to support learning	The module and justification make it clear that content has been accurately and appropriately represented to support effective learning	The module and justification make it clear that content has been accurately, creatively and insightfully represented to support deep learning
Contextualisation *Designs the module in a way that caters to the selected audience and institutional context*	Not evident	The content and activities are generic or inappropriate for the selected audience and institutional context	The learning design is appropriate for the selected audience and institutional context	The module is clearly designed in a way that would be engaging for the selected audience in the institutional context	The module is creatively and insightfully designed in way that would clearly be engaging and meaningful for the selected audience within the institutional context
Alignment *Aligns learning outcomes, tasks, and assessments*	Not evident	There are several places where the tasks, assessment and outcomes are not aligned	There is alignment between tasks, assessment and outcomes	There is clear and close alignment between tasks, assessment and outcomes	The tasks and assessments have clearly been designed in a way that enables students to effectively achieve the outcomes and educators to accurately assess that those outcomes have been achieved
Scholarship *Integrates educational research to substantiate the module design*	Not evident	The justification only superficially references scholarly literature	Scholarly literature is appropriately used to justify the design of the module	A wide range of scholarly literature is appropriately and effectively used to justify the design of the module	A wide range of carefully selected and highly relevant scholarly literature has been integrated to insightfully and convincingly justify the module design
Argumentation *Clearly argues the virtue of the module design*	Not evident	The justification is superficial or unclear, with some erroneous arguments or only a few valid points	The justification provides a clear and appropriate rationale for the design of the module	The justification provides a clearly communicated rationale for the design of the module, in a way that demonstrates a degree of critical insight	The justification articulately and convincingly communicates the rationale for the module design, in a way that demonstrates sustained critical insight
Referencing *Uses APA referencing procedures*	Not evident	The referencing is erroneous in a way that renders it inadequate for academic purposes	There is evidence of accurate referencing with few errors	There is sustained evidence of accurate referencing with few errors	There is sustained evidence of entirely accurate referencing
Copyright *Adheres to copyright and acknowledges sources*	Not evident	There a numerous cases where the work of others is inappropriately used or not appropriately acknowledged	The work of others has been appropriately used and acknowledged with only a few minor omissions	The work of others has been appropriately used and acknowledged with only one or two minor omissions	All work of other people has without exception been appropriately used and acknowledged
Groupwork reflection *Critically reflects on the groupwork process*	Not evident	The group work reflection lacks clarity and specificity	The group work reflection clearly outlines events and reflects upon them	The group work reflection clearly outlines key events and provides some critical reflection upon them	The critical reflection of the groupwork process incorporates deep analysis of events and insight into effective strategies for groupwork contexts

Appendix 14: Distribution of PK TK CK and Context vs their Scores

Individual distribution of PK vs individual Pedagogy scores in the final artefacts in I2 and I3												
	TPK	**TPACK**	**TK**	**TCK**	**PK**	**PCK**	**DK**	**C**	**CK**	**Total**	**Pedagogy total**	**%**	**Pedagogy scores**
Ellie	4	10	13	27	104	19	315	12	90	594	137	17.5	5.0
Aria	1	3	10	11	56	25	184	5	51	346	85	16.2	3.0
Jaden	6	38	33	13	43	15	135	17	91	391	102	11.0	4.0
Daisy	0	2	1	9	30	15	190	3	43	293	47	10.2	4.0
Millie	0	9	66	44	56	14	225	6	203	623	79	9.0	5.0
Macy	14	35	123	18	77	71	477	15	296	1126	197	6.8	5.0
Jessica	4	23	68	16	28	7	187	3	137	473	62	5.9	3.0
Layla	5	17	41	24	17	8	91	4	98	305	47	5.6	5.0
Alyssa	4	18	58	20	21	7	140	7	110	385	50	5.5	5.0
Jasmine	10	39	91	29	38	45	235	5	206	698	132	5.4	3.0
Marley	1	11	99	37	38	15	289	7	204	701	65	5.4	2.0
Zoe	14	17	128	13	37	36	426	5	170	846	104	4.4	3.0
Paige	6	82	92	56	35	13	286	20	231	821	136	4.3	3.0
Summer	4	4	53	4	18	10	213	1	138	445	36	4.0	4.0
Evelyn	0	12	64	76	25	17	260	6	246	706	54	3.5	4.0
Ruby	5	3	55	20	10	7	241	0	104	445	25	2.2	4.0
Lucy	1	7	10	16	5	2	121	1	85	248	15	2.0	4.0
Amelia	8	2	113	19	14	10	438	0	180	784	34	1.8	3.0

Individual distribution of TK vs individual Technology scores in the final artefacts in I2 and I3													
	TPK	TPACK	TK	TCK	PK	PCK	DK	C	CK	Total	Technology total	%	Technology scores
Zoe	14	17	128	13	37	36	426	5	170	846	172	15.1	5
Alyssa	4	18	58	20	21	7	140	7	110	385	100	15.1	4
Amelia	8	2	113	19	14	10	438	0	180	784	142	14.4	4
Jessica	4	23	68	16	28	7	187	3	137	473	111	14.4	5
Marley	1	11	99	37	38	15	289	7	204	701	148	14.1	4
Layla	5	17	41	24	17	8	91	4	98	305	87	13.4	5
Jasmine	10	39	91	29	38	45	235	5	206	698	169	13.0	5
Ruby	5	3	55	20	10	7	241	0	104	445	83	12.4	3
Summer	4	4	53	4	18	10	213	1	138	445	65	11.9	4
Paige	6	82	92	56	35	13	286	20	231	821	236	11.2	4
Macy	14	35	123	18	77	71	477	15	296	1126	190	10.9	4
Millie	0	9	66	44	56	14	225	6	203	623	119	10.6	3
Evelyn	0	12	64	76	25	17	260	6	246	706	152	9.1	4
Jaden	6	38	33	13	43	15	135	17	91	391	90	8.4	4
Lucy	1	7	10	16	5	2	121	1	85	248	34	4.0	3
Aria	1	3	10	11	56	25	184	5	51	346	25	2.9	5
Ellie	4	10	13	27	104	19	315	12	90	594	54	2.2	2
Daisy	0	2	1	9	30	15	190	3	43	293	12	0.3	3

Individual distribution of CK vs individual Content scores in the final artefacts in I2 and I3													
	TPK	TPACK	TK	TCK	PK	PCK	DK	C	CK	Total	Content total	%	Content scores
Evelyn	0	12	64	76	25	17	260	6	246	706	351	34.8	4
Lucy	1	7	10	16	5	2	121	1	85	248	110	34.3	4
Millie	0	9	66	44	56	14	225	6	203	623	270	32.6	5
Layla	5	17	41	24	17	8	91	4	98	305	147	32.1	4
Summer	4	4	53	4	18	10	213	1	138	445	156	31.0	3
Jasmine	10	39	91	29	38	45	235	5	206	698	319	29.5	4
Marley	1	11	99	37	38	15	289	7	204	701	267	29.1	4
Jessica	4	23	68	16	28	7	187	3	137	473	183	29.0	5
Alyssa	4	18	58	20	21	7	140	7	110	385	155	28.6	4
Paige	6	82	92	56	35	13	286	20	231	821	382	28.1	3
Macy	14	35	123	18	77	71	477	15	296	1126	420	26.3	5
Ruby	5	3	55	20	10	7	241	0	104	445	134	23.4	3
Jaden	6	38	33	13	43	15	135	17	91	391	157	23.3	3
Amelia	8	2	113	19	14	10	438	0	180	784	211	23.0	4
Zoe	14	17	128	13	37	36	426	5	170	846	236	20.1	3
Ellie	4	10	13	27	104	19	315	12	90	594	146	15.2	3
Aria	1	3	10	11	56	25	184	5	51	346	90	14.7	4
Daisy	0	2	1	9	30	15	190	3	43	293	69	14.7	3

Individual distribution of Context vs individual Context scores in the final artefacts in I2 and I3													
	TPK	TPACK	TK	TCK	PK	PCK	DK	C	CK	Total	Context total	%	Context scores
Jaden	6	38	33	13	43	15	135	17	91	391	17	4.3	5
Paige	6	82	92	56	35	13	286	20	231	821	20	2.4	5
Ellie	4	10	13	27	104	19	315	12	90	594	12	2.0	4
Alyssa	4	18	58	20	21	7	140	7	110	385	7	1.8	4
Aria	1	3	10	11	56	25	184	5	51	346	5	1.4	3
Macy	14	35	123	18	77	71	477	15	296	1126	15	1.3	5
Layla	5	17	41	24	17	8	91	4	98	305	4	1.3	4
Daisy	0	2	1	9	30	15	190	3	43	293	3	1.0	3
Marley	1	11	99	37	38	15	289	7	204	701	7	1.0	3
Millie	0	9	66	44	56	14	225	6	203	623	6	1.0	2
Evelyn	0	12	64	76	25	17	260	6	246	706	6	0.8	5
Jasmine	10	39	91	29	38	45	235	5	206	698	5	0.7	5
Jessica	4	23	68	16	28	7	187	3	137	473	3	0.6	4
Zoe	14	17	128	13	37	36	426	5	170	846	5	0.6	4
Lucy	1	7	10	16	5	2	121	1	85	248	1	0.4	3
Summer	4	4	53	4	18	10	213	1	138	445	1	0.2	3
Ruby	5	3	55	20	10	7	241	0	104	445	0	0.0	3
Amelia	8	2	113	19	14	10	438	0	180	784	0	0.0	3

Appendix 15: Inter-rater Reliability between Two Markers in Marking I2 and I3 Final Artefacts

Individual average scores of Pedagogy, Technology, Content and Context and average final scores between two markers in I2																		
		Pedagogy			**Technology**			**Content**			**Contextualisation**			**Final**				
Iteration 2		M1	M2	Ave	M1	M2	Ave	M1	M2	Ave	M 1	M2	Ave	M1	M2	Ave	Grades
Group 1	Jessica	5	5	**5**	4	4	**4**	4	4	**4**	4	4	**4**	33	32	32.5	D
	Lucy	4	4	**4**	3	3	**3**	3	3	**3**	3	3	**3**	27	27	27	CR
	Alyssa	3	4	**3.5**	4	4	**4**	4	4	**4**	4	4	**4**	28	28	28	CR
Group 2	Paige	5	5	**5**	5	5	**5**	5	5	**5**	5	5	**5**	37	38	37.5	HD
	Jaden	5	5	**5**	5	5	**5**	5	5	**5**	5	5	**5**	34	35	34.5	HD
	Layla	5	5	**5**	4	5	**4.5**	4	4	**4**	4	4	**4**	29	30	29.5	CR
Group 3	Ellie	4	5	**4.5**	5	5	**5**	4	5	**4.5**	4	4	**4**	35	36	25.5	HD
	Aria	3	3	**3**	2	3	**2.5**	3	3	**3**	3	3	**3**	20	22	21	P
	Daisy	3	3	**3**	3	3	**3**	3	4	**3.5**	3	3	**3**	26	27	26.5	CR

Individual average scores of Pedagogy, Technology, Content and Context and average final scores between two markers in I3																	
Iteration 3		Pedagogy			Technology			Content			Contextualisation			Final Scores and Grades			
		M1	M2	Ave	M1	M2	Ave	M1	M2	Ave	M1	M2	Ave	M1	M2	Ave	Grade
Group 1	Marley	3	3	**3**	3	3	**3**	3	4	**3.5**	3	4	**3.5**	29	28	28.5	CR
	Evelyn	4	4	**4**	5	4	**4.5**	4	4	**4**	5	4	**4.5**	34	32	33	HD
	Millie	2	3	**2.5**	4	4	**4**	4	3	**3.5**	2	3	**2.5**	25	25	25	P
Group 2	Summer	4	4	**4**	4	4	**4**	3	3	**3**	3	3	**3**	28	27	27.5	CR
	Ruby	3	3	**4**	4	4	**4**	3	3	**3**	3	3	**3**	28	26	27	CR
	Amelia	3	3	**3**	3	3	**3**	3	3	**3**	3	3	**3**	24	26	25	P
Group 3	Zoe	3	4	**3.5**	4	5	**4.5**	4	4	**4**	4	4	**4**	29	29	29	CR
	Jasmine	4	4	**4**	5	5	**5**	4	4	**4**	5	5	**5**	38	37	37.5	HD
	Macy	5	5	**5**	4	5	**4.5**	5	5	**5**	5	5	**5**	38	38	38	HD

Appendix 16: Justification for the Main Effects and Interactions Added to the Maximal Models

The current study was interested in finding out any possible correlations between Gender, Age, Tutor, Practicum Experience, and Target Degree and eight dependent variables of Average_All_TPACK, Average_TK, Average_CK, Average_PK, Average_PCK, Average_TCK, Average_TPK, and Average_TPACK over the years (Year) and across the cohort (Pre_or_Post). In saying that, there should be eight maximal models, one for each depedent variable. In this section on fitting statistical data in an LMM, the model with representative Average_All_TPACK as a dependent variable is used to exemplify and explain the whole precedures. The same principles were applied to the remaining seven dependent variables.

First, all possible main effects and interactions between the terms were included in the initial maximal model. Again, a main effect is the fixed effect due to a variable by itself. A model with only main effects looks like:

Average_All_TPACK = Year + Pre_or_Post + Gender + Age + Tutor + Practicum Experience + Target Degree

Second, because this study was interested in finding out whether the Average_All_TPACK score was improved across the cohort over the years, this two-way interaction was added to the maximal model, denoted as: Year*Pre_or_Post.

Also, because this study was interested in finding out how Gender, Age, Tutor, Practicum Experience, Target Degree influenced Average_All_TPACK across the cohort, these two-way interactions were put into the model: Year*Gender, Year*Age, Year*Tutor, Year*Practicum Experience, and Year*Target Degrees.

Furthermore, because this study wasinterested in finding out how Gender, Age, Tutor, Practicum Experience, Target Degree influenced Average_All_TPACK over the years, these two-way interactions were put into the model: Pre_or_Post *Gender, Pre_or_Post *Age, Pre_or_Post *Tutor, Pre_or_Post *Practicum Experience, and Pre_or_Post *Target Degrees.

Amalgamating these constructs, the initial maximal model with 7 main effects and 11 interactions of interest was:

Average_All_TPACK = Year + Pre_or_Post + Gender + Age + Tutor + Practicum Experience + Target Degree + Year*Pre_or_Post +Year*Gender + Year*Age + Year*Tutor + Year*Practicum Experience + Year*Target Degrees + Pre_or_Post *Gender + Pre_or_Post *Age + Pre_or_Post *Tutor + Pre_or_Post *Practicum Experience + Pre_or_Post *Target Degrees.

Two-way interactions between Age, Gender, Practicum Experience and Degree were not included in the maximal model. One might argue that that there were interactions between Gender and Age. For example, male participants who were20 years old or younger witnessed an improvement in Average_All_TPACK scores compared to female participants belonging to the same age group. However, this inquiry is beyond the scope of this study. Plus there would be too many similar random 2-way interactions to account for considering there being seven fixed factors in one model.

Similarly, three-way interactions were not included in the maximal model. One might also argue that it would be interesting to observe the changes in Average_All_TPACK across the cohort over the year in relation to Gender. For example, female participants were more confident about Average_All_TPACK than their counterparts prior to the course in 2017 while it was the reverse in 2018. In order to find this out, this 3-way interaction of Pre_or_Post*Year*Gender was to be added to the model. This is a topic that arguably warrants further investigation. However, this addition would add extra complexity to the model. Once a 3-way interaction is added to the model, all of other related 2-way interactions (Pre_or_Post*Year, Pre_or_Post*Gender, and Year*Gender) must be added as well. Otherwise, SPSS will automatically calculate these 2-way interactions. It would have been too complicated for reporting the results and intepreting data, too, considering multilevel variables to take into account in just one 3-way interactions, let alone hundreds of other similar possibilities occuring to other variables such as Pre_or_Post*Year*Age, Year*Gender*Age, etc., which is again far beyond the scope of this study.

This aligns with the purpose of minising the main effects and interactions to arrive at a minimal adequate model, to simplify the best fit model, not to make it more complicated. After the main effects and interactions that should be added to the maximal model were selected, the next step was to run the maximal model so that non-significant effects and interactions with $p<0.05$ were identified and excluded.

Appendix 17: Fitting Maximal Models in SPSS

Below are the steps that were used to fit eight maximal models in SPSS. The dependent variable of Average_All_TPACK was chosen as an example to demonstrate the procedures.

First, a Linear Mixed Model (LMM) analysis was conducted with the subject variable set to Student ID and the repeated variable set to Pre_or_Post (see Figure A). Student ID represented the respondents to the surveys and the pre- as well as post-course surveys were used as repeated measurements over two iterations.

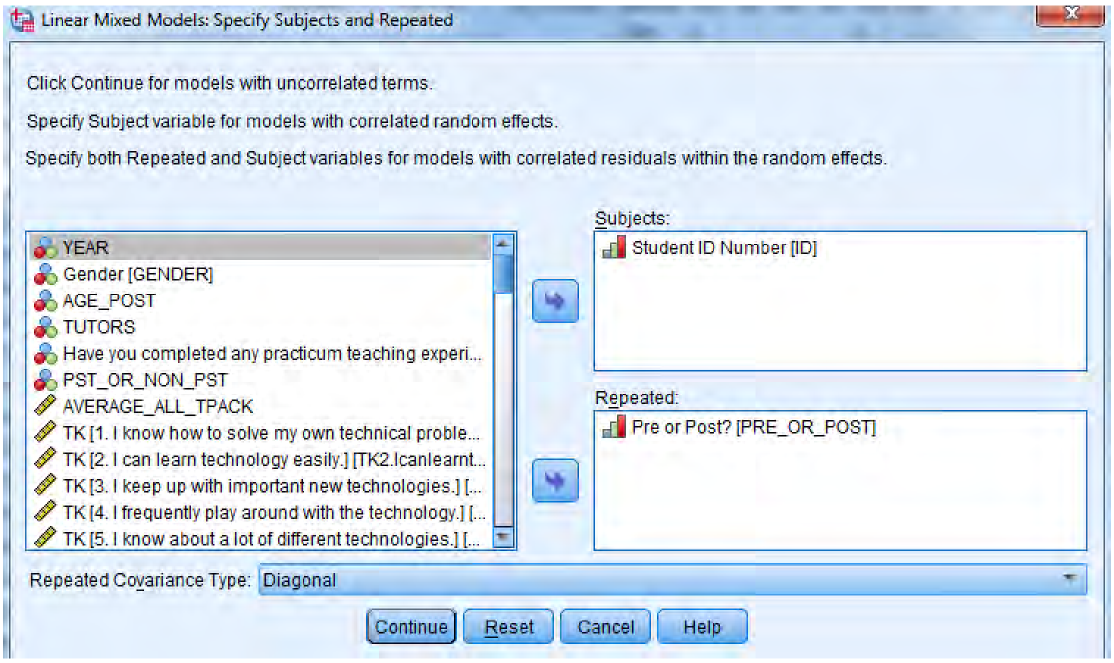

Figure A: Specify Subjects and Repeated

To inform SPSS what dependent variable and independent one(s) the researcher wanted to be present in the model, Average_All_TPACK was selected as a sample dependent variable to be analysed, all the remaining categorical factors/independent variables (Pre_or_Post, Year, Gender, Age, Tutors, Practicum Experience, and PST_or_Non_PST) were also added to the model under *Factor(s)* (see Figure B). The inclusion of all the factors in the model was to guarantee that all possible influential factors were considered before a final reduced model was decided upon.

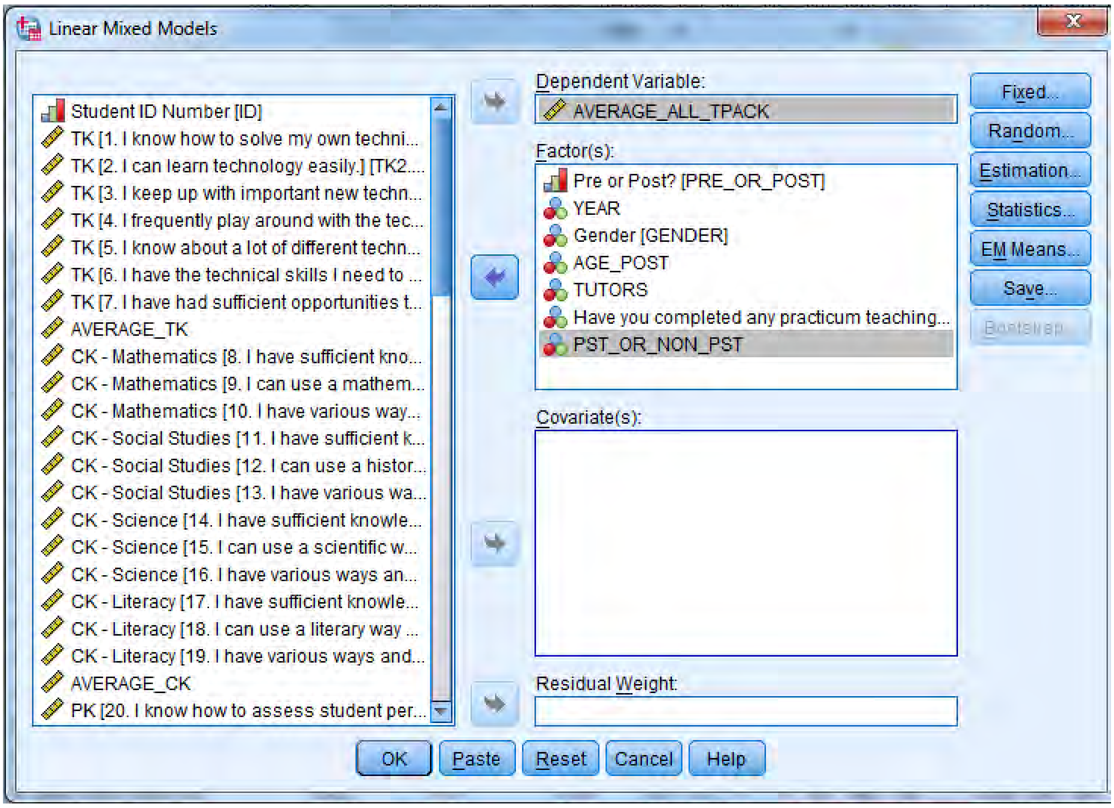

Figure B: Fitting dependent variables and independent variables in LMM

Likewise, to inform SPSS of what Main Effects and Interactions it was commanded to run and examine, the main effects of all the fixed factors such as Pre_or_Post, Year, Gender, Age, Tutors, Practicum Experience, PST_or_Non_PST to be investigated were added to the model, as illustrated in Figure C.

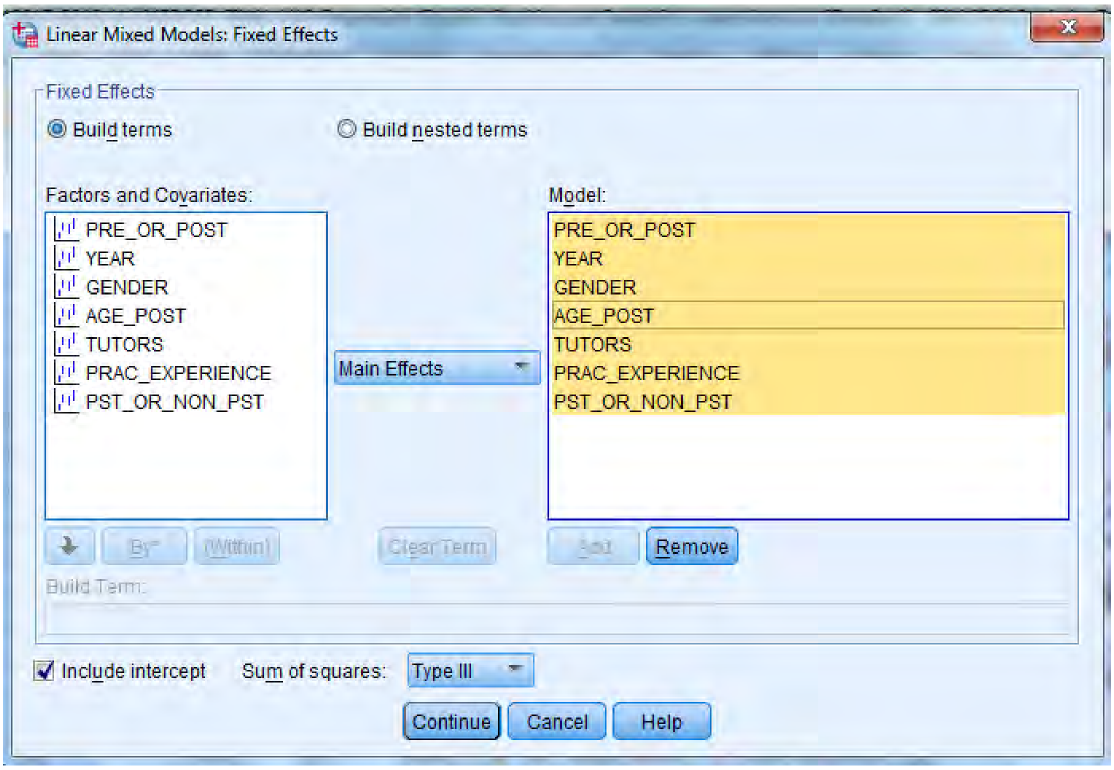

Figure C: Fitting main effects in LMM

After that, all 2-way interactions between Pre_or_Post and the remaing factors as well as between Year and the remaing factors were added to the model, as illustrated in Figure D. Justification for why all these seven main effects and eleven 2-way interactions were included in the Fixed Effects model is detailed in Appendix 16.

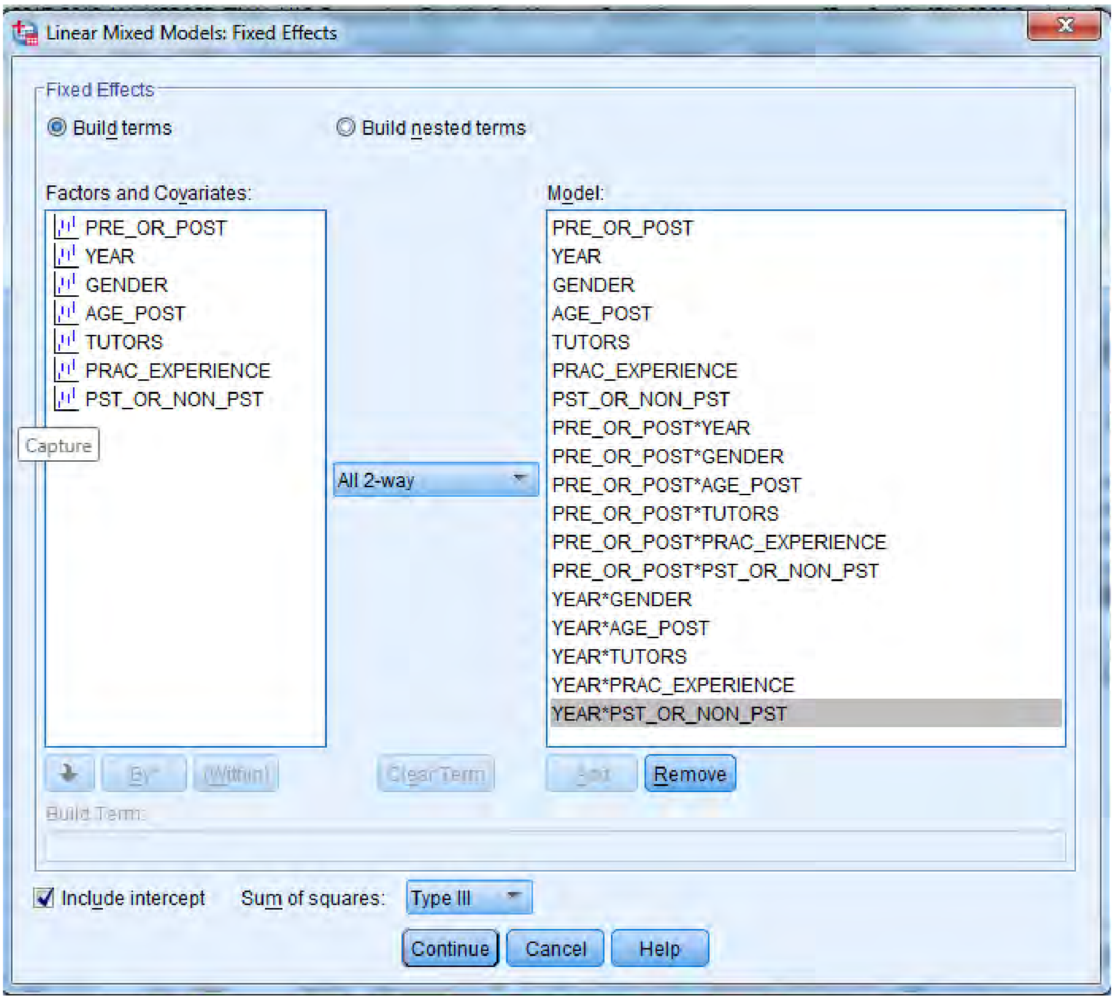

Figure D: Fitting all 2-way interactions in LMM

This was an intercept Random Effects model only (see Figure E) with *Include intercept* selected to stay computationally friendly, which makes it practically desirable. The researcher experienced fitting several main effects and interactions in the Random Effects model, the result of which was it took SPSS one day to finish running the test, not to mention the worries about a computer crash-down.

In the current study, Student ID was a random effect factor. Although the sample population was not randomly selected, it could be treated as a sample of all potential students by being add to *Combinations* from *Subjects* under *Subject Groupings*. This addition was to define the random variable and to imply that although the cohort of 200 respondents in this data set might have some idiosyncrasies, the research did not care about them with the goal of generalising to the broader population. That is, the results will be generalisable to students beyond the group surveyed in this study (Winter, 2013).

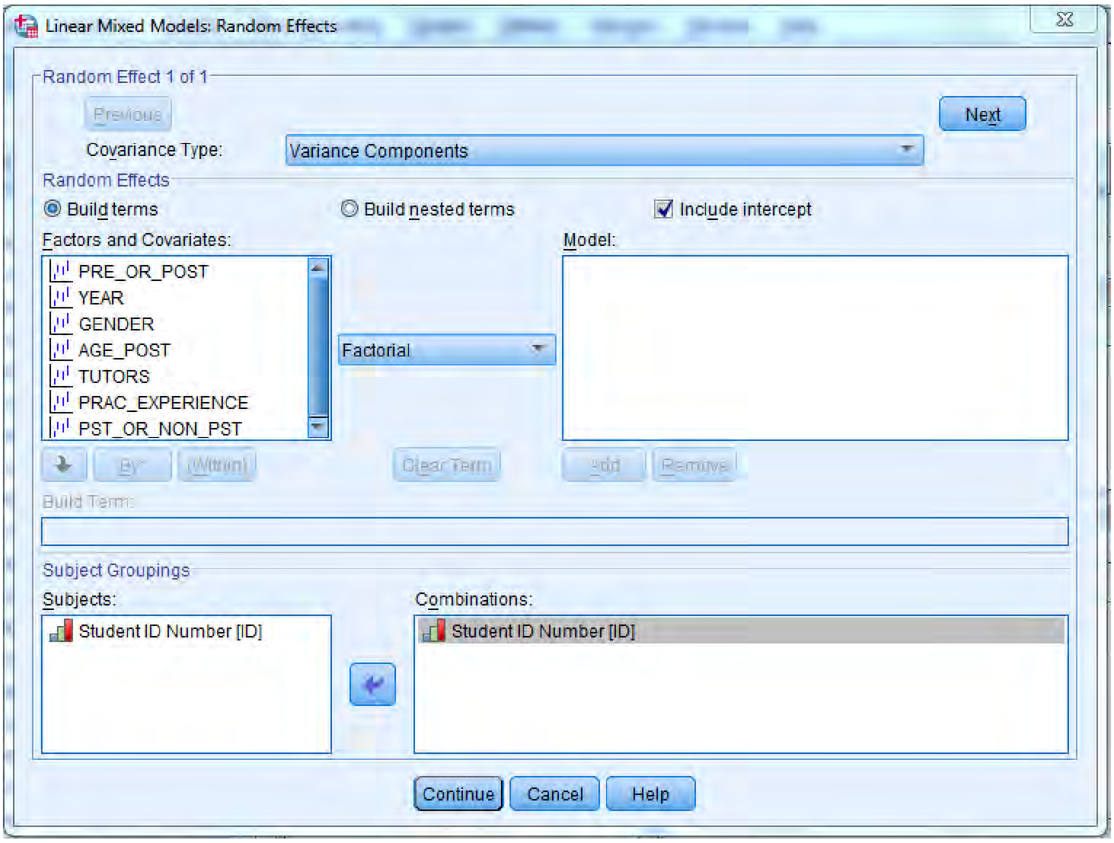

Figure E: Fitting the Random Effects LMM

Estimated Marginal Means of Fitted Models were chosen for all the main effects and interactions specified in the above Mixed Effects model (see Figure F). These are the means calculated based on the model rather than the actual data. *Bonferroni* adjustment for multi comparison was used to with the mean difference being significant at the .05 level.

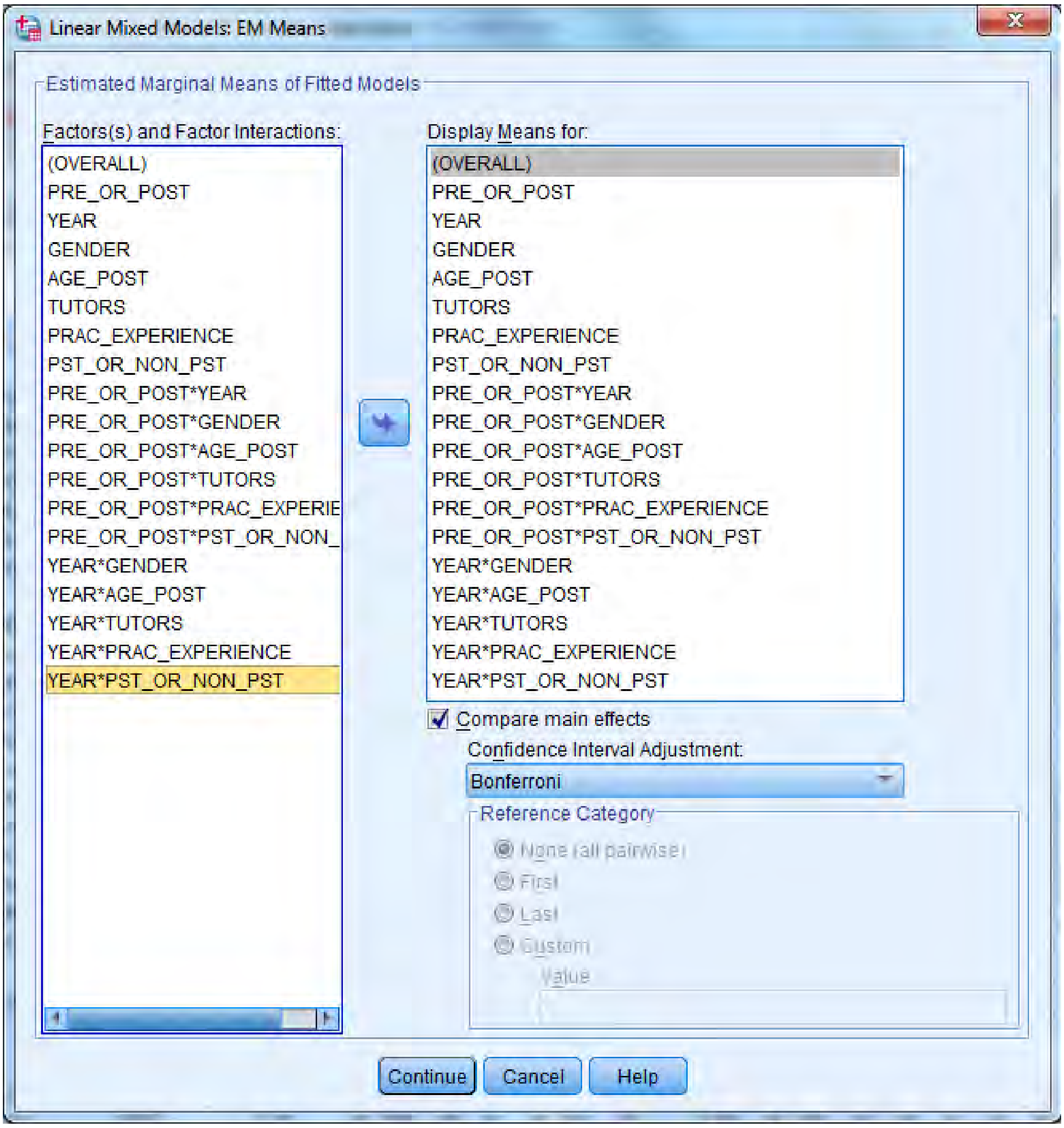

Figure F: Selecting EM Means in LMM

The last step in SPSS settings above completed the procedure of fitting all the justified main effects and 2-way interactions to the maximal model for Average_All_TPACK. The whole procedures were repeated for the 7 remaining depedent variables: Average_TK, Average_CK, Average_PK, Average_PCK, Average_TCK, Average_TPK, and Average_TPACK.

Appendix 18: Multi Regression Outputs

SUMMARY OUTPUT FOR PEDAGOGY

Regression Statistics	
Multiple R	0.222185778
R Square	0.04936652
Adjusted R Square	-0.010048073
Standard Error	0.928176487
Observations	18

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.715814538	0.715814538	0.83088207	0.375547079
Residual	16	13.78418546	0.861511591		
Total	17	14.5			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	3.52707825	0.400929435	8.79725443	1.5832E-07	2.677145816	4.377011	2.677146	4.377011
%	0.045618375	0.050046086	0.91152733	0.37554708	-0.06047459	0.151711	-0.06047	0.151711

SUMMARY OUTPUT FOR TECHNOLOGY

Regression Statistics	
Multiple R	0.5302844
R Square	0.281201544
Adjusted R Square	0.236276641
Standard Error	0.762579778
Observations	18

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	3.639998	3.639998	6.259368916	0.023585171
Residual	16	9.304447	0.581528		
Total	17	12.94444			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.951227495	0.435784	6.772226	4.48238E-06	2.027406805	3.875048	2.027407	3.875048184
%	0.097407387	0.038934	2.501873	0.023585171	0.014871451	0.179943	0.014871	0.179943323

SUMMARY OUTPUT FOR CONTENT

Regression Statistics	
Multiple R	0.448812917
R Square	0.201433034
Adjusted R Square	0.151522599
Standard Error	0.674343771
Observations	18

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1.835279	1.835279	4.035890149	0.06172468
Residual	16	7.275832	0.45474		
Total	17	9.111111			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.465621786	0.672216	3.667903	0.002078605	1.040588293	3.890655	1.040588	3.890655
%	0.050286568	0.025031	2.008953	0.06172468	-0.002777286	0.10335	-0.00278	0.10335

SUMMARY OUTPUT FOR CONTEXT

Regression Statistics	
Multiple R	0.503550059
R Square	0.253562662
Adjusted R Square	0.206910328
Standard Error	0.839624081
Observations	18

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	3.831614	3.831614	5.435154942	0.033135209
Residual	16	11.2795	0.704969		
Total	17	15.11111			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	3.239659879	0.304043	10.65526	1.12787E-08	2.59511693	3.884203	2.595117	3.884203
%	0.458711767	0.196759	2.331342	0.033135209	0.041601983	0.875822	0.041602	0.875822

Appendix 19: Final Minimal Adequate Model Outputs for 8 Dependent Variables

1. Fitting AVERAGE_ALL_TPACK to LMM Minimal Adequate Model

Estimates[a]

Pre or Post?	Mean	Std. Error	df	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
PRE Response	2.548	.042	227.823	2.465	2.631
POST Response	2.980	.041	217.316	2.899	3.060

a. Dependent Variable: AVERAGE_ALL_TPACK.

Pairwise Comparisons[a]

(I) Pre or Post?	(J) Pre or Post?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	95% Confidence Interval for Difference[c] Upper Bound
PRE Response	POST Response	-.432*	.031	197.000	.000	-.493	-.371
POST Response	PRE Response	.432*	.031	197.000	.000	.371	.493

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_ALL_TPACK.

c. Adjustment for multiple comparisons: Bonferroni.

Estimates[a]

Have you completed any practicum teaching experience?	Mean	Std. Error	df	95% Confidence Interval	
				Lower Bound	Upper Bound
Yes	2.832	.056	194.402	2.722	2.942
No	2.696	.037	194.367	2.623	2.768

a. Dependent Variable: AVERAGE_ALL_TPACK.

Pairwise Comparisons[a]

(I) Have you completed any practicum teaching experience?	(J) Have you completed any practicum teaching experience?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
						Lower Bound	Upper Bound
Yes	No	.136*	.055	194.118	.013	.029	.244
No	Yes	-.136*	.055	194.118	.013	-.244	-.029

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_ALL_TPACK.

c. Adjustment for multiple comparisons: Bonferroni.

Estimates[a]

Pre or Post?	Have you completed any practicum teaching experience?	Mean	Std. Error	df	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
PRE Response	Yes	2.641	.062	223.368	2.518	2.764
	No	2.455	.042	218.951	2.373	2.537
POST Response	Yes	3.023	.060	214.999	2.905	3.141
	No	2.937	.040	212.250	2.858	3.015

a. Dependent Variable: AVERAGE_ALL_TPACK.

Pairwise Comparisons[a]

Have you completed any practicum teaching experience?	(I) Pre or Post?	(J) Pre or Post?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	95% Confidence Interval for Difference[c] Upper Bound
Yes	PRE Response	POST Response	-.382*	.051	197.000	.000	-.482	-.282
	POST Response	PRE Response	.382*	.051	197.000	.000	.282	.482
No	PRE Response	POST Response	-.481*	.036	197.000	.000	-.552	-.411
	POST Response	PRE Response	.481*	.036	197.000	.000	.411	.552

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_ALL_TPACK.

c. Adjustment for multiple comparisons: Bonferroni.

Pairwise Comparisons[a]

Pre or Post?	(I) Have you completed any practicum teaching experience?	(J) Have you completed any practicum teaching experience?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
							Lower Bound	Upper Bound
PRE Response	Yes	No	.186*	.064	200.499	.004	.059	.313
	No	Yes	-.186*	.064	200.499	.004	-.313	-.059
POST Response	Yes	No	.086	.061	199.045	.158	-.034	.207
	No	Yes	-.086	.061	199.045	.158	-.207	.034

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_ALL_TPACK.

c. Adjustment for multiple comparisons: Bonferroni.

Estimates[a]

Pre or Post?	YEAR	Mean	Std. Error	df	95% Confidence Interval	
					Lower Bound	Upper Bound
PRE Response	2017	2.600	.049	222.684	2.502	2.697
	2018	2.496	.063	228.316	2.372	2.621
POST Response	2017	3.032	.048	214.591	2.938	3.126
	2018	2.927	.062	217.337	2.806	3.049

a. Dependent Variable: AVERAGE_ALL_TPACK.

Pairwise Comparisons[a]

YEAR	(I) Pre or Post?	(J) Pre or Post?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
							Lower Bound	Upper Bound
2017	PRE Response	POST Response	-.432*	.040	197.000	.000	-.512	-.353
	POST Response	PRE Response	.432*	.040	197.000	.000	.353	.512
2018	PRE Response	POST Response	-.431*	.044	197.000	.000	-.519	-.343
	POST Response	PRE Response	.431*	.044	197.000	.000	.343	.519

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_ALL_TPACK.

c. Adjustment for multiple comparisons: Bonferroni.

Pairwise Comparisons[a]

Pre or Post?	(I) YEAR	(J) YEAR	Mean Difference (I-J)	Std. Error	df	Sig.[b]	95% Confidence Interval for Difference[b]	
							Lower Bound	Upper Bound
PRE Response	2017	2018	.103	.076	226.784	.177	-.047	.254
	2018	2017	-.103	.076	226.784	.177	-.254	.047
POST Response	2017	2018	.105	.074	216.876	.157	-.041	.250
	2018	2017	-.105	.074	216.876	.157	-.250	.041

Based on estimated marginal means

a. Dependent Variable: AVERAGE_ALL_TPACK.

b. Adjustment for multiple comparisons: Bonferroni.

2. Fitting AVERAGE_ALL_TPACK to LMM Minimal Adequate Model

Estimates[a]

Pre or Post?	Mean	Std. Error	df	95% Confidence Interval	
				Lower Bound	Upper Bound
PRE Response	2.611	.068	227.588	2.477	2.744
POST Response	3.018	.064	205.027	2.892	3.143

a. Dependent Variable: AVERAGE_TK.

Pairwise Comparisons[a]

(I) Pre or Post?	(J) Pre or Post?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
						Lower Bound	Upper Bound
PRE Response	POST Response	-.407*	.042	197.001	.000	-.490	-.324
POST Response	PRE Response	.407*	.042	197.001	.000	.324	.490

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_TK.

c. Adjustment for multiple comparisons: Bonferroni.

Estimates[a]

Have you completed any practicum teaching experience?	Mean	Std. Error	df	95% Confidence Interval	
				Lower Bound	Upper Bound
Yes	2.698	.090	196.129	2.520	2.876
No	2.930	.060	195.948	2.812	3.048

a. Dependent Variable: AVERAGE_TK.

Pairwise Comparisons[a]

(I) Have you completed any practicum teaching experience?	(J) Have you completed any practicum teaching experience?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
						Lower Bound	Upper Bound
Yes	No	-.232*	.089	194.702	.010	-.407	-.056
No	Yes	.232*	.089	194.702	.010	.056	.407

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_TK.

c. Adjustment for multiple comparisons: Bonferroni.

Estimates[a]

Pre or Post?	Have you completed any practicum teaching experience?	Mean	Std. Error	df	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
PRE Response	Yes	2.476	.100	223.502	2.279	2.674
	No	2.745	.067	219.317	2.613	2.877
POST Response	Yes	2.920	.093	204.418	2.737	3.103
	No	3.115	.062	203.368	2.993	3.236

a. Dependent Variable: AVERAGE_TK.

Pairwise Comparisons[a]

Have you completed any practicum teaching experience?	(I) Pre or Post?	(J) Pre or Post?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	95% Confidence Interval for Difference[c] Upper Bound
Yes	PRE Response	POST Response	-.444*	.069	197.001	.000	-.580	-.309
	POST Response	PRE Response	.444*	.069	197.001	.000	.309	.580
No	PRE Response	POST Response	-.370*	.048	197.001	.000	-.465	-.275
	POST Response	PRE Response	.370*	.048	197.001	.000	.275	.465

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_TK.

c. Adjustment for multiple comparisons: Bonferroni.

Pairwise Comparisons[a]

Pre or Post?	(I) Have you completed any practicum teaching experience?	(J) Have you completed any practicum teaching experience?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
							Lower Bound	Upper Bound
PRE Response	Yes	No	-.269*	.104	201.473	.010	-.473	-.065
	No	Yes	.269*	.104	201.473	.010	.065	.473
POST Response	Yes	No	-.194*	.093	197.172	.037	-.377	-.012
	No	Yes	.194*	.093	197.172	.037	.012	.377

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_TK.

c. Adjustment for multiple comparisons: Bonferroni.

Estimates[a]

Pre or Post?	YEAR	Mean	Std. Error	df	95% Confidence Interval	
					Lower Bound	Upper Bound
PRE Response	2017	2.710	.080	222.858	2.553	2.867
	2018	2.512	.102	227.958	2.311	2.713
POST Response	2017	3.137	.074	204.272	2.992	3.282
	2018	2.898	.097	204.861	2.708	3.089

a. Dependent Variable: AVERAGE_TK.

Pairwise Comparisons[a]

YEAR	(I) Pre or Post?	(J) Pre or Post?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
							Lower Bound	Upper Bound
2017	PRE Response	POST Response	-.427*	.055	197.001	.000	-.536	-.319
	POST Response	PRE Response	.427*	.055	197.001	.000	.319	.536
2018	PRE Response	POST Response	-.387*	.060	197.001	.000	-.506	-.268
	POST Response	PRE Response	.387*	.060	197.001	.000	.268	.506

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_TK.

c. Adjustment for multiple comparisons: Bonferroni.

Pairwise Comparisons[a]

Pre or Post?	(I) YEAR	(J) YEAR	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
							Lower Bound	Upper Bound
PRE Response	2017	2018	.198	.123	226.668	.109	-.045	.440
	2018	2017	-.198	.123	226.668	.109	-.440	.045
POST Response	2017	2018	.239*	.115	204.983	.039	.012	.466
	2018	2017	-.239*	.115	204.983	.039	-.466	-.012

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_TK.

c. Adjustment for multiple comparisons: Bonferroni.

3. Fitting AVERAGE_ CK to LMM Minimal Adequate Model

Estimates[a]

Pre or Post?	Mean	Std. Error	df	95% Confidence Interval	
				Lower Bound	Upper Bound
PRE Response	2.601	.054	236.506	2.495	2.706
POST Response	2.892	.049	204.097	2.795	2.988

a. Dependent Variable: AVERAGE_CK.

Pairwise Comparisons[a]

(I) Pre or Post?	(J) Pre or Post?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
						Lower Bound	Upper Bound
PRE Response	POST Response	-.291*	.035	197.000	.000	-.361	-.221
POST Response	PRE Response	.291*	.035	197.000	.000	.221	.361

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_CK.

c. Adjustment for multiple comparisons: Bonferroni.

Estimates[a]

Have you completed any practicum teaching experience?	Mean	Std. Error	df	95% Confidence Interval	
				Lower Bound	Upper Bound
Yes	2.826	.070	198.196	2.688	2.964
No	2.666	.046	197.814	2.575	2.758

a. Dependent Variable: AVERAGE_CK.

Pairwise Comparisons[a]

(I) Have you completed any practicum teaching experience?	(J) Have you completed any practicum teaching experience?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
						Lower Bound	Upper Bound
Yes	No	.160*	.069	195.304	.022	.024	.296
No	Yes	-.160*	.069	195.304	.022	-.296	-.024

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_CK.

c. Adjustment for multiple comparisons: Bonferroni.

Estimates[a]

Pre or Post?	Have you completed any practicum teaching experience?	Mean	Std. Error	df	95% Confidence Interval Lower Bound	Upper Bound
PRE Response	Yes	2.674	.080	229.985	2.517	2.832
	No	2.527	.054	224.193	2.421	2.633
POST Response	Yes	2.978	.071	203.539	2.837	3.118
	No	2.806	.047	202.572	2.713	2.899

a. Dependent Variable: AVERAGE_CK.

Pairwise Comparisons[a]

Have you completed any practicum teaching experience?	(I) Pre or Post?	(J) Pre or Post?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	Upper Bound
Yes	PRE Response	POST Response	-.303*	.058	197.000	.000	-.417	-.189
	POST Response	PRE Response	.303*	.058	197.000	.000	.189	.417
No	PRE Response	POST Response	-.279*	.041	197.000	.000	-.359	-.199
	POST Response	PRE Response	.279*	.041	197.000	.000	.199	.359

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_CK.

c. Adjustment for multiple comparisons: Bonferroni.

Pairwise Comparisons[a]

Pre or Post?	(I) Have you completed any practicum teaching experience?	(J) Have you completed any practicum teaching experience?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
							Lower Bound	Upper Bound
PRE Response	Yes	No	.148	.084	202.200	.079	-.017	.312
	No	Yes	-.148	.084	202.200	.079	-.312	.017
POST Response	Yes	No	.172*	.071	196.817	.016	.032	.312
	No	Yes	-.172*	.071	196.817	.016	-.312	-.032

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_CK.

c. Adjustment for multiple comparisons: Bonferroni.

Estimates[a]

Pre or Post?	YEAR	Mean	Std. Error	df	95% Confidence Interval	
					Lower Bound	Upper Bound
PRE Response	2017	2.611	.064	229.063	2.486	2.736
	2018	2.590	.081	237.580	2.431	2.749
POST Response	2017	2.928	.056	203.405	2.816	3.039
	2018	2.856	.074	203.943	2.710	3.002

a. Dependent Variable: AVERAGE_CK.

Pairwise Comparisons[a]

YEAR	(I) Pre or Post?	(J) Pre or Post?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
							Lower Bound	Upper Bound
2017	PRE Response	POST Response	-.317*	.046	197.000	.000	-.408	-.225
	POST Response	PRE Response	.317*	.046	197.000	.000	.225	.408
2018	PRE Response	POST Response	-.266*	.051	197.000	.000	-.366	-.165
	POST Response	PRE Response	.266*	.051	197.000	.000	.165	.366

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_CK.

c. Adjustment for multiple comparisons: Bonferroni.

Pairwise Comparisons[a]

Pre or Post?	(I) YEAR	(J) YEAR	Mean Difference (I-J)	Std. Error	df	Sig.[b]	95% Confidence Interval for Difference[b]	
							Lower Bound	Upper Bound
PRE Response	2017	2018	.021	.098	234.835	.832	-.172	.213
	2018	2017	-.021	.098	234.835	.832	-.213	.172
POST Response	2017	2018	.072	.088	204.058	.416	-.102	.246
	2018	2017	-.072	.088	204.058	.416	-.246	.102

Based on estimated marginal means

a. Dependent Variable: AVERAGE_CK.

b. Adjustment for multiple comparisons: Bonferroni.

4. Fitting AVERAGE_PK to LMM Minimal Adequate Model

Estimates[a]

Pre or Post?	Mean	Std. Error	df	95% Confidence Interval	
				Lower Bound	Upper Bound
PRE Response	2.661	.054	232.261	2.554	2.769
POST Response	3.042	.051	211.648	2.941	3.143

a. Dependent Variable: AVERAGE_PK.

Pairwise Comparisons[a]

(I) Pre or Post?	(J) Pre or Post?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
						Lower Bound	Upper Bound
PRE Response	POST Response	-.381*	.039	197.002	.000	-.457	-.304
POST Response	PRE Response	.381*	.039	197.002	.000	.304	.457

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_PK.

c. Adjustment for multiple comparisons: Bonferroni.

Estimates[a]

Have you completed any practicum teaching experience?	Mean	Std. Error	df	95% Confidence Interval	
				Lower Bound	Upper Bound
Yes	3.021	.071	195.589	2.881	3.161
No	2.682	.047	195.444	2.590	2.775

a. Dependent Variable: AVERAGE_PK.

Pairwise Comparisons[a]

(I) Have you completed any practicum teaching experience?	(J) Have you completed any practicum teaching experience?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
						Lower Bound	Upper Bound
Yes	No	.339*	.070	194.458	.000	.201	.476
No	Yes	-.339*	.070	194.458	.000	-.476	-.201

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_PK.

c. Adjustment for multiple comparisons: Bonferroni.

Estimates[a]

Pre or Post?	Have you completed any practicum teaching experience?	Mean	Std. Error	df	95% Confidence Interval Lower Bound	Upper Bound
PRE Response	Yes	2.855	.081	226.650	2.696	3.014
	No	2.468	.054	221.451	2.361	2.575
POST Response	Yes	3.187	.075	210.180	3.040	3.335
	No	2.897	.050	208.222	2.799	2.995

a. Dependent Variable: AVERAGE_PK.

Pairwise Comparisons[a]

Have you completed any practicum teaching experience?	(I) Pre or Post?	(J) Pre or Post?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	Upper Bound
Yes	PRE Response	POST Response	-.333*	.063	197.002	.000	-.457	-.208
	POST Response	PRE Response	.333*	.063	197.002	.000	.208	.457
No	PRE Response	POST Response	-.429*	.044	197.002	.000	-.516	-.341
	POST Response	PRE Response	.429*	.044	197.002	.000	.341	.516

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_PK.

c. Adjustment for multiple comparisons: Bonferroni.

Pairwise Comparisons[a]

Pre or Post?	(I) Have you completed any practicum teaching experience?	(J) Have you completed any practicum teaching experience?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
							Lower Bound	Upper Bound
PRE Response	Yes	No	.387*	.084	200.924	.000	.221	.552
	No	Yes	-.387*	.084	200.924	.000	-.552	-.221
POST Response	Yes	No	.290*	.076	198.036	.000	.142	.439
	No	Yes	-.290*	.076	198.036	.000	-.439	-.142

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_PK.

c. Adjustment for multiple comparisons: Bonferroni.

Estimates[a]

Pre or Post?	YEAR	Mean	Std. Error	df	95% Confidence Interval	
					Lower Bound	Upper Bound
PRE Response	2017	2.727	.064	225.832	2.601	2.853
	2018	2.596	.082	233.077	2.435	2.757
POST Response	2017	3.093	.059	209.896	2.976	3.211
	2018	2.991	.077	211.552	2.838	3.143

a. Dependent Variable: AVERAGE_PK.

Pairwise Comparisons[a]

YEAR	(I) Pre or Post?	(J) Pre or Post?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
							Lower Bound	Upper Bound
2017	PRE Response	POST Response	-.366*	.051	197.002	.000	-.466	-.266
	POST Response	PRE Response	.366*	.051	197.002	.000	.266	.466
2018	PRE Response	POST Response	-.395*	.056	197.002	.000	-.504	-.285
	POST Response	PRE Response	.395*	.056	197.002	.000	.285	.504

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_PK.

c. Adjustment for multiple comparisons: Bonferroni.

Pairwise Comparisons[a]

Pre or Post?	(I) YEAR	(J) YEAR	Mean Difference (I-J)	Std. Error	df	Sig.[b]	95% Confidence Interval for Difference[b]	
							Lower Bound	Upper Bound
PRE Response	2017	2018	.131	.099	230.871	.186	-.064	.326
	2018	2017	-.131	.099	230.871	.186	-.326	.064
POST Response	2017	2018	.103	.093	211.416	.268	-.080	.285
	2018	2017	-.103	.093	211.416	.268	-.285	.080

Based on estimated marginal means

a. Dependent Variable: AVERAGE_PK.

b. Adjustment for multiple comparisons: Bonferroni.

5. Fitting AVERAGE_PCK to LMM Minimal Adequate Model

Estimates[a]

Pre or Post?	Mean	Std. Error	df	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
PRE Response	2.434	.055	253.444	2.325	2.543
POST Response	2.875	.050	224.687	2.778	2.973

a. Dependent Variable: AVERAGE_PCK.

Pairwise Comparisons[a]

(I) Pre or Post?	(J) Pre or Post?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	95% Confidence Interval for Difference[c] Upper Bound
PRE Response	POST Response	-.441*	.050	197.003	.000	-.540	-.342
POST Response	PRE Response	.441*	.050	197.003	.000	.342	.540

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_PCK.

c. Adjustment for multiple comparisons: Bonferroni.

Estimates[a]

Have you completed any practicum teaching experience?	Mean	Std. Error	df	95% Confidence Interval	
				Lower Bound	Upper Bound
Yes	2.834	.067	197.419	2.702	2.966
No	2.476	.044	197.124	2.388	2.563

a. Dependent Variable: AVERAGE_PCK.

Pairwise Comparisons[a]

(I) Have you completed any practicum teaching experience?	(J) Have you completed any practicum teaching experience?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
						Lower Bound	Upper Bound
Yes	No	.359*	.066	195.130	.000	.229	.489
No	Yes	-.359*	.066	195.130	.000	-.489	-.229

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_PCK.

c. Adjustment for multiple comparisons: Bonferroni.

Estimates[a]

Pre or Post?	Have you completed any practicum teaching experience?	Mean	Std. Error	df	95% Confidence Interval	
					Lower Bound	Upper Bound
PRE Response	Yes	2.681	.083	240.868	2.517	2.846
	No	2.188	.057	231.915	2.076	2.299
POST Response	Yes	2.987	.073	221.261	2.843	3.131
	No	2.763	.049	217.564	2.667	2.860

a. Dependent Variable: AVERAGE_PCK.

Pairwise Comparisons[a]

Have you completed any practicum teaching experience?	(I) Pre or Post?	(J) Pre or Post?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
							Lower Bound	Upper Bound
Yes	PRE Response	POST Response	-.306*	.082	197.003	.000	-.467	-.144
	POST Response	PRE Response	.306*	.082	197.003	.000	.144	.467
No	PRE Response	POST Response	-.576*	.058	197.003	.000	-.690	-.462
	POST Response	PRE Response	.576*	.058	197.003	.000	.462	.690

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_PCK.

c. Adjustment for multiple comparisons: Bonferroni.

Pairwise Comparisons[a]

Pre or Post?	(I) Have you completed any practicum teaching experience?	(J) Have you completed any practicum teaching experience?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
							Lower Bound	Upper Bound
PRE Response	Yes	No	.494*	.090	203.953	.000	.317	.671
	No	Yes	-.494*	.090	203.953	.000	-.671	-.317
POST Response	Yes	No	.224*	.075	201.161	.003	.075	.372
	No	Yes	-.224*	.075	201.161	.003	-.372	-.075

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_PCK.

c. Adjustment for multiple comparisons: Bonferroni.

Estimates[a]

Pre or Post?	YEAR	Mean	Std. Error	df	95% Confidence Interval	
					Lower Bound	Upper Bound
PRE Response	2017	2.478	.066	239.362	2.348	2.609
	2018	2.391	.083	256.826	2.228	2.553
POST Response	2017	2.889	.058	220.699	2.774	3.003
	2018	2.862	.075	224.896	2.715	3.009

a. Dependent Variable: AVERAGE_PCK.

Pairwise Comparisons[a]

YEAR	(I) Pre or Post?	(J) Pre or Post?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
							Lower Bound	Upper Bound
2017	PRE Response	POST Response	-.410*	.066	197.003	.000	-.540	-.281
	POST Response	PRE Response	.410*	.066	197.003	.000	.281	.540
2018	PRE Response	POST Response	-.472*	.072	197.003	.000	-.614	-.330
	POST Response	PRE Response	.472*	.072	197.003	.000	.330	.614

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_PCK.

c. Adjustment for multiple comparisons: Bonferroni.

Pairwise Comparisons[a]

Pre or Post?	(I) YEAR	(J) YEAR	Mean Difference (I-J)	Std. Error	df	Sig.[b]	95% Confidence Interval for Difference[b]	
							Lower Bound	Upper Bound
PRE Response	2017	2018	.088	.101	249.680	.386	-.111	.287
	2018	2017	-.088	.101	249.680	.386	-.287	.111
POST Response	2017	2018	.026	.090	223.959	.770	-.151	.204
	2018	2017	-.026	.090	223.959	.770	-.204	.151

Based on estimated marginal means

a. Dependent Variable: AVERAGE_PCK.

b. Adjustment for multiple comparisons: Bonferroni.

6. Fitting AVERAGE_TCK to LMM Minimal Adequate Model

Estimates[a]

Pre or Post?	Mean	Std. Error	df	95% Confidence Interval	
				Lower Bound	Upper Bound
PRE Response	2.417	.064	243.764	2.291	2.543
POST Response	2.944	.059	217.684	2.828	3.059

a. Dependent Variable: AVERAGE_TCK.

Pairwise Comparisons[a]

(I) Pre or Post?	(J) Pre or Post?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
						Lower Bound	Upper Bound
PRE Response	POST Response	-.527*	.052	197.000	.000	-.630	-.425
POST Response	PRE Response	.527*	.052	197.000	.000	.425	.630

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_TCK.

c. Adjustment for multiple comparisons: Bonferroni.

Estimates[a]

Pre or Post?	YEAR	Mean	Std. Error	df	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
PRE Response	2017	2.397	.076	233.652	2.247	2.547
	2018	2.436	.096	245.674	2.248	2.625
POST Response	2017	2.981	.068	215.026	2.846	3.115
	2018	2.907	.089	217.677	2.733	3.082

a. Dependent Variable: AVERAGE_TCK.

Pairwise Comparisons[a]

YEAR	(I) Pre or Post?	(J) Pre or Post?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	95% Confidence Interval for Difference[c] Upper Bound
2017	PRE Response	POST Response	-.584*	.068	197.000	.000	-.718	-.449
	POST Response	PRE Response	.584*	.068	197.000	.000	.449	.718
2018	PRE Response	POST Response	-.471*	.075	197.000	.000	-.618	-.323
	POST Response	PRE Response	.471*	.075	197.000	.000	.323	.618

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_TCK.

c. Adjustment for multiple comparisons: Bonferroni.

Pairwise Comparisons[a]

Pre or Post?	(I) YEAR	(J) YEAR	Mean Difference (I-J)	Std. Error	df	Sig.[b]	95% Confidence Interval for Difference[b]	
							Lower Bound	Upper Bound
PRE Response	2017	2018	-.039	.116	241.290	.735	-.269	.190
	2018	2017	.039	.116	241.290	.735	-.190	.269
POST Response	2017	2018	.073	.106	217.267	.490	-.136	.283
	2018	2017	-.073	.106	217.267	.490	-.283	.136

Based on estimated marginal means

a. Dependent Variable: AVERAGE_TCK.

b. Adjustment for multiple comparisons: Bonferroni.

7. Fitting AVERAGE_ TPK to LMM Minimal Adequate Model

Estimates[a]

Pre or Post?	Mean	Std. Error	df	95% Confidence Interval	
				Lower Bound	Upper Bound
PRE Response	2.706	.052	251.854	2.603	2.810
POST Response	3.154	.046	217.121	3.063	3.244

a. Dependent Variable: AVERAGE_TPK.

Pairwise Comparisons[a]

(I) Pre or Post?	(J) Pre or Post?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
						Lower Bound	Upper Bound
PRE Response	POST Response	-.447*	.045	197.000	.000	-.536	-.359
POST Response	PRE Response	.447*	.045	197.000	.000	.359	.536

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_TPK.

c. Adjustment for multiple comparisons: Bonferroni.

Estimates[a]

Gender	Mean	Std. Error	df	95% Confidence Interval	
				Lower Bound	Upper Bound
Female	3.004	.049	198.911	2.907	3.102
Male	2.856	.056	198.301	2.745	2.967

a. Dependent Variable: AVERAGE_TPK.

Pairwise Comparisons[a]

(I) Gender	(J) Gender	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
						Lower Bound	Upper Bound
Female	Male	.149*	.060	194.000	.013	.031	.266
Male	Female	-.149*	.060	194.000	.013	-.266	-.031

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_TPK.

c. Adjustment for multiple comparisons: Bonferroni.

Estimates[a]

PST_OR_NON_PST	Mean	Std. Error	df	95% Confidence Interval	
				Lower Bound	Upper Bound
PST	3.042	.034	197.223	2.975	3.109
NON-PST	2.818	.078	196.693	2.665	2.971

a. Dependent Variable: AVERAGE_TPK.

Pairwise Comparisons[a]

(I) PST_OR_NON_PST	(J) PST_OR_NON_PST	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	Upper Bound
PST	NON-PST	.224*	.082	194.000	.007	.063	.385
NON-PST	PST	-.224*	.082	194.000	.007	-.385	-.063

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_TPK.

c. Adjustment for multiple comparisons: Bonferroni.

Estimates[a]

Pre or Post?	YEAR	Mean	Std. Error	df	95% Confidence Interval Lower Bound	Upper Bound
PRE Response	2017	2.795	.063	237.234	2.671	2.918
	2018	2.618	.078	255.487	2.464	2.772
POST Response	2017	3.206	.054	214.245	3.100	3.312
	2018	3.101	.069	217.192	2.965	3.238

a. Dependent Variable: AVERAGE_TPK.

Pairwise Comparisons[a]

YEAR	(I) Pre or Post?	(J) Pre or Post?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	Upper Bound
2017	PRE Response	POST Response	-.411*	.059	197.000	.000	-.527	-.295
	POST Response	PRE Response	.411*	.059	197.000	.000	.295	.527
2018	PRE Response	POST Response	-.483*	.064	197.000	.000	-.611	-.356
	POST Response	PRE Response	.483*	.064	197.000	.000	.356	.611

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_TPK.

c. Adjustment for multiple comparisons: Bonferroni.

Pairwise Comparisons[a]

Pre or Post?	(I) YEAR	(J) YEAR	Mean Difference (I-J)	Std. Error	df	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
PRE Response	2017	2018	.177	.096	247.898	.066	-.012	.365
	2018	2017	-.177	.096	247.898	.066	-.365	.012
POST Response	2017	2018	.104	.083	216.637	.210	-.059	.268
	2018	2017	-.104	.083	216.637	.210	-.268	.059

Based on estimated marginal means

a. Dependent Variable: AVERAGE_TPK.

b. Adjustment for multiple comparisons: Bonferroni.

8. Fitting AVERAGE_ TPACK to LMM Minimal Adequate Model

Estimates[a]

Pre or Post?	Mean	Std. Error	df	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
PRE Response	2.415	.058	241.794	2.301	2.528
POST Response	2.943	.054	219.700	2.837	3.048

a. Dependent Variable: AVERAGE_TPACK.

Pairwise Comparisons[a]

(I) Pre or Post?	(J) Pre or Post?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	95% Confidence Interval for Difference[c] Upper Bound
PRE Response	POST Response	-.528*	.047	197.002	.000	-.621	-.435
POST Response	PRE Response	.528*	.047	197.002	.000	.435	.621

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_TPACK.

c. Adjustment for multiple comparisons: Bonferroni.

Estimates[a]

Gender	Mean	Std. Error	df	95% Confidence Interval	
				Lower Bound	Upper Bound
Female	2.762	.057	195.680	2.650	2.875
Male	2.595	.065	195.457	2.466	2.723

a. Dependent Variable: AVERAGE_TPACK.

Pairwise Comparisons[a]

(I) Gender	(J) Gender	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
						Lower Bound	Upper Bound
Female	Male	.168*	.069	194.002	.017	.031	.304
Male	Female	-.168*	.069	194.002	.017	-.304	-.031

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_TPACK.

c. Adjustment for multiple comparisons: Bonferroni.

Estimates[a]

Have you completed any practicum teaching experience?	Mean	Std. Error	df	95% Confidence Interval	
				Lower Bound	Upper Bound
Yes	2.782	.073	195.756	2.638	2.926
No	2.575	.048	195.612	2.480	2.671

a. Dependent Variable: AVERAGE_TPACK.

Pairwise Comparisons[a]

(I) Have you completed any practicum teaching experience?	(J) Have you completed any practicum teaching experience?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
						Lower Bound	Upper Bound
Yes	No	.207*	.072	194.600	.004	.065	.348
No	Yes	-.207*	.072	194.600	.004	-.348	-.065

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_TPACK.

c. Adjustment for multiple comparisons: Bonferroni.

Estimates[a]

Pre or Post?	Have you completed any practicum teaching experience?	Mean	Std. Error	df	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
PRE Response	Yes	2.573	.086	233.864	2.404	2.742
	No	2.256	.058	227.233	2.142	2.370
POST Response	Yes	2.991	.079	217.253	2.836	3.146
	No	2.894	.053	214.338	2.790	2.998

a. Dependent Variable: AVERAGE_TPACK.

Pairwise Comparisons[a]

Have you completed any practicum teaching experience?	(I) Pre or Post?	(J) Pre or Post?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	95% Confidence Interval for Difference[c] Upper Bound
Yes	PRE Response	POST Response	-.418*	.077	197.002	.000	-.569	-.267
	POST Response	PRE Response	.418*	.077	197.002	.000	.267	.569
No	PRE Response	POST Response	-.638*	.054	197.002	.000	-.744	-.531
	POST Response	PRE Response	.638*	.054	197.002	.000	.531	.744

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_TPACK.

c. Adjustment for multiple comparisons: Bonferroni.

Pairwise Comparisons[a]

Pre or Post?	(I) Have you completed any practicum teaching experience?	(J) Have you completed any practicum teaching experience?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
							Lower Bound	Upper Bound
PRE Response	Yes	No	.317*	.091	203.373	.001	.138	.495
	No	Yes	-.317*	.091	203.373	.001	-.495	-.138
POST Response	Yes	No	.097	.080	200.467	.230	-.062	.256
	No	Yes	-.097	.080	200.467	.230	-.256	.062

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_TPACK.

c. Adjustment for multiple comparisons: Bonferroni.

Estimates[a]

Pre or Post?	YEAR	Mean	Std. Error	df	95% Confidence Interval	
					Lower Bound	Upper Bound
PRE Response	2017	2.460	.068	232.793	2.326	2.595
	2018	2.369	.086	243.325	2.199	2.539
POST Response	2017	2.972	.063	216.819	2.849	3.095
	2018	2.913	.081	219.705	2.754	3.073

a. Dependent Variable: AVERAGE_TPACK.

Pairwise Comparisons[a]

YEAR	(I) Pre or Post?	(J) Pre or Post?	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
							Lower Bound	Upper Bound
2017	PRE Response	POST Response	-.512*	.062	197.002	.000	-.633	-.390
	POST Response	PRE Response	.512*	.062	197.002	.000	.390	.633
2018	PRE Response	POST Response	-.544*	.067	197.002	.000	-.677	-.411
	POST Response	PRE Response	.544*	.067	197.002	.000	.411	.677

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: AVERAGE_TPACK.

c. Adjustment for multiple comparisons: Bonferroni.

Pairwise Comparisons[a]

Pre or Post?	(I) YEAR	(J) YEAR	Mean Difference (I-J)	Std. Error	df	Sig.[b]	95% Confidence Interval for Difference[b]	
							Lower Bound	Upper Bound
PRE Response	2017	2018	.091	.105	239.666	.386	-.116	.297
	2018	2017	-.091	.105	239.666	.386	-.297	.116
POST Response	2017	2018	.059	.097	219.241	.546	-.133	.250
	2018	2017	-.059	.097	219.241	.546	-.250	.133

Based on estimated marginal means

a. Dependent Variable: AVERAGE_TPACK.

b. Adjustment for multiple comparisons: Bonferroni.