Developing and Evaluating Second Level Teachers' Technology Integration in Classroom Practice

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Declaration

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of Doctor of Philosophy is entirely my own work, that I have exercised reasonable care to ensure that the work is original, and does not to the best of my knowledge breach any law of copyright, and has not been taken from the work of others, save and to the extent that such work has been cited and acknowledged within the text of my work.

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It feels surreal writing this section. It honestly felt like this day would never come. There are several people who, over the past five years, have made this research possible. Without their love, support and friendship I may not have been here writing this section.

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Abstract

Over the past twenty years, significant advances have been made in addressing intrinsic and extrinsic barriers to technology integration that has led to an increased use of technology-supported teaching and learning in the classroom. However, a key challenge remains in the design and implementation of professional development programmes, for both pre-service and in-service teachers, which can increase the impact of technology-enhanced classroom practices.

This thesis presents three studies that examined second level teachers' technology integration in their classroom practices. The first and second case studies discusses the practices of two cohorts of teachers (n=15). The first cohort were awarded a set of tablet devices for a whole year group, the second cohort were provided tablets by the research team for one academic term. The final study, which built upon the findings in case studies one and two discusses the design and implementation of an undergraduate module for second level pre-service science teachers (n=10), with no prior teaching experience, to extend their technological pedagogical knowledge.

These studies present data collected from teacher's lesson plans, interviews, and independent classroom observations. The Technological Pedagogical Content Knowledge Framework (TPACK), proposed by Koehler & Mishra (2006), was used as an operational framework to discuss teacher's classroom practices.

The results of this thesis highlight that even though the barriers to technology integration have been significantly reduced, and in some cases eliminated, teachers continue to struggle to integrate technology in their pedagogical practices. While school-based professional development was shown to increase in-service teachers' use of technology-enhanced strategies, the teachers' felt they required significantly more support, both to design and implement changes in their classroom practices. The pre-service teachers believed the exposure to new technologies and tools enhanced their confidence and attitudes to integrating technology in their pedagogical approaches. However, observations from a micro-teaching observation with this cohort illustrated that these pre-service teachers had good levels of technology literacy but generally low TPACK levels. This research has focussed on the teachers' approaches to technology-enhanced classroom practices, however further research needs to be conducted to examine the impact on student learning. In addition, it highlights the need for extended studies on the design and implementation of different models for professional learning programmes that can impact on the technology-enhanced classroom practices of both pre- and in-service teachers.

Chapter 1 Introduction

1.1 Introduction

Over the past two decades there has been a resurgence of interest in examining the integration of technology at all educational levels, in particular the implementation of policies and adaptation of classroom practices (Jing and Yong, 2008; Wall and Che, 2013). Many cycles of research have been conducted throughout these decades that produced new knowledges to research such as technology enhanced learning, (Kirkwood and Price, 2014), e-learning/distant learning (Gaskell and Mills, 2014), flipped learning (Wang, 2017) and one-to-one (or 1:1) (Freiman *et al.*, 2010). One of the main aims of technology integration is the promotion of pedagogical change as a result of effective use of technology (McGarr, 2009).

The examination of how technology effects pedagogy was a central aspect of this thesis, as was the converse; what effect did existing pedagogical practices have on technology? (McGarr, 2009). Now more than ever these questions need to be addressed as policy reform in Ireland dictates a new direction for the role of technology in Irish education. The primary goal of this thesis was to examine how teachers with minimal experience of technology integration use technology in their classroom practice.

This chapter will provide an overview of the thesis and detail the layout and focus of chapter sections within the thesis.

1.2 Education System in Ireland

Public education in Ireland is divided into three sectors, Primary, Secondary (post-primary) and Higher education. A child typically enrols in primary school at five years of age and secondary school at 12 years of age. Students follow a Junior Cycle programme within the first three years of secondary school and sit National Examinations at the end of their third year at approximately 15 years of age. Following certification of the Junior Cycle programme, students either elect to complete an optional fourth year known as Transition Year or move straight into the two-year Senior Cycle programme. The Transition Year programme is designed to act as a bridge between the Junior Cycle to Senior Cycle programmes and provide the students with the opportunity to develop maturity and vocational experiences before entering the highly structured Senior Cycle and higher levels of education. The Senior Cycle is a continuation of the Junior Cycle system at a higher content level that prepares the students for continuation into third level education. At the end of the Senior Cycle, students sit a terminal examination whereby they are awarded points. These points are used in the selection process into higher education degree programmes.

A reform of the Junior Cycle programme began in 2015. This reform includes the introduction of classroom-based assessments to reduce the focus and potential stress facing students completing a 100 per cent terminal exam. Participation in the Junior Cycle programme may guide the student's selection of subjects in the Senior Cycle programme. The subjects selected for the Senior Cycle programme may influence the student's choice of higher education degree programmes. The reformed Junior Cycle programme is designed to give schools "*greater flexibility to design programmes that are suited to the needs of their junior cycle students and to the particular context of the school*" (Department of Education, 2015, p. 7). It also seeks to balance the focus between knowledge and skills through the publication of 24 statements of learning (SOLs) (see figure 1.1). These SOLs underpin the principles of the new framework and detail eight key skills. These skills include: being literate, managing myself, staying well, managing information and thinking, being numerate, being creative, working with others and communicating (Department of Education, 2015). These SOLs and key skills are expected to be integrated into new syllabi that will be rolled out for each subject over the coming years.

Several SOLs contain explicit references to technology. For example, SOLs 20, 21 and 24 state that the student *"uses appropriate technologies in meeting a design challenge"* (20)*; "applies practical skills as she/he develop models and products using a variety of materials and technologies"* (21) *and "uses technology and digital media tools to learn, communicate, work and think collaboratively and creatively in a responsible and ethical manner* (24)" (Department of Education and Skills, 2012, p. 6).

Central to these SOLs and key skills are the eight guiding principles that underpin the whole philosophy behind the reformed framework for Junior Cycle programme. The eight principles include learning to learn, choice and flexibility, quality, creativity and innovation, engagement and participation, continuity and development, inclusive education and wellbeing (Department of Education, 2015).

The implementation of the new Junior Cycle began with the introduction of the new English curriculum in 2015. Science and Business curricula were implemented in 2016, Irish, Modern Languages and Art were deployed in 2017. Home Economics, Mathematics, History, Music and Geography curricula were rolled out in 2018 and finally, the new Technology and Religious Education curricula will be implemented in 2019.

Ireland is currently at the precipitous of a major educational reformation. The Irish government has demonstrated a willingness and a desire to invest in and pursue technology integration across the educational sector by 2020. However, with the major changes teachers currently face technology may either become a key driver in reforming their teaching and learning or may get left behind.

The student:

1. communicates effectively using a variety of means in a range of contexts in L1[5]
2. listens, speaks, reads and writes in L2 and one other language at a level of proficiency that is appropriate to her or his ability
3. creates, appreciates and critically interprets a wide range of texts
4. creates and presents artistic works and appreciates the process and skills involved
5. has an awareness of personal values and an understanding of the process of moral decision making
6. appreciates and respects how diverse values, beliefs and traditions have contributed to the communities and culture in which she/he lives
7. values what it means to be an active citizen, with rights and responsibilities in local and wider contexts
8. values local, national and international heritage, understands the importance of the relationship between past and current events and the forces that drive change
9. understands the origins and impacts of social, economic, and environmental aspects of the world around her/him
10. has the awareness, knowledge, skills, values and motivation to live sustainably
11. takes action to safeguard and promote her/his wellbeing and that of others
12. is a confident and competent participant in physical activity and is motivated to be physically active
13. understands the importance of food and diet in making healthy lifestyle choices
14. makes informed financial decisions and develops good consumer skills
15. recognises the potential uses of mathematical knowledge, skills and understanding in all areas of learning
16. describes, illustrates, interprets, predicts and explains patterns and relationships
17. devises and evaluates strategies for investigating and solving problems using mathematical knowledge, reasoning and skills
18. observes and evaluates empirical events and processes and draws valid deductions and conclusions
19. values the role and contribution of science and technology to society, and their personal, social and global importance
20. uses appropriate technologies in meeting a design challenge
21. applies practical skills as she/he develop models and products using a variety of materials and technologies
22. takes initiative, is innovative and develops entrepreneurial skills
23. brings an idea from conception to realisation
24. uses technology and digital media tools to learn, communicate, work and think collaboratively and creatively in a responsible and ethical manner

Figure 1.1 SOLs in the new Junior Cycle Schools Award (Department of Education, 2015)

1.3 Context/Rationale for the Study

The Department of Education and Skills (DES) (2018) published eight key policies specifically for second level education in Ireland. These include: Anti-bullying, Child protection, Data protection, Guidance plan, Internet safety: Acceptable use policy, Relationships and sexuality education, Student council and Substance use. At present, the DES have not yet published an Information Communication Technology (ICT) policy that schools are requirement to implement.

Over the last two decades, the DES embraced technological solutions for classroom practice. In 2001, the DES awarded a capital grant of 6,500 Irish pounds under the Schools Integration Project to each second level school for the sole purpose of purchasing data logging equipment. More recently, in 2013, when the Government of Ireland published the "Building towards a Learning Society: A National Digital Strategy (NDS) for Schools", there was a clear push towards integrating technology into teaching over the coming years. The goal as set out in this document was the "optimal economic and social use of the internet by Business, Government and Individuals" (Department of Communication, 2013). Phase one of this document was divided into three strands of which one focused on education (Strand 3: Education and eLearning). This strand promoted the use of ICT to its' full potential in all sectors of education such as the roll out of 100MB broadband to all second level schools, peer to peer teacher support workshops and case studies, professional development and eLearning initiatives for teachers, development of digital skills, construction of new ICT strategies for schools and a greater emphasis placed on the role of ICT in the new Junior Cycle programme (Department of Communication, 2013, p. 3).

According to this document, the value of digital goods to Ireland's Gross Domestic Product (GDP) in 2012 was valued at €7.1 billion or 4.4% of its GDP. Aside from the significant contribution to the Irish economy, current economic trends have indicated that the digital sector has grown at 10 times the rate of other sectors (Department of Communication, 2013). In order to increase the use and access of ICT in Phase one, the government detailed six aims. 1) eGovernment. to make more extensive use of technology and online services within the public service. 2) Appointment of a digital champion. David Putnam was appointed in December 2013 and his role was to provide independent advice on digital inclusion and act as a leader to stakeholders. 3) Cross departmental action. 4) Obtainment of better customer data. 5) The role of the media in raising awareness of digital inclusion. 6) Increasing the usability and accessibility of web services. This indicates potential benefits of ICT in education that include the sharing and creation of information and resources, student and teacher collaborations, enhanced learning experiences and development of key digital skills. This document also states that the use of technology will increase the efficiency and allow *"for focus on higher level skills such as problem solving, critical and collaborative thinking, team working, creativity and innovation*" (Department of Communication, 2013, p. 22). To support and develop this strand of the NDS, the Department of Communication, Energy and Natural Resources (DCENR) outlined seven actions to be completed in Phase one. The first step was the complete roll out of 100Mb broadband to all 750 second level schools by the end of 2014. Secondly, the DES was to develop a new ICT strategy for schools based on its findings from an online census as well as feedback from key stakeholders in a variety of roles in education. Step three was to integrate ICT into the primary and secondary curricula. The fourth and fifth steps involved empowering teachers by providing digital content and increasing access to peer to peer support. In a similar vein, step six was to pursue the integration of ICT into teaching and learning by supporting teachers with professional development. The final step was to identify and work on developing key ICT skills such as coding.

In 2015, a subsequent report was published by the DES called the Digital Strategy for Schools (DSS) 2015 – 2020 Enhancing Teaching, Learning and Assessment. This report begins with the DES's vision for ICT: that in Irish education we:

"*Realise the potential of digital technologies to enhance teaching, learning and assessment so that Ireland's young people become engaged thinkers, active learners, knowledge constructors and global citizens to participate fully in society and the economy*." (Department of Education and Skills, 2015, p. 5)

The DSS is divided into four key themes:

- Teaching, Learning and Assessment using ICT
- Teacher Professional Learning
- Leadership, Research and Policy and
- ICT Infrastructure.

Theme one highlights the central role technology can play in transforming teaching, learning and assessment practices for both teachers and students. It states that schools may not have a clear strategy for technology integration or even have a clear perception as to what it should look like in the classroom. As such, the DES pledges to provide advice, guidance and examples of best practice to both teachers and schools. The UNESCO ICT Competency Framework for teachers underpins the DES strategy to provide clarity to teachers around the concept of ICT integration (UNESCO, 2011).

Under theme two the DES recognises that both principals and teachers are instrumental to ensuring the success of ICT integration across schools. The report stresses the need to ensure that all teachers have the skills, knowledge and confidence to wield ICT effectively and integrate it into their practices. To this, the DES called upon state providers of professional development to embed technology use into their future CPD designs.

The third theme examines the role the DES plays in being a leader to other agencies and the role research and policies play in monitoring and evaluating the success of national strategies. The report also highlights the role school management structures have under leadership within their school community and how important it is that management take ownership of the challenge that faces them in integrating technology. The DES hopes that innovative practice and experiences will be captured by schools and other education providers and distributed freely to improve the overall education experience.

The final theme, ICT infrastructure simply states the importance broadband access has on making informed decision makers out of students. At the time of publication, the rollout of the 100mb broadband strategy had not been completed by its initial deadline of December 2014 (Department of Communication, 2013). As such, the DES continues to provide funding in the form of grants to schools who wish to purchase equipment such as PC, laptops, notebooks, printers etc.

While technology lends itself to constructivist teaching methodologies, it does not necessarily equate to improved teaching and learning (Jonassen, Peck and Wilson, 1999). Considering the DES push towards the integration of technology into second level education and the significant financial investment involved, it is important to examine teachers' use of technology in their classroom practice. It has been shown that where schools made this investment it was often a top down approach. This approach could leave teachers questioning the value of ICT rather than take ownership and develop plans for successful implementation (Hennessy, Ruthven and Brindley, 2005).

1.4 Objectives of the study

The overall objective of this study was to examine teachers' use of technology to enhance teaching and learning in their classroom practice at second level in Ireland. An embedded multiple case study design was selected to capture teacher's experiences of using technology in their classroom practice. The implementation of the embedded case study design enabled the exploration of the derisible phenomena within the cases (Yin, 2009). The phenomenon examined in this study was teachers' technology integration. However, as will be discussed in chapter two, there is no agreed definition of technology integration within the literature. This lack of definition for technology integration presented a problem when discussing teachers' use of technology in the literature. While this work uses the definition provided by An & Reigeluth (2011), it became clear that such definitions fail to account for the factors that influence teachers technology integration (Bebell, Russell and O'Dwyer, 2004; Ottenbreit-Leftwich *et al.*, 2010). The definition provided by An & Reigeluth (2011) posits that at its' most basic, technology integration is the substitution of technology into existing teaching practices. However, technology integration definitions, such as that provided by An & Reigeluth (2011), do not account for major influencing factors such as teachers' attitudes and beliefs towards technology and teaching, nor does it refer to the teachers' pedagogical beliefs and practices. Therefore, the present work redefines technology integration, not as an operational tick box procedure, but as a series of challenges a teacher must overcome in order to effectively use technology appropriately in their classroom practices. To do this, the author used the works of Hughes (2005) levels of technology integration to provide a clear distinction between teachers' uses of technology that was coupled with Bloom's taxonomy (1956) to provide context for the complexity of the activity in which technology was used. Finally, the observational Technological Pedagogical Content Knowledge Protocol (TPACK) developed by Canbazoglu Bilici *et al.*, (2016) was used as a means to derive teachers' operation of TPACK knowledge constructs in their classroom practice. It is intended that the combination of these tools will provide a more meaningful and operational definition of technology integration that can provide substantive data.

With this in mind the following research questions were developed;

1. How do in-service teachers with minimal experience of technology integration use technology in their classroom practice?
2. What support do in-service teachers need in order to improve their technology integration in classroom practice?
3. How do pre-service teachers with no technology integration experience integrate technology into their classroom practice?
4. What support do pre-service teachers need in order to improve their technology integration in classroom practice?

1.5 Thesis layout

The purpose of this thesis is two-fold. Firstly, it sets out to document the practices of in-service Irish post-primary teachers using tablet technology for the first time. Secondly, the thesis presents a framework for developing pre-service science post-primary teachers' technological pedagogical content knowledge, based on the findings of the first study. Within the thesis there are three studies. The first study examines how a cohort of second level teachers of first year students adapts their teaching and learning when their school was awarded tablet devices. The second study builds on the findings of study one and examines how a small cohort of in-service teachers in an urban school integrate technology into their teaching and learning. Finally, study three determines the effectiveness of a framework, derived from case studies one and two results, in evolving pre-service teachers' Technological Pedagogical Content Knowledge (TPACK).

This thesis is presented over eight chapters. Chapter one details the background context to the Irish education system and the rationale this present study.

Chapter two presents the theoretical background underpinning this research. It examines what technology is and how is it defined. This chapter discusses research on how technology can be used to enhance skill development, teaching and learning and how technology is currently used in schools. The second section of the theoretical background examines technology integration, the barriers to and influences of technology integration and outlines the existing frameworks. The third section examines research on tablet technology, its advantages, disadvantages and key findings. The fourth section examines how teachers use technology and how their experiences of technology were captured and presented. The final section of this chapter discusses the national digital strategy and current junior cycle reforms.

Chapter three presents the methodology selected for conducting this research. It begins by discussing the different types of data and methods by which this data can be analysed. The selected methodology, case study research design, is then discussed along with types of case studies and validity and reliability of case study research. The next section discusses types of analysis methodologies before moving onto the justification for choosing the case study methodology. This section outlines the propositions of the study, the unit of analysis, the research questions and the statement of the case. The philosophical assumptions underpinning this research are outlined before finally discussing the data collection methods and analysis that were conducted in each of the three case studies.

Chapter four provides the background information on School one which was obtained in an effort to examine the effects of a whole school approach to technology integration implementation. It is worth mentioning that the data and methodology contained in this chapter does not reflect those discussed in chapter three which was subsequently implemented in case studies one, two and three. In this chapter data concerning the background information of all teaching staff, their beliefs and attitudes towards teaching and technology and their wishes and wants for their students to succeed in their subjects are all presented. The above-mentioned data was collected through a mixed methods survey instrument adapted from the OECDs Teaching and Learning International Survey (2013). A timeline specific to the events of chapter 4 is included at the beginning of the chapter.

Chapter five discusses the findings from school one. While the original aim of the study was to evaluate a whole school approach to technology integration, the focus of this study shifted to a smaller cohort of nine participating teachers. This chapter describes the first of the three cases studies contained in this thesis and presents the findings from these teachers' observed technology enabled lessons. Findings from the classroom interactions, TPACK and perceived barriers are presented and discussed.

Chapter six introduces the second case study which was conducted in a second post-primary school. Similar in structure to chapter five, this chapter presents the data and findings from six participating teachers in school two. This chapter discusses these teachers' classroom interactions, technological pedagogical content knowledge and perceived barriers to technology integration.

Chapter seven presents the final case study. This case study involved the restructuring of a second-year undergraduate science education module to focus on developing pre-service science teachers' technological pedagogical content knowledge. The data contained in this chapter is discussed at length to include the results of their technology enabled microteaching lessons and their attitudes and beliefs towards technology.

The final chapter, number eight, ties together and compares the results obtained in chapters five, six and seven. This chapter includes a summary of the findings from chapters five, six and seven before addressing the research questions. The limitations of the present studies are highlighted and finally the contributions this work has made to the field of educational technology are outlined.

Chapter 2 Theoretical Background

2.1 Introduction

This chapter examined how teaching and learning has been enhanced through the use of technology. A discussion on the definition of technology integration is presented before moving onto identifying the challenges faced when integrating technology into classroom practice. The next section examined studies which have evaluated the impact technology integration has had on classroom practice before concluding with a brief discussion of the research questions answered in this body of work.

For the last two decades, the body of literature concerning teaching and learning with technology has seen a surge of interest (Li *et al.*, 2010). The potential to enhance and improve teaching and learning (Hew and Brush, 2007), supporting students' knowledge construction (Scardamalia and Bereiter, 1991), fostering collaboration, providing authentic learning situations and accessing complex and contextualised knowledge (Jonassen, Peck and Wilson, 1999) are some of the contributing factors responsible for this surge of interest. The literature contains a multitude of studies that examine different areas of technological research. Some describe the use of certain technologies (Bishop-Clark, Courte, & Howard, 2006), tools (Diacopoulos, 2015), potential benefits they possess (Burns, 2013) and research on teachers' attitudes and beliefs towards teaching with technology (Ertmer, 1999). Within the context of the literature, one could forget the reasons why technology should or should not be used in teaching: what are the benefits? What are the challenges and how are they overcome? This section will justify the purpose of researching the educational technology field by assessing the literature that describes how technology has been used to enhance both teaching and learning.

Technology has been closely linked to education over the past two decades with several research papers arguing for the many benefits technology may provide (Honey and Moeller, 1990; Carolyn Yang and Chang, 2013). Within those two decades, the literature has seen a variety of technological trends that have come and gone. Martin *et al.* (2011) presented a forecast of the most promising technological trends based on the yearly Horizon reports. Over the ten-year period, 2004-2014, they identified trends that rose to prominence one year, and disappeared in subsequent years, for example, educative gaming, learning objects, intelligent search, knowledge web and ubiquitous computing. However, in their analysis, they found that, from 2010, the saturation of the mobile market, which includes smartphones, laptops and tablet devices, led to the resurrection of past trends, concluding that mobile technologies are making previous trends viable again.

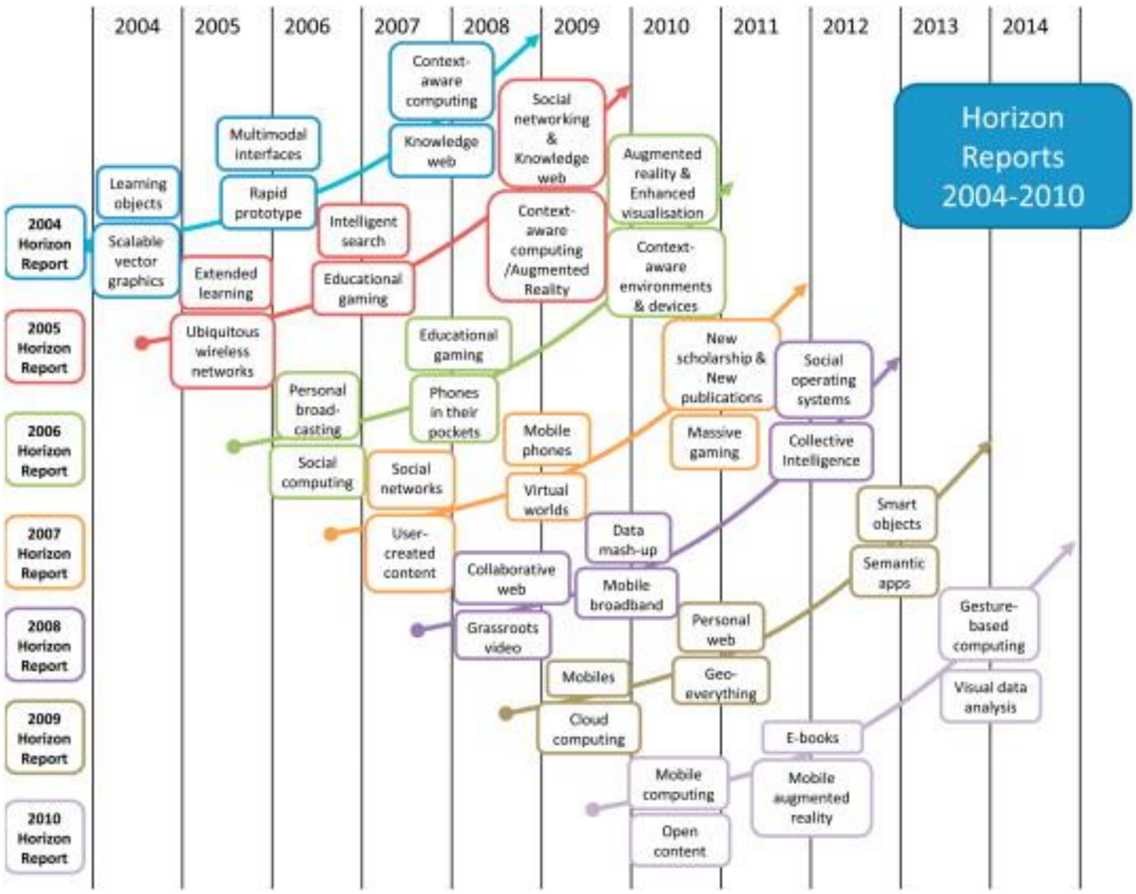


Figure 2.1 List of technologies identified by Martin *et al.*, (2011) which were most likely to impact education.

2.2 How is teaching and learning enhanced through the use of technology?

The following section discusses how technology has been implemented though all levels of education for the benefit of both teaching and learning. A selection of studies is presented in table 2.1 below and follow up discussion is presented below. The list of included literature in table one is not intended to be exhaustive or definitive but highlights how technology has been used to enhance teaching and learning under the following headings: student skill development, motivation and engagement, 1:1 initiatives, data logging in science and interactive whiteboard.

Table 2.1 contains a summary of literature that was reviewed within this chapter. Contained in this summary is the technology used for the research, the participants, the impact being examined and finally the reference. This list is not exhaustive nor is it the only literature examined in the context of this thesis, it is however, a synthesis of the most relevant research within the area of technology integration and technology enhanced learning. This particular literature was selected for inclusion due to the impact it had on the direction of the research. The literature included in table 2.1 in some way informed the research, either through new knowledge and understandings, or providing useful insights for the development of the research. Additionally, the included literature provides a coherent sense of the scale of research conducted within these areas. The majority of participants in the literature were university students or second level teachers and students. The research often focused on the impact of specific aspects of learning such as: independent learning, engagement, conceptual understanding etc while also focussing on the extent to which teachers can be limiting factors in effective technology integration. In the sections below the studies are examined and discussed after which the theoretical framework underpinning this thesis is presented.

Technology	**Participants**	**Impact on:**	**Literature Ref**
One Screen Multi-Mouse Display	Primary school children	"Silent collaboration" and students' collaboration skills	(Szewkis *et al.*, 2011)
Mixed reality environment	Primary school children	Students' enjoyment of learning.	(Yannier *et al.*, 2016)
Integrated Write to Learn Methodology	Grade one students	Reading and writing skills	(Genlott and Grönlund, 2013)
Virtual Learning Environment for assessing ICT skills	Second level students	Students as effective consumers of information but poor producers	(Claro *et al.*, 2012)
1:1 laptops	Second level students	Students understanding of the nature of science, interaction between science and technology and social, economic, political and environmental impact of science and technology	(Freiman *et al.*, 2010)
Web 2.0 eJournal	University English as a Foreign Language students	Communication and Comprehension	(Chang and Lin, 2014)
Digital Game Based Learning	University Biology students	Critical thinking skills	(Carolyn Yang and Chang, 2013)
Computer Assisted Instruction Program	University Design students	Freehand sketching accuracy	(Luh and Chen, 2013)
Computer programming course	University students	Students working in groups experienced significantly higher enjoyment of course	(Bishop-Clark, Courte And Howard, 2006)
Blogging	University students	Personal innovation in IT, extraversion, conscientiousness and agreeability impacted on enjoyment of blogging	(Wang, Lin and Liao, 2012)
Tablet PCs	University students	Students' conceptual understanding of mathematics	(Galligan *et al.*, 2010)
1:1 laptop use	Teachers	Mathematics teachers self-reported beliefs impact on their classroom practice	(Kim *et al.*, 2013)
1:1 laptops vs laptop carts	Teachers and students	1:1 classroom exhibited more instances of student independent learning, dialogue and increases in student engagement.	(Bebell, Russell and O'Dwyer, 2004)
Technology infused initial teacher education	Pre-service teachers	Pre-service teacher technology integration and TPACK.	(Buss *et al.*, 2018)

Table 2.1 Table of literature discussed in chapter 2 section 2.2 arranged by age of participants in study

2.2.1 What is the impact of technology on student learning?

Technology Enhanced Learning in Skill Development

Over the last decade, there has been an increased focus on the development on skills, both subject specific skills and 21st century skills through the use of technology in the classroom. The Organisation for Economic Cooperation and Development (OECD) outlined in the 2010 report "*Better Skills, Better Job, Better Lives*" how 21st century skills have become the global currency in the 21st century market place (OECD, 2010, p. 10). The technology enhanced learning literature contains a number of studies examining the impact technology has on developing these skills such as: communication, group work, organisation, read and write, critical thinking, drawing, ICT skills and knowledge retention.

In his social development theory, Vygotsky postulated that social interactions play a fundamental role in the cogitative development process (Vygotsky, 1962 as cited in Berk and Winsler, 1995). With social interactions playing such a key role in the cognitive development of students it stands to reason that TEL research would examine the effects of technology on communication and collaboration skills. Recent technology research has shown that communication and group working skills in particular have seen significant improvements due to the introduction of Web 2.0 technologies (Chang and Lin, 2014). The introduction of web 2.0 tools means students can now communicate with each other instantly over a wide variety of software and devices. It also makes learning more personal, social and flexible (Lam, Chung and Lam, 2010). In recent studies, when communication and web 2.0 tools were integrated as part of the study design, the researchers found that students literacy communication and overall enjoyment of the topic increases. One such study was conducted by Chang and Lin (2014). In their study the authors examined what effect a web based reflective learning journals had on English as a Foreign Language (EFL) students' English comprehension and communication abilities. To evaluate the effect the authors recruited 98 university students enrolled in a multimedia based English programme consisting of fifteen online units. The students were divided into two groups; those using reflective journals and those who were not. Using a randomised post-test only design, the study deployed the General English Proficiency Test (GEPT) at the close of the course and compared the scores of the two groups. Data was also obtained from surveys, interviews and students own reflective journals. Their results showed that utilising the reflective learning journal deepened the students' quality of learning as it provided them with an opportunity to practice important reflection on curriculum material and make progress towards transformative learning.

One study that highlighted the effectiveness of technology on student collaboration was conducted by Szewkis *et al.*, (2011). In their study the authors wanted to demonstrate that even with cheap technology, teaching and learning, can be enhanced with technology, in particular collaboration. Using a single display and a connection of multiple mice (per student), the researchers developed a classification matrix for use in a Spanish language learning classroom.

The premise of the matrix was to utilise a "*silent collaboration*" (p.1) approach in which students compare their thoughts and suggestions silently with their class via the single display and multiple mice setup. To assess whether collaborative learning was achieved the researchers outlined their six conditions for collaborative learning, these were: 1) working towards a common goal, 2) coordination and communication between peers, 3) Individual accountability, 4) Joint rewards, 5) awareness of peers' work and 6) positive interdependence between peers (Szewkis *et al.*, 2011). Their results showed that all six conditions of collaboration were met and that in large groups collaboration can still lead to effective learning in the classroom.

Another set of skills that have received some attention in the research are critical thinking and problem solving. One such example was a study conducted by Yang and Chang (2013) on whether Digital Game Based Learning impacted on the student critical thinking skills, concentration and academic performance. In this study 67 second grade biology students took part in a 19-week long experiment. They were divided into two test groups: experimental and comparison. The groups were set different tasks over the duration of the study. The experimental group were tasked with designing a digital game while the comparison group designed flash animations. The game and animations were based on the content of the biology course they were currently studying. The researchers implemented a pre-test, post-test and delayed post-test collection method to gather results. It was found that students in the experimental group demonstrated improvements in their critical thinking skills at both the post-test and delayed post-test compared to the comparison group.

The combination of critical thinking skills, problem solving, communication and collaboration are a subset of the group of skills now known as 21st century skills (Rivero, 2010; OECD, 2013). The studies above have shown that with purposeful implementation technology can be used to enhance students development of these 21st century skills, which are needed to succeed in the 21st century workplace (OECD, 2010). These are not the only skills that technology studies have examined for enhancement. Studies examining the development of subject specific skills or read/write are presented below.

In their paper, Luh and Chen (2013) identified that current educational practice of free hand sketching was inadequate. Arguing that freehand sketching is a key tool for conceptualising a project in its early stages, Luh and Chen believe improper instruction could lead to incorrect construction of three-dimensional units (2013), this in turn increases the development time of the design process. In their study, Luh and Chen developed a Computer Assisted Instruction (CAI) program based on two principles: observe and memorise and visualise and verify. The program would present the participant with a 3D image which they would commit to memory and using the graphics tablet provided, replicate as closely as possible a free hand sketch of the image. The program would then inspect the participants sketch, point out errors and return an overlay for improving the accuracy of the sketch. The CAI was trialled on 40 first year design students who had no formal experience with free hand sketching, eliminating previous experience as a variable. The cohort was divided into a control and experimental group. The control group experienced the traditional lecturing method of the course while the experimental group used the CAI and pen and paper instructions instead. After six weeks it was found that the use of the CAI improved students free hand sketching accuracy by 19% for 3D cube shapes.

Another example of subject specific skill development, albeit more generalised, was in Genlott and Grönlund's (2013) study on the effects a particular methodology had at enhancing grade one students' read and write skill. This was achieved by delaying the writing portion of the Swedish curriculum until grade two and instead, focusing on reading. The Integrated Write to Learn (iWTR) methodology allowed students to use computers as well as other ICT tools to compose text and engage in discussions with their peers. This placed the emphasis on the cognitive development of learning to read while postponing the motor development skill until later. Students also used published materials and social networks to communicate and comment on articles. What distinguishing this methodology from the one specified in the Swedish curriculum was its active learning approach via the engagement of published material, peer feedback, active writing and formative assessments. The study consisted of four groups, two test groups and two control groups. Using standardised tests and observations it was found that students in the test group considerably improved their reading skills. However, the biggest result was observed in the students writing skills. Students in the test groups were able to construct longer texts, demonstrate more eloquence and clearly outline their content knowledge.

Another branch of 21st century skills are ICT skill. Claro *et al.,* (2012) implemented a virtual learning environment built as a performance-based assessment to assess ICT literacy. In their study the authors defined ICT skills as the capacity to solve problems of information, communication and knowledge in digital environments (p.1042). This study found that in excess of three-quarters of the students were able to use information provided to solve the tasks at hand. Fifty percent of the participants were able to effectively organise their digital information. On the other hand, when students were tasked to create information, very few students were able to succeed. The assessment application developed by the authors created a virtual learning environment, consisting of applications designed to emulate real life scenarios such as office packages, email clients, web browsers and chat windows. Four key dimensions were saturated throughout the story of the application, ethics, communication, social impact and information. The program was tested for reliability and found that the social and ethical components appeared as distinct factors while the information and communication factors were later considered to be uni-dimensional. This study highlights that students are effective consumers of information, but struggle to be producers of information.

Motivation and engagement in technology enhanced classrooms

One developing field of research within the educational technology arena is the effects of enjoyment and immersion on students' engagement with learning.

One of the first studies to examine the effect technology has on students' enjoyment was by Bishop-Clark *et al.,* (2006). In their study, sixty-four students participated in and completed an introductory computer programming course in which they were assigned a task to be completed within one week. The students in this study were divided into two distinct groups, the first consisted of individual students working alone on the task, the second were pairs of students completing the task together. Their results found that while every student cited an increase of confidence in their programming skills, the students of group two, that is, the pairs, experienced a significantly higher level of enjoyment than those students who worked individually.

Six years later, during the proliferation of blogging in the educational setting, researchers Wang, Lin and Liao (2012) investigated the personal characteristic differences of perceived enjoyment in students' use of blogging. To do this, the researchers used two research instruments to create their research model: individual differences related to computer skills, and the Big Five personality traits (extraversion, agreeability, conscientiousness, neuroticism and openness to experience). Using the survey data collected from 358 university students, the structural equation modelling software was used to test against the proposed research model. Their results found that several factors had a significant impact on students perceived enjoyment of blogging. These factors included: students' personal innovation in IT, extraversion, conscientiousness and agreeability. However, there were major limitations with this research: for example, the exclusion of several other individual difference factors such as prior experience and computer anxiety among others.

Currently, there is a push towards integrating new Augmented Reality applications due to their perceived ability to provide students with real-world immersive experiences thereby promoting enjoyment and engagement in learning (de Souza e Silva and Delacruz, 2006). However, immersion and valid ways to measure it, especially in the AR context have been notably absent (Georgiou and Kyza, 2017). However, a recent study conducted by Georgiou and Kyza (2017) put forward a novel augmented reality immersion survey specifically developed to measure immersion. The 21-item survey instrument was developed through two rounds of factor analysis. Firstly, the authors used exploratory factor analysis with 202 second level students' responses, after which twelve items were deleted. The second stage included confirmatory factor analysis on data obtained from 162 questionnaires. However, the results showed that the construct was not valid and in order to improve this validity, an item selection procedure was initiated to maximise the validity of items. This resulted in a 21-item instrument with Cronbach alphas of over 0.70. Aside from the limitations imposed by self-reported data, this instrument is the first of its kind to evaluate immersion in location aware augmented reality environments, which the authors believed should drive research on this new field of technology innovation. Augmented reality is not the only immersive educational experience currently under investigation. A study conducted by Yannier *et al.*, (2016) examined the effect a mixed reality environment had on primary science students learning and enjoyment of the subject. Using the programme "*EarthShake*", the researchers developed a controlled experiment with sixty-seven students between the ages of four and eight. Earthshake uses a variety of tools and objects to achieve its mixed reality. Focussing on balance and stability, the programme uses a Kinect sensor and a display screen behind a multimodal purpose-built table. Using the predict/observe/explain cycle students are asked to make predictions regarding the stability of a set of blocks, observe the outcomes and then explain those outcomes. Using a purpose-built design of Earthshake and scenarios specifically created for this study, the researchers found that the use of mixed reality lead to significant gains not only in student enjoyment but also in learning. The results imply that the use of physical manipulatives in science through the use of mixed reality may have the potential to increase students' knowledge and understanding of scientific content.

2.2.2 What types of technology have been used to enhance teaching and learning?

1:1 technologies in the technology enhanced classroom.

One-to-One (1:1) technology is an emerging use of technology in education and has been increasing due to decreasing cost and increasing availability of such devices. In the last couple of years, this field has received considerable attention, mainly due to affordability and ease of access to tablet and laptop technologies (Keengwe *et al.,* 2012, Jopling, 2012). While this is still a fresh area of research, there appears to be two main themes emerging from the literature for 1:1 use, Online and Face-to-Face (Jopling, 2012). In this review the focus will be on Face-to-Face use of 1:1 computing as it is the most applicable to the context of the studies conducted within this body of work.

Many studies have identified that 1:1 initiatives improve students' technology literacy, develop 21st century skills, literacy and numeracy and increase motivation during lessons. One study examined the impact 1:1 initiatives had on students in a New Brunswick school in Canada. In a two-year study of laptop use in schools in New Brunswick's, Canada, Freiman *et al.,* (2010) argued that while laptops by themselves may not increase test scores, they can encourage innovation by creating open-ended, collaborative classrooms that are constructivist in nature and use cognitively rich learning tasks. The study used pre- and post-test interviews, questionnaires, problem-based learning scenarios and classroom observations to collect data. Samples of teachers' planning documents and students' work were also collected and analysed. Rather than rely on standardised tests to evaluate the students' achievement, the researchers used four problem-based scenarios, two for each grade. These PBL scenarios tasked the students with solving real-life complex problems with curricular links. These PBL scenarios were given to students at the beginning and end of the school year. Students were grouped into 3 or 4 per group. To track the changes in scientific knowledge, the students were required to draw concept maps – more complex maps suggested a somewhat conceptual change in student thinking. This study also tracked changes in: 1) The understanding of the nature of science and the ability to generate scientific attitudes and skills in practice 2) The interaction between science and technology 3) Understanding of social, economic, political and environmental aspects of science and technology (Freiman *et al.,* 2010). Significant improvements were found in all three areas as well as in the concept maps in both grade groups. The scope of the study was restricted to science lessons, and, with respect to the subject, the findings showed that students developed skills in organisation, communication, group work, research and literacy. The researchers found that the PBL scenarios allowed the students to engage in more meaningful ways. It was also found that the students used the devices to direct their own learning. The researchers conclude that in order for teaching with technology to be effective, a "paradigm shift" in the teachers' pedagogy must occur. In essence, the focus should be on the process of learning rather than learning for examinations.

Galligan *et al.,* (2010) looked at how tablet PCs can be used in universities to help students understand mathematics. The researchers looked at three areas of tablet use: lectures, tutorials and consultations. In the lectures, the tablet was used as a writing tool, which was displayed on the data projector. The lectures were recorded, and students could access these afterwards. Students reported mostly positive feedback from the tablet use. Hughes (2005) described three phases of technology use: replacement, where the technology is simply used to replace existing technology, e.g., using the tablet as opposed to the Whiteboard. Such practice provides no meaningful integration of technology (Hughes, 2005). The second instance were tutorials. These tutorials were held synchronously online. The tablet once again was used as a digital whiteboard, which all students could see. Consultations were the third and final example. These consultations were performed online, again similar to the tutorials, but focused on 1:1 interaction. Once again, the tablet was used as a digital whiteboard.

In terms of integrating 1:1 technology into lessons, Carolyn Yang and Chang (2013) report that Mathematics teachers are the most reluctant (Carolyn Yang and Chang, 2013). Kim *et al.,* (2013) conducted a mixed methods research to investigate 28 mathematics teachers' beliefs related to technology integration practices. Questionnaires and semi-structured interviews were conducted to collect data. Not all teachers participated in both questionnaire and interviews. The questionnaire consisted of 72 items where responses were measured on a 5-point Likert scale. Results from the questionnaires were analysed to generate a scoring system. Comparisons could be made between teachers with similar scores on beliefs, attitude and confidence. Analysis of the data revealed three main groups: Non-Adopters, Cautious Adopters, and Early Adopters (Carolyn Yang and Chang, 2013). Analysing the responses, it was apparent in these 1:1 schools that bringing in the laptop was optional. As a result, some teachers reported that students only brought their laptops in once a week. It is never stated whether students purchased their own laptops, or if they were provided by the school. The results show that the most frequent use of laptops in mathematics lessons was working with spreadsheets, drill and practice, and eBooks. One of the main reported problems with using laptops in the mathematics class was the difficulty of writing formulae. Non-Adopters and Cautious Adopters reported students were off-task more often than early adopters and were more likely to stop using laptops in class as a result. Another hindrance was the lack of professional development for teachers and collaboration amongst colleagues. It was found that two beliefs were commonly held across all adopters "*maths is something you do on paper*" and "*laptops are more useful for higher-ability students*" (Carolyn Yang and Chang, 2013, p.335). Such beliefs can influence teachers' willingness to engage with technology and thwart their progress implementing technology into their lessons effectively. Interestingly of the 19 teachers interviewed only one expressed the view that laptops were an engaging resource for teaching and learning. However, in the questionnaire, it was revealed that there was strong support for this view. Such discrepancies raise concerns about the validity of self-reported data as a means of quantitative analysis (Genlott and Grönlund, 2013). Another issue with this questionnaire was the focus on the use of specific technologies. This study provides insight into studies implementing a cross-subject approach in so far as the teaching and methodologies of each specific subject must be considered before technology can be effectively implemented. Otherwise, teachers will remain in the replacement phase of technology integration or may even stop using technology in their lessons.

Russell, Bebell and Higgins (2004) conducted a study to determine if there were differences in teaching and learning in a primary school setting for those who have 1:1 access or laptop carts. The laptop cart was shared between classes on a weekly basis. The study was carried out for two months where a mixed methods approach was used to collect data. Surveys for students were carried out and interviews and structured observations with teachers. Some examples of student's drawings were also taken. Unfortunately, the students already had laptops and as such the researchers were not able to implement a pre-test post-test design. However, the purpose of this study was to examine and compare any differences in pedagogy and learning activities between the 1:1 classroom and the laptop cart classroom. In total 209 students participated in this study. Interestingly, in the year previous to this study the principal developed a volunteer program where parents could purchase laptops for their child. This presented a problem as a 1:1 classroom was non-existent. As a result, a fund was set up to allow any parents who wished to be involved in this program purchase laptops for their child. In total four 1:1 classrooms were established and five shared laptop cart classrooms. 44 classroom observations were accounted for during the study. During each observation several measurements were taken including:

1. Student engagement
2. Student group sizes

3. Student engagement with technology/non-engagement
4. The role of the teacher

Measurements were taken every 10 minutes using an observational checklist. Each observation lasted an hour and at the end a detailed reported was produced. Like other studies teachers were interviewed using a semi-structure approach. The interview revolved around the teachers' use of technology. All 209 students completed the survey which provided information on the student's specific use of technology at home and during school. Finally, students were also given a drawing prompt where they were asked to draw a picture of themselves doing work in the classroom. The researchers implemented three analysis techniques for evaluating the observations. Firstly, readers who were unaware of the purpose of the research read the transcriptions and were asked to identify patterns and trends in each of the classrooms. Also, each reader was asked to comment on any similarities or differences between the classes in terms of teaching and learning activities. Secondly, codes were created to describe and quantify the observation notes, in total 102 codes were created. Thirdly, the observational checklist was examined, this checklist provided information on groupings, level of engagement, roles of the teacher and number of students working with technology. Means were also calculated across all the intervals. The student surveys were examined, and sample t-tests were conducted at the .05 significance level. Lastly, the student's drawings were analysed using an analytical coding framework developed by the authors during a previous study. Four themes were analysed using this coding system:

1. Student characteristics (What is he/she doing?)
2. Technology Present (What is depicted?)
3. Student demeanour (Is the student depicted positively negatively or neutral?)
4. Other features (Teacher present, other students etc.) (Tenekeci, 2011)

A statistical significance was found between the 1:1 and laptop cart groups. It was found that when 1:1 laptops were used, the technology use for academic purposes increases significantly. It was also found that students were more likely to work independently in 1:1 classrooms and that the interactions between teacher and students change. Student engagement also increased significantly as well as the amount of time students spent on writing tasks.

In a two-year longitudinal study, Buss *et al.*, (2018) examined the effectiveness of a technology infused approach to increasing pre-service teachers' technology integration. Technology infusion related to the integration of technology throughout the curricula and course materials with the intention of developing teacher preparedness for technology integration. Using the TPACK framework as a model for technology integration the study, the authors replaced one-year standalone courses with technology infused variants. The authors worked closely with the professional development coordinator to revise the syllabi of the courses and include assignments which were technology-rich. In the two, technology infused courses, the purpose of the of technology component was to provide students with an opportunity to engage with technology as a learning tool, attaining experiences with different technologies, understanding ethics and integrating technology into teaching. In total, there were 71 participants in their study out of a possible 300 who completed all four data collections. The study utilised a mixed methods design to gather quantitative survey data and TPACK scores, and qualitative data from focus group interviews. To calculate the TPACK scores of the pre-service teachers', the authors used an adapted version of Schmidt *et al.*, (2009) TPACK assessment instrument. The survey contained 53 items all placed on a 5-point Likert scale ranging from strongly disagree to strongly agree. During the interviews, the six participants were asked questions on their technology integration practices and their attitude and beliefs towards technology integration. In their discussion, the authors found that a technology infused methods course was effective in developing pre-service teachers' technology integration and TPACK. The results from this study may suggest that earlier interventions may be needed in pre-service teacher education to ensure future teachers are prepared to engage with and develop technology enabled lessons where appropriate.

In all, the research shows that use of 1:1 technology increases student's time on task increases motivation and interest in learning as well as their academic performance and can be used to develop 21st century skills.

2.3 Theoretical Framework

This section has highlighted some of the key studies conducted over the last two decades focussing on how various forms of technology have enhanced teaching and learning. The research has shown that improvements can be made to students' skill development, their motivation and engagement and their academic performance when technology is utilised innovatively. However, one field of study not discussed in the literature was teachers' experiences using 1:1 or tablet technologies for the first time in their teaching. As will be discussed later in this chapter, teachers' attitudes and beliefs can have a significant impact on a teachers' willingness to implement technology and as such may hinder any enhancements as a result of the successful integration of technology. Therefore, this study sets out to examine how teachers integrate technology into their classroom practice and addresses four research questions:

1. How do in-service teachers with minimal experience of technology integration, use technology in their classroom practice?
2. What support do in-service teachers need in order to improve their technology integration in classroom practice?
3. How do pre-service teachers with no technology integration experience, use technology in their classroom practice?
4. What support do pre-service teachers need in order to improve their technology integration in classroom practice?

2.3.1 What is technology integration?

This section examines how technology enhanced teaching and learning has been discussed in the literature and presents the definition for technology integration as utilised in this research. Up until 2004 no formal definition existed for the naming of technology integration (Bebell, Russell and O'Dwyer, 2004). Even post 2005, the literature examining technology integration failed to provide a formal view or definition of their understanding of technology integration, making the assumption that there is a clear understanding of what technology integration means. Hew and Brush (2007) recognised that no standard definition existed citing at least three understandings of technology integration in the literature. The first examined technology integration in terms of low or high-level teacher computer use. The second definition examined technology integration as the implementation of technology to conduct familiar activities more efficiently or reliably. The final definition acknowledged teachers who use technology to develop student critical thinking skills. Hew and Brush (2007) continue to then define their own vision of technology integration which was used in their study. They defined technology integration as the use of computer devices for instructional purposes.

While these definitions clearly describe their view on technology integration, it is this author's view that they ignore the fundamental educational developments over the past century, developments such as constructivist teaching methods and differentiation of teaching and instructional materials. As such, a new definition for technology integration was utilised throughout this study. The purpose of creating a new definition in this work was to address the concerns raised above and present a definition that encompasses not only the use of technology, but the level at which technology is used and considered teaching methodologies adopted by those teachers using technology. To do this, Hughes (2005) framework of technology supported pedagogy (discussed in Section 2.3.2) was combined with Canbazoglu Bilici, Guzey and Yamak's (2016) framework for Technological Pedagogical Content Knowledge (TPACK) (discussed in Section 2.3.3). These two frameworks create a clear distinction between levels of technology use, while also lending credence to the importance of a teacher's knowledge of content, pedagogy and technology. From here on, technology integration will be defined as "*the considered and differentiated use of technology in any teaching and learning environment*".

2.3.2 Framework for technology supported pedagogy

Hughes (2005) study examined the nature of English teachers' learning throughout professional development activities to improve technology supported pedagogies. This study presented a framework for examining technology integration in the classroom by defining three categories from which technology supported pedagogies could be described:

1) Replacement: Teachers replace a teaching method with technology, e.g. using PowerPoint instead of writing on the blackboard.

2) Amplification: A teacher uses technology to accomplish tasks more efficiently, e.g. using online documents for group projects that allow all group members to simultaneously work on and edit a document.

3) Transformation: Technology is used in innovative ways to encourage and engage students, to assist with cognitive development, e.g. using data recording equipment in science class to record results, previously unobtainable without the use of technology (Chong and Lee, 2012).

This breakdown of the levels of technology integration was used to distinguish between effective and non-effective use of technology in the classroom (Hughes, 2005). In their study, Hughes (2005) found that novice teachers tended to utilise replacement technology supported pedagogies more than their more experienced colleagues who had higher occurrences of amplification and transformative lessons. In the literature technology integration and technology enhanced learning have often been used interchangeably.

In the last few years' two major review studies conducted by Kirkwood and Price (2013) and Bayne (2015) examined the literature area of technology enhanced learning (TEL). In their study Kirkwood and Price (2013) conducted a critical literature review to examine the claims and evidence related to technology enhanced learning within the period 2005 – 2010. In total 47 articles were reviewed using the keywords "*technology*", "*university*" "*higher education*", "*teaching*", "*learning*" and "*empirical*" or "*evidence*" (p. 9). Thematic analysis was conducted on these 47 articles and it was found that, even though not specified, the goals of each study could be characterised into one of three themes:

"*Replicating existing teaching methodologies*",

"*Supplementing existing teaching practices*" and

"*Transforming the learning experience*". (p. 9)

Studies that were categorised into one of the first two themes tended to focus on how to improve students' scores and knowledge retention. The third theme "*Transforming the learning experience*" was concerned with improving students' ability to learn and develop their skill set (Reilly, 2005). Of the 47 studies, nine were coded into theme one, replicated existing teaching methodologies. In eight of these studies, the participants replicated some element of conventional "*sage on the stage*" (Van Ast, 1997) teaching with technology, while the last study compared the same teaching method using differing technologies. 23 studies were identified as supplementing existing teaching practices (theme two), which included making existing course materials available online for students or adapted versions specifically for consumption with technology. Finally, a further 15 studies focussed on redesigning learning activities (theme three) to be more active or, in some cases, investigated how TEL activities could promote richer learning experiences. In their discussion, Kirkwood and Price (2013) commented on the scarcity of literature reporting on TEL research. As such, they identified six areas that warrant further research, these were: a) differing ways in which enhancement and evidence were conceived, b) the methods and evaluation of the studies, c) the types of evidence used, d) difficulty in identifying causality and e) the extent to which the findings can be generalised (Kirkwood and Price 2013). Kirkwood and Price (2013) recommended further research on reporting actual teaching and learning situations that draw upon or shed light on the evidence appropriate to the study, rather than evaluations of teaching enhancements.

While the use of technology integration and TEL are sometimes used interchangeably, Bayne (2014) takes issue with the premise of TEL. In their position paper, Bayne (2014) presents the argument against using TEL and takes issue with the lack of clarity, in part due to the implication that enhancement of learning can only be achieved through technology. Prior attempts to clarify TEL have failed to satisfy Bayne as these definitions lack social and material characteristics. Several of the studies reviewed by Bayne emphasise the enhancement of learning through the implementation of technological artefacts into already established teaching practices with no rationale as to why this transition is a desirable one. Bayne recalls the critique brought forward by Hamilton and Friesen (2013) against online education literature. This literature is overly dependent on two common sense understandings of the nature of technology, the essentialist and the instrumentalist (Hamilton and Friesen, 2013). Essentialism bestows technological artefacts with the ability to achieve pre-defined goals such as improve learning. Whereas instrumentalism highlights that technology presents the means to this nirvana. Hamilton and Friesen (2013) go further, adding:

"*Both approaches see technology as an independent realm of pure technical and scientific law, unsullied by the differences, values or interests that typify the social world*" (p.20)

Concluding, Bayne (2014) states that we must consider the sociotechnical and sociomaterial effects of technology and not just technology in isolation. Rich data should be collected on the interaction of the participants between the social and material. The notion that learning is open to enhancement merely by application of technology should be dismissed, and examination of the complex relationship between teaching and learning with respect to social and material contexts should be conducted.

The criticism levelled at TEL by Bayne (2014) provides further evidence that technology integration should be considered separate to TEL and warrants its own distinct definition. A definition that, as stated in section 2.3.1 placed an emphasis on the interactions between teachers' understanding of teaching and learning, and their development of technology enabled lessons. To strengthen the definition of technology integration we must try to conceptualise the relationship between teachers' understanding of technology and pedagogy.

2.3.3 Framework for Technological Pedagogical Content Knowledge

Currently the only proposed framework for conceptualising the relationship between teachers' knowledge of successful technology integration and pedagogical practices is the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra and Koehler, 2006). Building upon the pedagogical content knowledge (PCK) framework developed by Shulman (1986), Mishra and Koehler (2006) presented TPACK as an amalgamation of several knowledge domains. The framework describes the relationship between Content Knowledge (CK), Technological Knowledge (TK) and Pedagogical Knowledge (PK) and how the relationships between these domains form new subdomains, namely Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK) and Technological Pedagogical Knowledge (TPK). The central construct of TPACK, namely, TPCK was first introduced by Pierson (2001) in their paper entitled "*Technology Integration Practice as a Function of Pedagogical Expertise*".

It is important to discuss the main critiques within the literature pertaining to TPACK. The first issue actually dates back to 1986 and Shulmans concept of Pedagogical Content Knowledge (Shulman, 1986). The TPACK framework is an extension of Shulmans PCK and as a result brings with it the criticism that still pertain to this day (Marks, 1990; Hu, 2014). The main criticism levelled at PCK is the inability to distinguish between the constructs since no formal definitions are provided. In their paper Marks (1990) found that in the field of mathematics education, researchers have used PCK, but little work had been done to clarify it, still leaving the differences between the constructs "*fuzzy*". This "*fuzzy-ness*" was still present through the early to mid-2000s with Gess-Newsome (2002) eventually recognising that it is difficult to produce adequate definitions of "*complex concepts and…establishing clear, discrete and manageable categories*" that can in turn be examined (p.6). In response to this difficulty, they developed two approaches to PCK, the integrative and the transformative. In the integrative model, PCK is not a unique form of knowledge but rather a combination of content and pedagogical knowledge. In the transformative model, PCK is viewed as a unique form of knowledge, one that is developed from the interaction and transformation of pedagogical and content knowledges. Since TPACK builds upon the fuzzy foundations laid by Shulman and adds additional layers of conceptually difficult notions, it becomes even harder for researchers to accurately measure TPACK (Graham, 2011). Graham (2011) continues that in order to accurately measure TPACK, one must align themselves firmly either with the integrative or transformative model of PCK. Only then can understanding be assigned to the instrument. With the limitations of the TPACK framework stated, an examination of how TPACK has been utilised in the literature is presented below.

A study conducted by Schmidt *et al.,* (2009) developed a valid and reliable instrument to measure pre-service teachers' TPACK and associated knowledge domains. The instrument, Survey of Pre-service Teachers' Knowledge of Teaching and Technology, which was developed for a course introducing pre-service teachers to technology use in K-6 classrooms, contained 75 measurable items: 17 for CK, 8 for TK, 10 for PK, 8 for PCK, 15 for TCK, and 9 for TPK. Each of these items was ranked on a five-point Likert scale from strongly disagrees to strongly agree. A factor analysis was conducted on each TPACK domain and it was concluded that this survey instrument was valid and reliable in measuring these pre-service teachers' self-assessment of TPACK knowledge domains. Building upon this work, a subsequent study conducted by Mouza *et al.,* (2014) further examined pre-service teachers' ability to translate TPACK theory into practice.

Mouza *et al.,* (2014), designed a course for pre-service teachers that focused on understanding the impact knowledge of TPACK has on their practice. The purpose of the 15-week course was three-fold: introduce the teachers to different educational technologies available to them, consider different pedagogical approaches for use with these tools and examine methodologies that successfully combined the technology and pedagogical practices together. Mouza *et al.,* (2014) used mixed method data collection methods. Quantitative data were measured via the administration of the Survey of pre-service Teachers' Knowledge of Teaching and Technology (Schmidt *et al.,* 2009). Qualitative data were collected using open-ended questions and case study reports on lessons implemented as part of school placement. A pre-test post-test method was applied to the survey, which found that these pre-service teachers significantly increased in all domains of TPACK. The study also highlights the importance of showcasing models of teaching that emphasise the experiences at the intersection of pedagogy, content and technology. Mouza *et al.,* (2014) also discovered that these pre-service teachers were unable to distinguish between the different knowledge domains and felt this questioned the reliability of the TPACK instrument

Archambault and Barnett (2010) study examined the validity and reliability of the Survey of Pre-service Teachers' Knowledge of Teaching and Technology and called into question the existence the TPACK framework. This survey was distributed online to 1795 teachers with an overall response rate of 33% (n=596). Demographic statistics showed that the majority of teacher (77%) were female and between the ages of 26-45 (63%). A factor analysis was conducted on the responses and results found that teachers were unable to distinguish between the domains of TPACK. This called into question the existence of the seven constructs of TPACK (Archambault and Barnett, 2010).

In the years since many studies have tried to derive their own instruments for evaluating TPACK. In their meta-analysis, Chai *et al.*, (2013) reviewed 74 journal papers that investigated ICT integration using the TPACK model. Of these 74 papers 55 were "*data driven*" and 19 were "*non-data driven*" (p. 35). Focussing on the data driven papers the authors found that 11 used mixed methods, 13 followed a quantitative approach and 31 used qualitative methods. These were then broken down into a number of research method categories which included 32 intervention studies, 10 case studies, five instrument validations, four survey studies, two artefact evaluations and one software development study. Results from all of these studies showed that further work on design validation was warranted (Chai *et al.*, 2013, p. 31). Issues such as factor loading demonstrated the participants inability to clearly distinguish between the constructs (Chai *et al.*, 2013; Blackwell, Lauricella and Wartella, 2016).

Utilising the work of Gess-Newsome (1999), Canbazoglu Bilici, Guzey and Yamak (2016) developed the technological pedagogical content knowledge observation protocol (TPACK-OP). Aligning themselves firmly in the transformative camp, Bilici *et al.*, (2016) developed an instrument that was both valid and reliable to measure pre-service teachers' TPACK. Their study assessed the TPACK of undergraduate science pre-service teachers by using the TPACK-OP. The results showed that the pre-service teachers TPACK did increase due to the opportunities to practice and learn with technologies. The authors concluded that the TPACK-OP was useful for assessing TPACK, but data collection was intensive. The TPACK-OP represents the first instrument that not only adheres to Gess-Newsome's (1999) PCK spectrum, but was also found to be valid and reliable.

In their 2016 paper, Canbazoglu Bilici, Guzey and Yamak (2016) set out to assess pre-service science teachers TPACK through both observation and lesson planning documentation. Fully embracing the transformative PCK model, Canbazoglu Bilici, Guzey and Yamak drew upon the work by Magnusson, Krajcik and Borko (1999) to further delinate and distingish content and pedagogcial knowledge. They developed an observation and lesson planning protocols known as the TPACK Observation Protocol (TPACK-OP) and TPACK Lesson Plan Assessment Instrument (TPACK-LpAI) (Canbazoglu Bilici, Guzey and Yamak, 2013, 2016). In their study, 27 pre-service science teachers were enrolled in a Science Methods course and volunteered to participate in their research. During this five week course, the students were introduced to the five components of TPACK-OP: Orientations towards teaching science, assessment in science, students' understanding of science, instructional strategies and science curriuclum. In order to develop the pre-service teachers TPACK, activities were conducted each week related to the relevant TPACK component using a variety of instructional strategies and technolgoical tools. In week three of the course, the students were asked to plan and implement a series of microteaching technology enabled lessons. Samples of both the TPACK-OP and TPACK-LpAI were analysed to assess inter-rater reliablity and consistency and they were found to have coefficients of .945 and .950 respectively, suggesting the instrument was reliable. The results of their research showed that pre-service teachers were able to demonstrate TPACK in their lessons. Results and previous research had also shown that TPACK is increased when teachers gain first hand experience of technology and tools (Niess, 2011). The authors concluded that, not only were the TPACK-OP and TPACK-LpAI effective tools to assess pre-service teachers TPACK, but that a TPACK-focused science methods module does have a positive impact on pre-service teachers TPACK.

Using the TPACK Conceptual framework developed by Mishra and Koehler (2006), Ozgun-Koca (2009) presented a paper that provided a summary of findings from their TPACK audit of final year pre-service teachers. The aim of their study was to evaluate how well teacher education programmes were preparing their graduates for technology integration. Using a modified version of the TPACK Confidence Survey, 345 final-year pre-service teachers were surveyed. The basic demographic information revealed that 79 per cent of the students in this survey were female with over 50 percent of the students within the 20–29 age range. The study found that nearly 100 per cent (99.4 per cent) of these students owned a personal technological piece of equipment, e.g. computer, and 96.5 per cent had regular access to the internet. However, even with such a high penetration of technology in this student cohort, roughly a third of the participants expressed a lack of confidence in using ICT in teaching. The survey also found that in specific areas, such as multimedia development and web page design and development, students expressed an even lower level of confidence. The authors concluded that current initial teacher education programmes only focus on PCK elements of teaching and ignore the technological elements. If higher education institutes wish to accurately prepare their pre-service teachers for technology integration, attention must be paid to developing the students' technological domains.

2.3.4 Framework for Technology Integration

It can be seen that over the course of the last decade, TPACK has received considerable attention (Blackwell, Lauricella and Wartella, 2016; Buss *et al.*, 2018), and despite its fundamental misgivings, it provides an operational framework from which teachers' knowledge of technology, pedagogy and content can be captured and expressed. The addition of TPACK to Hughes (2005) levels of technology supported pedagogies creates a definition that is not only operational but also encompasses the technological and pedagogical knowledge of the teachers.

While this section has set out a definition for technology integration and supported that definition with the literature, there are still issues teachers and researchers face when integrating technology into teaching and learning environments. Section 2.4 describes the researched that focussed on identifying and addressing the barriers to technology integration.

2.4 What are the barriers to technology integration?

This section will focus on the work of Ertmer (1999) and their subsequent work (Ottenbreit-Leftwich *et al.*, 2010; Ertmer *et al.*, 2012; Tondeur *et al.*, 2017). Their work led to the identification of the barriers teachers, researchers and stakeholders face when integrating technology into teaching and learning.

2.4.1 First and second order barriers

There are two categories of barriers teachers face when integrating technology, First Order Barriers (External) and Second Order Barriers (Internal) (Ertmer and Ottenbreit-Leftwich, 2013, Ertmer *et al.,* 2012, Uslu and Bümen, 2012). Ertmer (2012) identifies the relationship between use of technology in the classroom and the perceived barriers.

The first order barriers include hardware, internet access, available software, tools, professional development and training and in school support structures (Ertmer and Ottenbreit-Leftwich, 2013). In recent years, there has been an increase in the availability and accessibility of computers, laptops, tablets and other forms of technology (Beauchamp and Kennewell, 2013). As a result, the number of schools and students with laptops, tablets, and smartphones has increased, thereby increasing the students and teachers access to the internet and a wide variety of tools. While the use of technology in lessons has been widely adapted in American schools (Grey, Thomas & Lewis, 2010), Ireland has historically been slow to adapt to new technologies (McGarr, 2009). The use of applications, Java and other online/download tools has seen a significant increase in usage in education (Chu *et al.*, 2011, Herrington and Parker, 2013). However, due to copyright, international restrictions and terms and conditions of app stores, a great deal of these applications cannot be accessed in certain international countries. Another first order barrier, training, is quoted as a key obstruction to implementing technology in the classroom (Ertmer and Ottenbreit-Leftwich, 2013, Ertmer *et al.,* 2012). Hew and Brush (2007) found that successful professional development includes three areas of focus: content, hands-on time and teacher's needs. With content, it is important that teachers' develop technology supported knowledge and skills this will improve their success in implementing technology in their lessons (Hew and Brush, 2007). Development of technology supported pedagogy relies on teachers' perspectives on the educational value of the technology being used as well as the relationship between subject content and technology (Chong and Lee, 2012). Professional development must be tailored to the needs of the teachers. It was found that professional development that was Just-in-time was the most beneficial (Granger *et al.,* 2002). This type of professional development course focuses on teachers' immediate needs as opposed to what teachers may need. The final external barrier relates to support. Support can be examined under many categories, administrative, professional, peer and technological (Ertmer *et al.*, 2012). It has been noted that support from the principal and staff has an effect on teachers' ability and willingness to implement technology in their lessons, a more supportive staff and administration increases the chances of technology been effectively integrated in lessons (Burns, 2013, Kopcha, 2012).

Second order barriers are internal barriers to the teacher. The teachers' beliefs and teaching pedagogy are identified as the biggest challenges to overcome with respect to second order barriers (Ertmer, 1999). These barriers can often go unnoticed and unchecked by the teachers themselves. A teacher who fails to adapt their pedagogical approaches may never be able to fully integrate technology into their lessons (Ertmer and Ottenbreit-Leftwich, 2013, Ottenbreit-Leftwich *et al.,* 2010, Ertmer, 1999). One of the major issues facing teachers is their conservative attitude to change. The implementation of technology will drastically change the dynamic of the classroom and, as such many teachers may resist this change (Ertmer and Ottenbreit-Leftwich, 2013). It is worth noting that some teachers may not face these barriers have little trouble implementing technology into their lessons. The issue of addressing these barriers appears to be simple but on closer inspection is a complex problem (Hinson, LaPrairie and Heroman, 2006; Reid, 2014; Wang, 2017). While it was thought that the removal of these barriers would lead to effective integration it became clear that other factors may also be influencing effective use of technology (Ertmer, 1999, Kim *et al.,* 2013). The teacher's level of technology literacy came into question and how high levels of usage affects the barriers.

Re-examining Hew and Brush (2007), the authors reviewed the literature through the period 1996 to 2006, detailing current gaps and identifying potential future research. The authors found that there was a total of 123 barriers from previous studies. These barriers could be categorised into six themes: Knowledge and skills, Institution, Resources, Subject Culture, Assessment and Attitudes and Beliefs. The most common concern amongst K-12 teachers were resources (Ertmer, 1999). They listed the factors as follows: Resources (40%), knowledge and skills (23%), Institution (14%), Attitudes and Beliefs (13%), Assessment (5%) and Subject Culture (2%). Resources referred to access to any available technology, time and technical support. Time as mentioned here, refers to time to assess appropriate content for lessons, planning, etc. as opposed to time management in class. Technology skills, pedagogy, and classroom management were all major barriers to technology. The institutional barriers are defined as time-tabling and school plans. Hew and Brush (2007) highlight results Becker (2000) found which stated that most (American) secondary schools have classes of less than one hour (~50 minutes). It was found that this lack of time limited the variety of methodologies used during the lesson and it is recommended that principals redesign their timetables so as to incorporate as many double classes as possible to maximise effective technology usage. Another institutional barrier is support from management. As Ertmer (1999, 2012) found, teachers need encouragement from management in order to effectively implement technology. In their review of the literature, Hew and Brush (2007) found that the majority of schools faced some form of high stakes examinations, which they believe makes it difficult to change teachers' assessment methods. In closing, Hew and Brush (2007) put forward five categorical strategies for overcoming these barriers. These were: 1) having a shared vision and technology integration plan 2) overcoming the scarcity of resources 3) changing attitudes and beliefs 4) conducting professional development and 5) reconsidering assessments. The authors believed that when a school develops a shared vision and technology plan it provides the teachers with a plateau that details the expectations from all stakeholders on how technology should be used and provides the teacher with achievable goals and appropriate guidance (Huang *et al.,* 2011).

While Ertmer (1999) paved the way for future research through the identification of the barriers to integration, the decades that followed showed that progress was made in most areas. In fact in their follow up paper Ertmer *et al.*, (2012) found that the majority of first order barriers were reduced to the point of having a negligible impact on integration. However, teachers' attitudes and beliefs were still a major sticking point and presented the biggest challenge for researchers to overcome.

Greenhow, Dexter and Hughes (2008) compared the differences in decision-making criteria for integrating online multimedia problem solving scenarios into their teaching between two cohorts of teachers: one pre-service the other in-service. The pre-service group consisted of 25 primary education teachers while the in-service teachers were recruited from a master's degree programme of which there were 22. In their study, the two sets of teachers were taught by the same instructor and approximately two thirds of the way through the course the cohorts were asked to complete a common assignment. This assignment was to complete three online case simulations and write an essay detailing their own instructional decisions with respect to technology integration. These cases were taken from the Educational Technology Integration Principle, which was used to provide the teachers with a set of students, who had various educational backgrounds and preparations, to practice in planning for technology integration within reality-based school contexts. The results of the study showed that pre-service teachers tended to be less critical and superficial in their selection criteria in contrast to the in-service teachers. However, neither group took into consideration the opportunities and challenges (affordances) each tool inherently possesses.

Banas (2010) conducted a study to assess their participants attitudes towards technology. To achieve this aim, the researchers examined 225 essay responses from a course reflection where the participants shared their attitude towards technology. The course being examined was an online masters in Learning with Technology. The participants in this study were masters students who were either in-service teachers or education professionals. Assessment of this course was in the form of an essay which included three sets of probing questions concerning their attitude towards technology, their goals for technology integration and the professional development steps they plan to talk to assist them to achieve these goals (p. 116). In their publication, the authors examined only the first set of questions. Results were analysed and coded into common responses, these were:

1) Didn't care, didn't do,

2) Cared, but saw obstacles so didn't do,

3) Cared, but just used myself,

4) Cared, was doing some (learning from) and

5) Cared, was doing (learning with).

Analysis showed that 13% of participants were coded as category five or learning with technology, while a further 7% were found to have not integrated technology at all. 52% utilised learning from integration. One interesting finding from this study was that 28% of students who cared were set back due to the obstacles. Banas (2010) probed further to find another common theme emerged - the obstacles to integration. These were then subdivided into six categories including: lack of knowledge about/skills to provide, lack of confidence to use technology, lack of resources/access, not enough time to learn [how to use technology], students too young/unskilled and non-supportive administration. The study found that a lack of knowledge/skills was cited by over 90 students, three times higher than the second and third most cited obstacles - lack of confidence and lack of resources. This finding mirrors those of Ertmer (1999), which found that the perception of first and/or second order barriers reduces a teacher's willingness to integrate technology. The authors offer no response to these findings regarding the obstacles, but instead highlight that a decade after the initial findings by Ertmer (1999), the same perceived barriers to integration exist.

2.5 Conclusion

The research that was conducted in this thesis was informed significantly by the theoretical discussion presented above. To evaluate second-level teachers' technology integration in classroom practice, the researcher decided to develop a new definition of technology integration to incorporate elements of teachers' TPACK domains, and differentiation levels of technology usage. To utilise TPACK to its fullest extent, the researcher adopted the transformative PCK model proposed by Gess-Newsome (1999). In doing so, the researcher states their informed belief that teachers' technological pedagogical content knowledge is a unique form of knowledge, moulded by the interactions and transformations of teachers' content, pedagogical and technological knowledge.

The theoretical discussion examined the current uses of technology and how studies have evaluated technology integration and its impact on teachers. A decade ago, researchers were focused on evaluating how certain software, tools and technologies impacted teacher and student teaching and learning (Joffe, 2001; Hwang *et al.*, 2014). Emphasis has now shifted towards evaluating what impact, if any, technology has on teachers current pedagogical practices and trying to conceptualise and evaluate technology integration (Koehler and Mishra, 2009; Canbazoglu Bilici, Guzey and Yamak, 2016). While progress has been made with the introduction and subsequent scrutiny of the TPACK Framework as well as the work that has made TPACK an operational and evaluation framework (Davies, 2011; Niess, 2011; Tondeur *et al.*, 2012; Koh, Woo and Lim, 2013; Agyei and Keengwe, 2014), more research is required to make these frameworks and assessments applicable to all subject areas and perform reliably for both pre-service and in-service teachers.

Therefore, this study built upon the work of previous research and examined the classroom practice of both in-service and pre-service teachers across a variety of subjects to align TPACK with common standards. In doing so, the data collected via interviews and observations informed the research on teachers' current technological usages in the Irish second level setting. From this data, information regarding teachers' perceptions of the barriers presented to them was also discovered and from this, a determination on the types of supports they required to successfully integrate technology in the future.

Chapter 3 Research, Design and Methods

3.1 Introduction

This chapter discusses the research design process and methodology utilised in this thesis. The aim of this research was to examine in-service and pre-service teachers' technology integration, identify teaching methods which facilitate the use of technology and outline strategies in going forward with technology integration. This research was conducted in two schools as well as with a cohort of pre-service science teachers. School one consisted of three key phases. Phase one extracted teachers' background information such as their attitude and beliefs towards teaching, technology and the role of technology in education. During this phase teachers' needs and wants for technology were also explored. Phase two built upon the findings in phase one introducing teachers to technology enabled tools which reflected their needs and wants as identified in phase one. These tools were then implemented by the teachers and observed. Phase three refined the observations which took place phase two down to a core group of six teachers and their experiences. The school two study consisted of only one phase - this phase was identical to that of phase three in school one where six teachers were asked to record their technology enabled lessons using tools identified by both the researcher and the teacher. The pre-service teachers' portion of this thesis did not involve any of the phases outlined above. Instead, the study examined the design and implementation of an undergraduate pre-service science teachers' module which was developed to extend their technological pedagogical knowledge.

This chapter begins with the rationale for adopting a case study methodology, an explanation of my epistemological and ontological views which underpin my research, as well as the methods of data collection employed throughout each of the studies. Also discussed in this chapter are the data collection procedures including issues of validity, reliability and ethical limitations of qualitative research.

3.2 Background to the Research Methodologies

3.2.1 Quantitative, Qualitative and Mixed Methods research models.

In education and other social sciences there are two main branches of research: quantitative and qualitative (Muijs, 2004). Quantitative methods employ mathematical and statistical based methods to explain phenomena (Muijs, 2004), while qualitative methods are flexible as opposed to rigid, inductive rather than prescriptive and the researcher needs to be reflexive at each stage of the project (Maxwell, 2012). In recent years however, many social scientists have advocated the use of mixed methods research which combines both qualitative and quantitative methods and makes use of the best features in both methods (Mackenzie and Knipe, 2006).

Historically quantitative and qualitative research were seen as the polar opposites of each other, realism verses subjectivism, the uncovering of the truth as opposed to the subjective nature of a truth (Muijs, 2004). More recently however, researchers have begun to mix the methods and as such blur the concepts of realism and subjectivism being solely affiliated with one method or the other.

3.2.2 Quantitative and Qualitative methods in education research

There are two main styles of quantitative research design: experimental and non-experimental design (Muijs, 2004). The experimental design methods follow a similar set of principles of those available to natural scientists. As such, the purpose of experimental design quantitative research is to test the validity of a hypothesis under strictly controlled conditions (Muijs, 2004), conversely non-experimental designs cannot control for all variables under strict conditions. In experimental designs, all variables are controlled for, groups are selected randomly to minimise bias and the researcher formulates their hypothesis for testing. This was done by formulating the null and alternative hypothesis. Only by rejecting the null hypothesis could the alternative hypothesis, which was what was set out in the research question, be accepted. Non-experimental designs are less experimental in their methods and use tools such as surveys and observations. In both methods of quantitative research, the purpose is to explain the phenomena using numerical data, this is in contrast to qualitative methodologies.

As discussed above, quantitative research contains two major designs, qualitative research however, has many methodologies and sub methods associated with it. The methods typically used in education research are Grounded Theory, Ethnography and Case Study (Glaser and Strauss, 2009; Richards and Morse, 2012; Bazeley, 2013; Patton, 2014). Grounded theory as described by Glaser & Strauss (2009) is "*how the discovery of theory from data – systematically obtained and analysed in social research*" (p. 2). Ethnography is the study of people, discovering patterns and developing an in-depth understanding of the participants through observations and other available data collection methods over long periods of time (Hammersley and Atkinson, 2007). The final branch of qualitative research is case study research. Case studies are "*useful in the study of human affairs because they are down to earth and attention holding*" (Stake, 1978, p. 1). They utilise the experience of people to advance our knowledge of a phenomenon (Stake, 1978; Yin, 2009).

The case study was chosen as the framework through which to conduct this study, and thus the case study will be discussed in detail below.

3.2.3 What defines a case study?

Cases studies have traditionally been implemented by social-scientists, certain groups of health scientists, political scientists, physiologist, educationalist and social workers (Swanborn, 2010). As a method of research the case study is used to "*contribute to our knowledge of individual, group, organisational, social, political and related phenomena*" (Yin 2009, p 4). The advantage of implementing a case study method is that it allows the researcher the ability to retain the complete account and characteristics of real life events. But what exactly is a case study? How does one define it? Yin (2009) believes that the answer to this question is three-fold: What type of research question is being posed, the extent of control the researcher has over the actual event(s) being researched and the focus of the study i.e. contemporary versus historical. Yin (2009) created a table of comparison outlining five branches of research methodologies which may be commonly misused as they share some similarities: experiment, survey, archival analysis, historical and case study (p 8).

As seen from figure 3.1, a case study asks the how and why questions, where it differs from historical studies is on its focus of contemporary events. A formal operational definition of case studies should then follow a similar focus on asking the how and why, one such definition presented by Schramm (1971) suggests that the essence of a case study is to "..*illuminate a decision or set of decisions: why they were taken, how they were implemented, and with what results*" (p. 6). However, Yin (2009) believes that the definition for a case study is twofold, it contains a *logic of design* (p. 6) and includes data collection methods which are context based on the phenomenon being studied. He states:

"1. A case study is an empirical inquiry that

- Investigates a contemporary phenomenon in depth and within its real-life context, especially when
- The boundaries between the phenomenon and context are not clearly evident

2. The case study inquiry

- Copes with the technically distinctive situation in which there will be many more variables of interest than data points and as one result
- Relies on multiple sources of evidence, with the data needing to converge in a triangulating fashion, and as another result
- *"Benefits from the prior development of theoretical propositions to guide data collection and analysis*." (Yin, 2009, p. 135).

3.2.4 Common issues relating to case study methodology

Yin (2009) describes the apparent disdain researchers have for the case study methodology highlighting what he believes to be the four key issues. One issue is the lack of generalisation from a single case. Single case research designs lack variance and studies which implement a single observation design approach also suffer from this limitation. These studies also face greater issues where more than one explanation may be present, but has not being explored due to the lack of measurement (George and Bennett, 2005). The answer lies in realising the limitations of one's generalisations, it is often the desire of the researcher to overstate his/her findings (Harland, 2014), however, single case studies can be generalizable, not to populations or the universe but to the theoretical proposition being made in the case (Yin, 2009).

A second issue pointed out by Yin (2009) is the common misconception that case studies yield massive, unreadable tomes, which can be a fair point given the rich nature of the data which case studies can collect (Swanborn, 2010). However, there are different forms of case studies and not all have to run over a lengthy period and often times the length narration of a case study can be foregone in certain instances.

Perhaps the single biggest concern is the lack of rigor sometimes seen in case studies. This is due to the researcher being sloppy, where they have failed to follow systematic procedures or have allowed their own bias to influence the interpretation and presentation of the data (Yin, 2009). That being said, this is not just a problem limited to the case study methodology, but rather qualitative data in general (Cohen, Manion and Morrison, 2007). There has, however, been a recent attempt to standardise an operating procedure for case study methodology led by Lyons (2009). Building upon some of his previous work, Lyons (2009) developed a set of tasks researchers should follow to produce a rigorous case study of publishable standard.

3.2.5 Case Study Research Design

Lyons (2009) identifies five components of research design which are particularly important to case studies. These are:

1. The research questions
2. The propositions of the research
3. The units of analysis
4. Linking of data and propositions
5. The criteria for interpreting the findings

As previously described in section 3.2.1, the questions of who, how, what, why and where are important in not only determining the focus of the study but also the research methodology to be utilised. In formulating a research question Yin (2009) devised three steps every researcher should follow to focus their efforts. Step one involves loosely reading literature in a field of interest. Once the researcher has identified an area of interest they should then move on to step two and examine a small body of literature dissecting their research questions and identifying potential extensions or loose ends in the research. Finally, once the researcher begins to formulate a research question, they should find another set of studies with the purpose finding support for their research questions.

The second component, study propositions are used to focus the researcher on what should be examined within the scope of their study (Yin, 2009). If the researcher states their propositions he or she will then focus on what's appropriate. Yin (2009) provides an example regarding organisations and how one might think that "*organisations collaborate because they derive mutual benefits*" (p 28). However, not all case studies lend themselves to explicit propositions, for example, the purpose of an exploratory case study is to explore. Nevertheless, the study should still contain some purposes. Without stating the purpose it is impossible to judge how successful a study has been (Yin, 2009).

The third component, the unit of analysis, refers to who or what the case is about. This brings us back to the fundamental question: what is a case? (Yin, 2009). For many researchers, a case can be an individual (Platt, 1992), an organisation or even a piece of technology (Kidder, 2011). Units of analysis could also consist of multiple cases such as the individuals in an organisation or teachers of the same subject from different schools and areas. In selecting the unit of analysis appropriate to the research, the primary research question should already specify the unit of analysis, if not, Yin (2009) suggests that either the primary research question is too vague or too numerous. However, Yin (2009) goes on to state that units of analysis are subject to change, this is because as data are collected and arguments are put forward, the researcher may discover that their initial unit of analysis and propositions may no longer support the current findings. For this, he suggests researchers clearly define their unit of analysis and are discerning with their definition of the case. For instance, if working with a small group of people from a larger group, it is important to clearly define the smaller group outside of the larger group.

At the design phase of the project Yin (2009) suggest that researchers be aware of how our choices for linking of the data and propositions will influence the case study. He does stress however that for first time researchers' problems will arise, such as knowing when too much or too little data has been collected and how this can interfere with the data analysis.

The final component is the criteria for interpreting the findings. This can be statistical analysis or theory building. Typically case studies will not rely on statistical interpretations, a good case study analysis strategy is to develop rival theories and prove/disprove them when data analysis has been completed (Yin, 2009).

By following this research design protocol, the researcher will be able to effectively begin to develop theories based on their findings. In case studies theory building is essential at the research design phase. Much like the propositions previously mentioned, developing a theory will focus the outcomes of the study and help future researchers in replicating the conditions of this study. The theory can be presented in four ways: as an individual theory, group theory, organisational theory or societal theory (Yin, 2009). Finally, an appropriately developed theory may lead to generalisation of the cases to a populational level or universal level. Case studies should often apply the analytical generalisation design. These case studies involve multiple cases and are often held in a higher regard than their single case counterparts (George and Bennett, 2005; Yin, 2009; Swanborn, 2010)

3.2.6 Types of case studies

There are four main variants of case study designs: the holistic single case study, the embedded single case study, the holistic multiple case study and the embedded multiple case study (Yin, 2009).

Single case studies can be used to present a critical case study on a well formulated theory in the field (Yin, 2009). In the early days of case studies they were generally used to present extreme cases or in the field of medicine rare medical occurrences (Swanborn, 2010). This explains the basic premise of a single case study, however depending on the unit of analysis the case study could be subdivided into one of two categories, holistic or embedded. Typically studies which focus on one unit of analysis are holistic i.e. a study which examines students' test scores in one school. Whereas an embedded design has multiple units of analysis called subunits. In the above example, the researcher may not just look at the test scores, but perhaps their happiness in school and their relationships with the teacher(s). It can be seen that for both holistic and embedded single case studies the unit of analysis is contained within one organisation and the distinguishing feature is whether or not there is one unit of analysis (holistic) or several subunits (embedded).

The multiple case design, as the name suggests, involves more than one case to be studied. In recent years the multiple case design has boomed, particularly in the educational field of research to study the effect of the implementation of a new curriculum or the effect of a new educational technology (Yin, 2009). Methodically, the multiple case study can be conducted exactly the same as the single case study, contrary to some classical researchers beliefs (Eckstein, 1975). As has been mentioned in section 3.2.3, the multiple case study is viewed as more compelling than the single case study as it is often associated with being more rigorous and robust (Firestone, 1993). When undertaking a multiple case study, the researcher must be aware that the study must follow a replication design, this means that what is conducted in one case must be replicated exactly in the other cases. As such, this is a more taxing research design and requires extensive resources and may be beyond the means of a single researcher (Yin, 2009). The best way to achieve this replication design is to follow or devise an operational theoretical framework (George and Bennett, 2005; Yin, 2009; Swanborn, 2010; Green, 2014).

In selecting a multiple case study design, the researcher has chosen to explore the impact of a phenomenon to a series of cases through the literal methodological replication of one case in the others. In a similar way to the difference between holistic and embedded in single cases, the multiple case study designs are differentiated by the type of analysis conducted. Yin (2009) summarises the differences quite eloquently. For example, consider conducting a study on the effect of curriculum change in different schools. Each school is therefore the case and the theoretical framework is replicated in each school to develop findings and conclusions. As is the case with embedded designs, multiple forms of data collection tools may be used, however these are all independent of each school, i.e. while test scores may be collected from each school, they are never compared. Once comparisons are made between cases the study now becomes holistic as the cases have become one individual case.

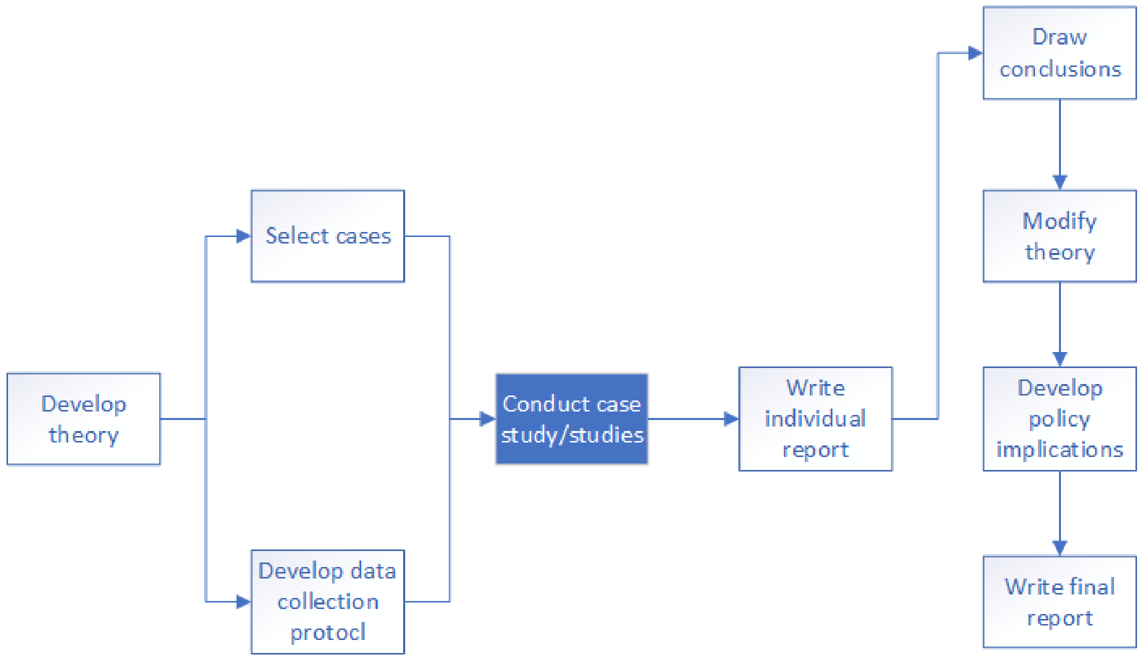


Figure 3.1 The multiple case study method design adapted from Yin (2009)

3.2.7 Validity and reliability in case studies

For many years empirical social researchers have used four tests to establish the quality of the study (Kidder *et al.*, 1986). Since these tests are commonly used in social science research they serve as a good foundation for testing the quality of a case study. The four tests are: construct validity, internal validity, external validity and reliability. Kidder and Judd (1986) presented the following four definitions for each test.

1. Construct validity: identifying correct operational measurement for the concepts being studied
2. Internal validity: seeking to establish a causal relationship, whereby certain conditions are believed to lead to other conditions, as distinguished from spurious relationships. Yin (2009) made a further note to this definition that it is only applicable to explanatory or casual case studies and not descriptive or exploratory studies.
3. External validity: defining the domain top to which a study's findings can be generalised
4. Reliability: demonstrating that the operations of a study – such as the data collection procedures – can be repeated, with the same results (Kidder *et al.*, 1986, pp. 26-29).

Construct validity is regarded as a particularly challenging test for case study researchers as others are often critical of the subject judgements made by them when they have failed to develop an appropriate operational set of measurements to collect the data. To avoid such issues with data collection the researcher needs to follow two steps: define the specific concepts and relate them to the original objectives of the study and identify the data collection methods which match the concepts. Yin (2009) identifies three ways of increasing one's construct validity. The first is to obtain multiple sources of evidence such as following a triangulation approach (Cohen, Manion and Morrison, 2007; Ingleby, 2012). The second method is to establish a chain of evidence. The typical sequence applicable to case studies for maintaining a chain of evidence is presented below in figure 3.2

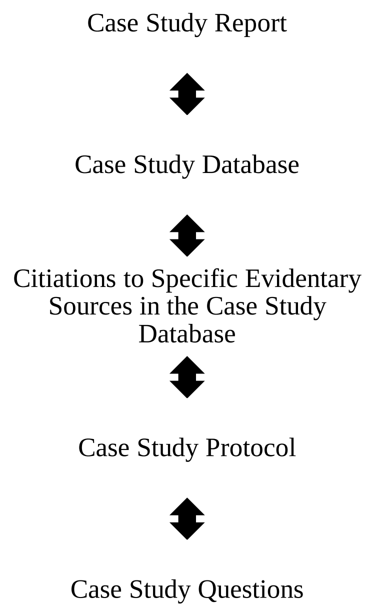


Figure 3.2 Sequence for maintain a chain of evidence adapted in Yin (2009)

This chain of evidence can be followed by another investigator in forward or backward directions and they should still see how the conclusions were made. This means that no evidence should be lost particularly through bias. The third and final method is to have the study proofed by the key stakeholders in the study. This will ensure that all raw data collected was given the appropriate amount of attention and was not subjected to unjust bias.

External validity focuses on knowing if a study is generalizable beyond the case in question. Opponents of case study methods state that single cases are a poor model to try to justify generalisations, however, as stated previously in 3.2.4, a case study which makes analytical generalisations is often more highly regarded. Therefore, the challenge in external validity relies on replicating the theory developed in one case to multiple cases.

To achieve a higher external validity the researcher must then consider how reliable their study is. Reliability is a way for an independent researcher to follow the same procedures set out in a case study and arrive at the same conclusion (Yin, 2009). In order to make a study highly reliable the researcher needs to make as many steps as possible operational (Yin, 2009).

To ensure the case study being conducted in this thesis reached an acceptable validity and reliability, the objectives of the research were clearly stated below and from this the data collection tools best suited to achieve the stated objectives were identified. Secondly, the researcher maintained a chain of evidence through their discussion of the results which was proofed by the supervisors of the researcher. As no current theories on teachers' technology integration in second level schools exists, the researcher used the data collected in this study to put forward a theory within the Irish context.

3.2.8 Types of case study evidence

There are typically six main sources of evidence which may be used to collect data in case studies, these are: Documentation, Interviews, Archival records, Direct observations, Physical artefacts and Participant observations (Yin, 2009). Documentation covers a wide range of documents such as minutes of meetings, newspapers and even curriculum specifications and lesson plans. Yin (2009) believes documents play an important role in any case study as they can be used to corroborate and inform the evidence from other sources. Interviews are an essential source of evidence for case studies, these interviews are guided discussions rather than rigid lines of questioning (Yin, 2009). In this respect, the researcher has two jobs in being an interviewer. Firstly, they must focus on discovering all they set out to learn (known as level 2 questions). Secondly, they must achieve this without creating an environment in which the interviewee becomes defensive as a result of the line of inquiry. Becker (1998) found that questions which are phrased as why, cause the participant to become defensive as you are asking them to defend why something was done, whereas if the interviewer asks a how question, the participant is not defensive and more willing to engage in a discussion. Interviews are not without their own problems though, as responses are dependent on the participants recollection and articulation and may be subject to their own biases (Yin, 2009). Direct observations are useful in directly witnessing a phenomenon or observing certain types of behaviours within the case setting (Yin, 2009; Swanborn, 2010). Observations can be both formal and informal and can range from activities such as classroom observations to walking tours of a facility. In some case studies it is advantageous to not only report on phenomenological observations but also on field observations of the case. These observations can be so important that it is recommended during each observation that there are multiple observers to ensure a complete picture of the phenomenon has been captured (Yin, 2009). There is another specialised form of observation, the participant-observation in which the research plays an active role in the phenomenon being studied (Swanborn, 2010). In this variant of observation, the researcher may be a member of a school carrying out their own investigations, a researcher trialling a new programme or perhaps the researcher is a member of the community being studied. While this type of observations provides many unique opportunities for data collection, there are major issues regarding not only participant bias and the time requirements, but more worryingly, the researcher may become the supporter of the group/organisation and as such develop false pretences which will no longer exist when the study has concluded (Yin, 2009; Swanborn, 2010).

Recall that in section 3.2.5 it was discussed how maintaining a chain of evidence increases the reliability of the data collected in the case study, this is but one principle in a three tiered structure which was proposed by Yin (2009). The base of this structure is collecting multiple sources of evidence or triangulation as it is more commonly known. The implementation of multiple sources of evidence allows the researcher to investigate a wider range of information from which their findings can be made and justified. Through this, the researcher can develop converging lines of inquiry, a method which may make the argument presented more convincing and accurate (Yin, 2009; Harland, 2014). The four methods of triangulation described by Patton (2014) are:

1. Triangulation through data sources
2. Triangulation among different investigators
3. Triangulation through theory
4. Triangulation through methodology

As Yin (2009) describes in his book, by implementing the multiple sources of evidence we can show a convergence of the evidence to a single fact, something which is not possible using only one source, or non-convergence of the data.

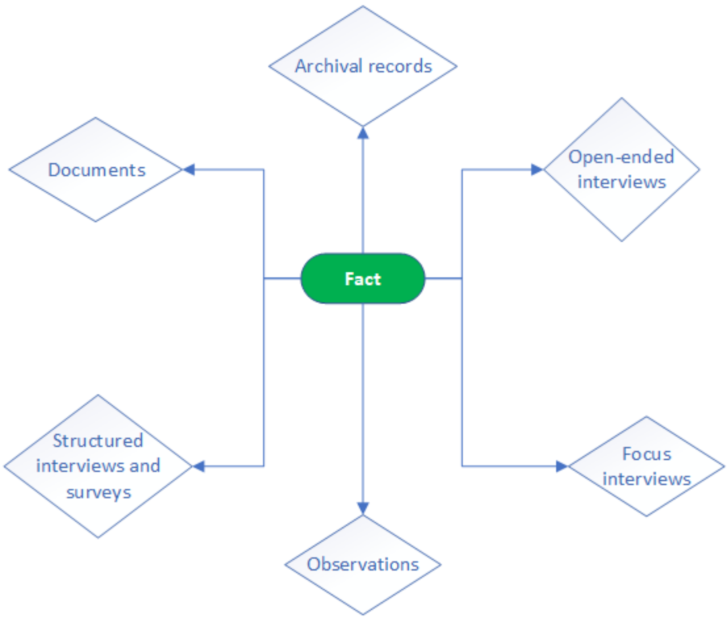


Figure 3.3 The convergence and non-convergence of evidence as adapted from Yin (2009)

The second and final principle in the structure is creating a case study database. In most studies the documentation obtained can be separated into two distinct categories, namely, the data-base and the report-base (Yin, 2009). The data-base is where all raw data is collected while the report-base is where the researcher compiles his/her reports, articles etc. Most research methods can make a clear distinction between these two bases, which allows one to scrutinise each base separately, such as survey results or test scores. However, given that the role of the case study researcher is to present the story of their case, the two bases can often become fused, which makes it impossible for a reader to extract what is raw data and what is inference (Yin, 2009; Harland, 2014). Yin (2009) advises researchers to develop a presentable database which, in principle could be examined by another investigator as this will not only allow your argument to be made more convincingly, but also increase the reliability of the study.

3.2.9 Observational Structure

Observations not only provide us with a candid view of the behaviours of the participant, but they have an "*overpowering*" claim to the validity of any study (Gillham, 2008, p. 1). The use of observations also allows researchers to discover the invisible elements of a phenomenon such as a person's thoughts, actions, behaviours etc. Observations can be used to challenge a participant's subjective view of their own self to ensure the validity of the research at hand. There are two distinct types of observations, structured and unstructured. Structured observations are highly focused systematic checks of the phenomenon (Gillham, 2008). Unstructured observations are the polar opposite, they are completely unfocused and instead are used as explanatory or descriptive methods of observations (Kingsley, 2000). From the definitions, it may be clear that structured observations are generally quantitative in nature while unstructured are mainly qualitative. Focusing on the research questions of this study and the chosen case study methodology, the researcher elected to conform to the unstructured observational approach for this study.

In educational research, there are two main types of observational protocols, these are known as holistic and segmented. A holistic protocol requires that the researcher codes each item for the whole class period, while the segmented protocol asks the researcher to code each item at short intervals of time, for example, every two or five minutes. A commonly used example of a holistic observation protocol is the Reformed Teaching Observation Protocol (RTOP) developed by Piburn and Sawada (2000). Designed to measure the extent to which active student knowledge construction occurs in inquiry based learning, the RTOP protocol has been shown to achieve higher interrater reliability amongst researchers (Marshall *et al.*, 2011). The RTOP is divided into five rating categories which contain five Likert scale ratings totalling 25 measurable items. One of the major segmented observation protocols is the Classroom Observation Protocol in Undergraduate STEM (COPUS) developed by Smith *et al.*, (2013). Using the Teaching Dimensions Observation Protocol (TDOP) as its foundation, the COPUS focusses on observing behaviours of both student and teacher in a small timeframe. Unlike the RTOP, COPUS provides the researcher with a set of 25 codes, 12 for students and 13 for teachers. The researcher then selects which codes were observed during the timeframe and repeats this procedure for the duration of the lesson. There are, however, issues with both observational protocols. In RTOP for example, descriptions defining the difference between the levels of the Likert scale were not present while in COPUS it was difficult to compare instructional styles within the 25 codes.

While either of these observational protocols would provide rich data for analysis, neither are particularly well aligned for use in a technology enable lesson, specifically, a lesson in which the focus of the observation is the determination of technology integration. For this, a new protocol needed to be assessed. Unfortunately, until very recently, no such protocol existed. This issue is further exacerbated by the ongoing disagreements with defining an appropriate technological integration framework. However, one research group operationalised the Technological Pedagogical Content Knowledge Framework (TPACK) into an observational protocol for use with pre-service science teachers to determine their levels of TPACK. This observational protocol, TPACK-OP was developed by (Canbazoglu Bilici, Guzey and Yamak, 2016). It contains six sections: background information, classroom demographics, learning objectives, setting and activities, ratings of key indicators, and additional comments. It is the rating of key indicators which aligns itself strongly towards observing technology integration. Split into five domains and eight key indicators, the observation protocol is ranked from 1 – 4 on a Likert scale. The five domains are: orientations toward science teaching with technology (Item 1), knowledge of assessment (Items 2 and 3), knowledge of students' understanding of science (Items 4 and 5), knowledge of instructional strategies (Item 6), knowledge of curriculum and curriculum materials (Items 7 and 8) (Canbazoglu Bilici, Guzey and Yamak, 2016). As this is a new observational protocol, very little research has been conducted to test its validity and reliability as well as identify the limitations within the protocol. The authors of the protocol found an internal reliability of 0.941 which indicates a consensus was reached between the observers. More research was needed if we wished to determine how effective TPACK-OP is for observing technology enabled lessons, as such, the TPACK-OP was used in this study as the observational framework.

The next section (Section 3.3) will discuss the methods of analysis used for each of the data collection tools utilised within this thesis.

3.3 Analysis Methodologies

This section begins by discussing the analysis methodology of the case study being conducted in each of the studies presented in this thesis. Then the reader will be presented with how quantitative and qualitative data obtained from surveys, professional development workshops and interviews were analysed. Finally, the analysis methodology for the classroom observations will be detailed.

3.3.1 Case study analysis methodology

It is vital that the researcher has an understanding of the analysis strategies and techniques which best suits their case. It is recommended that the researcher has identified, at the very least, their analytical strategy before collecting any data (Yin, 2009). There are four main analytical strategies for case study researcher designs, these are: 1) Mixed methods, 2) developing a case description, 3) relying on a theoretical proposition and 4) examining rival explanations (George and Bennett, 2005; Yin, 2009).

Mixed methods case studies employ the use of both quantitative and qualitative data. The use of quantitative data in case studies is relatively new, however, the qualitative must remain the central focus of the study (Yin, 2009). Using quantitative data is useful in ascertaining large amounts of statistical data regarding behavioural events or phenomena specific to the case or unit of analysis (Johnson and Onwuegbuzie, 2004; Yin, 2009). However, using quantitative data requires the researcher to become familiar with statistical methods and specific software for analysing this data (Cohen, Manion and Morrison, 2007; Yin, 2009; Ingleby, 2012).

When the researcher has not identified a particular strategy before collecting the data, they may then develop a case description as their method of analysis (Yin, 2009). In this strategy, the researcher specifically sets out the data which will be collected and presents a chapter layout of how the data will be described. Conversely, and more desirably, the researcher would have followed their original propositions set out after the literature review, during the formation of the research questions, and developed their analytical strategy based on the "*how*" and "*why*" questions (Yin, 2009). As discussed in section 3.2.3, good "*how*" and "*why*" questions naturally lead to methods of analysis.

The final strategy is the examination of rival theories. The objective of this strategy is to examine rival theories to direct the case study. Through examination of these theories, the researcher should be better able to conclude that their hypothesis is the correct one for the case they are presenting (Yin, 2009).

Once a strategy has been chosen for analysing the case study, the next step is to select the analytical technique. In their book, Yin (2009) describes the five most commonly used methods in case study analysis, these are: pattern matching, explanation building, time-series analysis, logic models and cross-case analysis. In the following paragraphs I discuss pattern matching, explanation building and the cross-case analysis methods in more detail.

Pattern matching is the most desirable of the analytical techniques to use for case study research (Yin, 2009). The objective of pattern matching is to compare observed patterns with those predicted at the outset of the study (Trochim, 1989). There are several variations of pattern matching including non-equivalent dependent variables and rival explanations. Based on Cook *et al*., (1979) research design there can be multiple dependent variables (outcomes). The researcher is to predict these outcomes and confirm these patterns. These predictions must be non-equivalent and provide a representative of the case and its outcomes. A major drawback with this method is that, to satisfy the initial predictions, all outcomes must be matched exactly as originally predicted. An alternative pattern analysis is rival explanations. For this technique the researcher must derive alternative rival explanations which describe the phenomenon with mutually exclusive independent variables. This means, if one explanation is to be validated, the other must be completely rejected.

The second of the three techniques to be discussed is explanation building. This technique is used, not to conclude about a case, but to develop it and its ideas for further study (Glaser and Strauss, 2009). To explain the phenomenon being studied, a set of presumed links, or the "*how*" and "*why*" something happened, are explored. Generally these explanation building case studies occur through a narrative form, however, if the narrative reflects on some theoretical propositions it may provide some much needed insight into the phenomenon and its links (Yin, 2009). Another, more systematic approach to the explanation building process is through an iterative nature. In this approach, the initial statements are made, and an initial case is conducted. The findings are compared to this case and revision of the statements may be made. The case is then compared again to the revised statements for clarity. Then, two or more cases are conducted, and the statements are compared to these. Revisions can be made again and the process repeats until a fully developed explanation is generated (Yin, 2009).

The final technique to be discussed is the cross-case synthesis. As suggested in the name, this technique is specifically used in the analysis of multiple cases. In this method, the researcher must treat each individual case study as a separate study in and of itself. Findings can be drawn from across the cases and where a large number of cases are being studied, the researcher may wish to include syntheses techniques used in other quantitative methods (Cooper and Hedges, 2009). If the study involves a modest amount of cases then other qualitative techniques should be employed such as word tables (Yin, 2009). The type of analysis conducted depends on what outcome(s) the researcher has focused on, but generally cross-case syntheses tend to focus on examining the similarities between the cases.

3.3.2 Qualitative analysis – Thematic Analysis

Thematic analysis is a qualitative data analysis method primarily deployed by researchers to identify patterns and reoccurring themes within the data (Braun and Clarke, 2008). Thematic analysis has many benefits one of which is flexibility (Braun and Clarke, 2008). While most analytical methods conform to a theory, thematic analysis is theoretically and epistemologically independent. Several papers are quick to point out that the conception of themes emerging or being discovered in that data is a fallacy (Anzul *et al.*, 1997; Taylor and Ussher, 2001; Braun and Clarke, 2008). Instead the researcher plays an active role in identifying the patterns which they believe will be of interest to the reader (Braun and Clarke, 2008).

Braun & Clarke (2008) devised a six-phase methodology for conducting thematic analysis. Phase one begins when the researcher immerses themselves in the data. To do this, they must read through all the data at least once in an active way, in other words actively searching for patterns, meanings etc. Once the researcher feels they are adequately familiarised with the data they can move onto phase two: coding. Phase two involves producing initial codes from the data. A code is a section, or a whole sentence, which contains a feature of the data the researcher finds interesting. The code provides some insightful information regarding the coded segment which assigns it some meaning. There are two types of codes, those which are data-driven and those which are theory-driven (Braun and Clarke, 2008). Depending on the epistemology selected the researcher may code according to the data or with specific questions around what to code. During this phase, it is important that all the data is attended to and treated equally ensuring most, if not all, of the data is coded. This is especially true in the context of contradictory codes which some researchers may want to hide as it conflicts with their current interpretations, but as Braun & Clarke highlight, these codes produce "…*an overall conceptualisation of the data patterns and relationships between them*" (Braun and Clarke, 2008, p. 19). Once all the data has been coded the researcher can move onto phase three: searching for themes. Once all the codes have been collated the researcher should begin identifying themes which tie a group of codes together. The objective of this phase is to critically analyse the codes and organise them into unique overarching themes. The researcher needs to examine the codes and identify potential relationships within and between the codes to generate these themes. Once an initial set of themes and subthemes have been generated, phase four may begin. In phase four the researcher reviews their themes and refines them. In 1990, Patton created two criteria for judging whether a theme was unique and worth keeping. These were: internal homogeneity and external heterogeneity (Patton, 1990). This requires that the data and codes which make up a theme are consistent within the theme as well as being identifiably different between other themes. Logically, this phase therefore involves two rounds of reviewing. The first-round reviews the coded data and extracts these codes to ensure that they form a coherent pattern to the theme. The second round involves reviewing the whole data set to ensure that the analysis has accurately assigned meaning to the data set presented; this also involves making sure that certain themes "*work*" within the data and making any additional refinements to the codes or themes. Once the researcher is satisfied with their final themes, they can move onto phase five: defining and naming the themes. In this phase, the researcher needs to provide a short definition presenting the essence of the theme as well as an explanation of the story that the theme tells the reader. This story should not only show the context of the theme in relation to the data set presented, but also to the research questions of the study (Braun and Clarke, 2008; Cadwell, 2015). The final phase, phase six, is the generation of the report. This report contains the finalised themes and analysis of the data. The purpose of the report is to convey the story being told by the data through the merits of the researcher's analysis.

Thematic analysis presented an opportunity for this study to fully examine the uses, complexities, difficulties etc. on the integration of one-to-one technology in second level schools. As such, thematic analysis was used throughout the qualitative methods as an analysis methodology.

3.3.3 Qualitative Analysis - Classroom Observation

A major component of this thesis was the analysis of both in-service and pre-service teachers' classroom practice. The purpose of these observations was to determine each teacher's level of technology integration. To do this, an observational framework was required. While there are several frameworks which have been widely used in the literature, such as RTOP, ICOT, and the one used in this study – Technological Pedagogical Content Knowledge, none of these provided the holistic overview that was required for my research. The biggest drawback of the two technologically focused frameworks (ICOT and TPACK) - in this researcher's view - was that they ignored key aspects of the teaching and learning process such as cognition and classroom interactions but also did not include aspects of the level of technology integration i.e. substitution, amplification, transformation (Hughes, 2005). Therefore, the researcher set out to develop their own observational framework – which will be discussed at length in section 3.5.5. A framework which incorporated elements of a teacher's knowledge of technology integration (TPACK), the cognitive considerations of the activities in the classroom and the level of technology integration involved was developed by the researcher.

As stated above, this framework is discussed in greater detail in section 3.5.5. However, in this section it is important to discuss how such a framework was valid and reliable. The framework used in this thesis was taken from three well-researched theoretical frameworks or taxonomies that had been shown to be valid at the content validity measure (Bloom and Krathwohl, 1956; Hughes, 2005; Canbazoglu Bilici, Guzey and Yamak, 2016). To address validity concerns the researcher took steps to ensure the reliability of the framework. This was achieved through interrater reliability (Creswell, 2014). To determine the interrater reliability, the supervisor of this thesis was asked to independently observe 10 video recorded observations and use the framework. Once completed, the results from the researcher and the supervisors scores were inputted into excel and the percentage of agreement was calculated (Creswell, 2009; Yin, 2009). It was found that the overall level of agreement was 0.83 which is above the accepted level of agreement of 0.75 (Kabakci Yurdakul *et al.*, 2012). The lowest level of agreement was found in item two, "*Assessment methods aim to evaluate important dimensions of learning*", of which the interrater reliability score was 0.6. The raters discussed the differences between their scores and an agreement was reached, the distinction between the levels of item two were further refined using Bloom's Taxonomy (1956) to ensure greater consistency between the raters.

3.3.4 Case Study Justifications

This thesis focuses on discovering, analysing and discussing the experiences of teachers who have integrated technology into their teaching for the first time. Two schools were selected to participate in this study, school one was a longitudinal 3-year study in a rural Irish school, whereas school two was conducted over a 5-month period in an urbanised Irish school. To outline the case study design that was implemented in this study, I refer to Yin's (Yin, 2009) five components of research design as discussed in section 3.2.3 and conclude with the type of case study this thesis conducted.

3.3.5 The Research Questions

In formulating a research question three steps were taken (Yin 2009; George & Bennett 2005). Firstly, the literature was used to narrow an interest in the field of technology educational research, without paying particular attention to any research questions at this early stage. Secondly, a few key studies were selected for a closer review (Archambault and Crippen, 2009; Tondeur, Cooper and Newhouse, 2010; Ertmer *et al.*, 2012; Kurt, 2013). Within these studies the research questions were identified by noticing a niche in the authors studies requiring further study. The final step involved examining an additional set of studies in a similar area which were used to provide support for the research questions generated by the researcher (Hew and Brush, 2007; Kopcha, 2012; Angeli and Valanides, 2013).

This review of the literature showed that while many studies have been conducted on very specific aspects of teaching with technology, such as using certain software, tools and hardware, very little research has been conducted on teachers' general experience with technology as well as their teaching strategies employed in technology enabled lessons, especially for teachers whom have never used technology in their lessons before. There is evidence to show that both first and second order barriers are still a factor in the integration of technology (Ertmer, 1999; Ottenbreit-Leftwich *et al.*, 2010; Ertmer *et al.*, 2012). Therefore, it is of importance that details on how teachers perceive these barriers regarding their daily integration of technology are collected to further our understanding of these barriers and their implications. This research, therefore, set out to answer the following questions:

1. How do in-service teachers with minimal experience of technology integration, use technology in their classroom practice?
2. What support do in-service teachers need in order to improve their technology integration in classroom practice?
3. How do pre-service teachers with no technology integration experience, use technology in their classroom practice?
4. What support do pre-service teachers need in order to improve their technology integration in classroom practice?

3.3.6 Justification for using a case study methodology

Section 3.2 discussed the theory, development, concerns and types of case studies used in modern academic research, while section 3.3.1 highlighted the analysis methods typically used in case studies. The argument was made that case studies contribute to our knowledge of specific groupings in society or to the exploration of an existing phenomena. The research questions outlined in section 3.3.5 focus on exploring the phenomenon of teachers' experience when integrating technology into their lessons, the factors which affect successful integration and how can these experiences be used to improve future teachers' success in integrating technology. The exploratory case study methodology was best suited to this type of study since a phenomenon (integration of technology) within a specific social group (teachers) was being explored. The embedded case study method allows for this study to examine the phenomena among several teachers to develop a substantiated model of the phenomena. This model may go some way to developing our understanding of the basic experiences teachers undergo while using technology and apply this new understanding to developing models for improving technology integration.

3.3.7 The propositions of the study

As discussed in section 3.2.3, simply stating one's propositions within the study helps to focus on what is to be examined. Dissecting the four research questions above it can be seen that there are some intrinsic propositions which should be stated. Firstly, the initial research questions are exploratory by nature and therefore do not naturally tend towards explicit propositions (Yin, 2009), however, some purpose should be stated. The focus of the first and third research questions are to capture all aspects involved in integrating technology at pre-service and in-service levels namely, planning, conducting and reflecting, therefore, emphasis was placed on the documentation and observational data collected during these lessons. The second and fourth research questions examined how, if at all, barriers to the integration of technology have impacted on the pre-service and in-service teachers' ability to integrate technology. The proposition being made here is two-fold; firstly, that where barriers exist, teachers are negatively affected by them and secondly, where no barriers exist, the teacher has encountered no issues with integrating technology.

3.3.8 The unit of analysis

In this thesis, the unit of analysis are the teachers of schools one and two and the pre-service teachers of a second-year undergraduate module. In each school, there was a core group of teachers who worked with the researcher and developed technology enabled lessons. These teachers are their own unit of analysis and as such there were 25 units of analysis, nine from case study one, six from case study two and a further ten from case study three.

3.3.9 Linking of data and propositions and interpreting the findings

The purpose of this research was to expand our limited knowledge on teachers' experiences with integrating technology. By exploring the propositions stated in section 3.3.2 and conducting thematic analysis on the data collected, it was hoped that a full picture of the range of experiences teachers undergo could be captured.

3.3.10 Bias and the role of the researcher

In any qualitative research design, it is imperative that the researcher identifies, and clearly states, any of the several sources of bias which may be present (Smith and Noble, 2014). Bias can have a major impact on the reliability and validity of one's research (Norris, 1997). Bias can be introduced in many ways such as self-selection, interviewer/researcher bias, recall bias, citation bias and even in the study design itself (Pannucci and Wilkins, 2010). In qualitative research particularly, bias is mostly unavoidable; the best one can hope for is identification of these potential sources of bias and to present a clear discussion how they intend to mitigate the effect of bias (Smith and Noble, 2014). In this section I will highlight two of the major sources of bias which may be present throughout this research, selection bias and the affinity of the researcher (Collier and Mahoney, 1996; Norris, 1997).

Historically, methodologist have been concerned with selection bias in small sample case studies (Collier and Mahoney, 1996). In particular, concern is raised in comparative case studies as researchers would select cases where the phenomenon may be more pronounced. Bias can occur in many ways, and in this particular study, bias could have been introduced at the selection of cases. For example, selecting teachers from a digital school to conduct this study would have had inherent selection bias as the teachers were already using technology. One way to reduce the effect of selection bias is to select participants who align with and are representative of the aims of the study and the study population (Smith and Noble, 2014). In the three cases studies conducted in this research there were two distinct groups of participants with two different recruitment methods. For example, the in-service teachers were recruited through volunteering. While the pre-service teachers were chosen due to their enrolment in the selected module.

The second source of bias is the researcher themselves, and their own interpretations of the data (Rajendran, 2001). However, arguments have been put forward that reducing this bias is down to how closely the researcher follows the specified methodology and analytical frameworks (Rajendran, 2001). As discussed in section 3.2.7, maintaining a chain of evidence is crucial to the integrity of any qualitative research design as it strengthens the validity and reliability of any conclusions made (Yin, 2009). Demonstrating, with evidence from the data, the logical steps taken by the researcher in their journey from data to interpretation reduces the impact of the researcher's subjective bias (Yin, 2009; Swanborn, 2010; Patton, 2014).

In addition to the potential for bias, the role of the researcher within the study also plays a critical part, particularly in how the researched engage with the researcher and their work. In this work there were two distinct environments from which the researcher was a member, these were post-primary schools and a university laboratory. Between these two settings the researcher played significantly different roles. Firstly, however, literature has shown that in any research, there is a fundamental imbalance between the researcher and the researched (Råheim *et al.*, 2016). This may cause unnecessary discord within the context of the study. However, the researched are just as integral to the project as the researcher and as such, form a central role in the creation of the work contained in any research (Karnieli-Miller, Strier and Pessach, 2008). Therefore it is important that the researcher identifies their role within a certain researched community and is aware of any power issues which may impact on their research (Karnieli-Miller, Strier and Pessach, 2008). Returning to the settings, the first setting, the post-primary school, had the researcher as an ambassador/ally to the teachers (Johnson, 2017). In this role, the researcher experienced the challenges of a community and engaged with them in external contexts such as workshops, interviews and observations. While in the pre-service teacher setting the research was in the role of a teacher/facilitator (Johnson, 2017). In this role, the researcher was in charge of the delivery of content and assessment which created an imbalance of power. To counteract this imbalance the researcher ensured a welcoming, non-threatening environment where the participants were willing to share their beliefs and experiences (Karnieli-Miller, Strier and Pessach, 2008). Additionally, the pre-service teachers' assessment was not linked to participation in the study and as such could experience the learning without being an active researched participant.

While there are many other sources of bias and issues relating to the roles of stakeholders within the research, this section aimed to provide a short synopsis of the most pressing issues related to bias and power.

3.3.11 Statement of case

This thesis aimed to capture the experiences of teachers' integration of technology. As stated above, the research was conducted in two separate schools and one university and it involved the participation of 25 teachers: nine in school one, six in school two as well as ten pre-service science teachers. As such, the study followed an embedded multiple case study design as the focus of the study was on multiple factors of their experiences which also implies that this study was exploratory in nature. By selecting this design it was chosen to explore the impact of a phenomenon, in this case, the integration of technology (Yin, 2009). The study collected multiple sources of data including interviews, lesson plans, video recorded observations and questionnaire data to establish a convergence of evidence (Yin 2009). This study utilised the analytical strategy of relying on the original theoretical proposition and replicated the strategy implemented in school one to school two. While some quantitative data was collected, the major focus within the units of analysis was the qualitative data. Finally, the analytical technique used in this study was explanation building to understand how both in-service and pre-service teachers integrate technology into their teaching practices.

3.4 Philosophical assumptions

In this thesis, the experiences that teachers go through as they integrate technology into their lessons was examined and documented. To do this, assumptions were made about the world that needed to be understand. The assumptions that were made were that: students learn in a variety of ways, teachers can utilise different pedagogical approaches and these approaches elicit different student responses.

The pragmatist approach was conformed to as outlined by Bazeley (2013). This outlines that:

1. All knowledge is tentative and needs to be tested against experience (p. 22). This means that for any person, reality is only derived from their experiences.
2. "*Truth*" of knowledge must match with what we have experienced and therefore must be tested through actions (Biesta, 2010; Bazeley, 2013).
3. Objects acquire meaning based on our social interactions and once a meaning has been defined it continuously becomes interpreted with this narrow view, neglecting the wider perspectives.

An embedded exploratory multiple case study design was selected to conduct this study as it allowed the researcher the scope to construct and present the data in an experiential narrative. In analysing these case studies, the theoretical propositions presented in section 3.3.1 were relied upon and data collection tools such as questionnaires, pedagogical focus groups, direct observation, teacher reflections and teacher interviews were all implemented. Under this methodology the data was regarded as true and taken as an emphatic approach to its interpretation. As the researcher was positioned emphatically with the data, the participant's voice is not lost in the generation of a theory. However, it is possible that some deeper understanding of the data may be lost in its interpretation.

3.5 Data Collection and Analysis

In this thesis, data were collected and analysed from three different cohorts of participating teachers and findings are presented as three separate Case Studies (Chapters 4, 5 and 6) that each examine the research questions of this thesis.

The three teacher cohorts that participated in these studies are both in-service (School 1 and School 2) and pre-service teachers (PST) and each teacher was assigned a unique code in the presentation of data. For example, a teacher in school one would be designated a school code of S1 and depending on their placement in a randomly generated list given a teacher number T; e.g. S1T25 and S2T4 (Business). In the case of the PST in case study three, they were all assigned based on the letter PST and a number allocation between one and ten, i.e. PST1.

The following sections of this chapter describe the methods used to collect and analysis data in the case studies contained within this thesis. The sections will describe how the methods were conducted during each phase of the study, what data was collected and provide examples as to how it was analysed. The purpose of any form of data analysis, be it quantitative or qualitative is to extract "*meaningful understanding*" from the raw data (O'Leary, 2013, p. 197). This study employed mainly qualitative data collection methods such as teacher workshops, interviews, classroom observations, teacher planning documentation and open-ended survey questions. Coffey & Atkinson (1996) stress that the main concern when it comes to analysing qualitative data is with "*transforming and interpreting*" the data in a "*rigorous and scholarly way to capture the complexities of the social worlds we seek to understand*" (p. 3). Furthermore they state that there is no singular right way to analyse qualitative data and it is of equal importance to find useful ways of interpreting the data (Coffey and Atkinson, 1996).

3.5.1 Timeline of Research

This thesis examined data from three case studies which used similar methodologies. In order to clearly present these case studies and the data collection contained therein, the research timeline presented in table 3.1 contains three colours, one for each case study and four sources of data collection. Case study one, which is contained in chapter five, is coloured green while case study two, which can be found in chapter six, is coloured orange. Finally, case study three, which contains data on the pre-service teachers and is found in chapter seven, is coloured blue.

Term	Teacher Survey	Teacher Workshop	Teacher Observations	Teacher Interviews
January - March 2014	TS1	TW1		
April - August 2014		TW2		
September - December 2014		TW3	TO1/2	TI1
January - March 2015			TO3	
April - August 2015			TO3	
September - December 2015				TI2
January - March 2016		TW1/2		
April - August 2016			TO1	
September - December 2016		TW 1/2/3/4/5/6	TO1	TI1
			TO1	
January - March -2017				TI1

Table 3.1 Timeline of data collection methods conducted in case studies one from school one (cells in green), case study two from school two (cells in orange) and case study three with pre-service teachers (cells in blue).

3.5.2 Background Survey

A background survey was conducted in school one and distributed to all the teachers using a Google Form (Appendix A). This online questionnaire was adapted from the OECD TALIS (2010) survey to extract teachers' core beliefs and attitudes towards teaching and technology. It was distributed via email to all 51 teaching members of staff in school one. The survey was constructed in Google Forms which allowed for the development, administration and analysis of survey data. The survey consisted of 26 items which contained both open ended questions as well as 5-point Likert scale responses. The questions were divided into six sections labelled A-F: background information, target cohort, experience with technology, classroom practice, collegial support and management and your skills. Section A, background information, collected basic demographic information such as the teachers level of qualification, their gender and which subjects they taught at the time. Section B asked respondents to answer questions on a specific cohort of Junior Certificate (Lower second level) students which became known as the "*target* *cohort*". To select this group the teachers were given an instruction to follow. They were to select the first junior certificate class they had after 11am on a Tuesday. This instruction was given to eliminate any potential bias the teacher may have to a gifted or weak group he or she may have.

Once the target cohort was identified the teachers answered questions regarding the ability of the group, the typical teaching methods utilised, what skills they deem important for this group and were asked to provide an indication of previous uses of technology with this cohort. Section C focused on the teacher's experiences with technology. Firstly, teachers were asked questions which may provide an insight into their attitude and beliefs towards technology such as their willingness to develop their technology skills and technological pedagogical knowledge. Next, they were asked to outline any professional development courses/training they had with respect to technology as well as detailing their personal and professional use of technology. Section D focused on classroom practice and required teachers to respond to statements regarding everyday classroom practices such as managing difficult classes, asking higher order questions etc. The penultimate section asked teachers to respond to Likert scale questions regarding the amount of contact time they have with their colleagues with topics such as observing each other's' classes, ensuring common standards in evaluating the students etc. The final section presented teachers with a set of statements used to determine the teacher's self-efficacy in 21st century skills such as: synthesising information, communicating effectively and other skills. After two weeks, the survey gathered 38 responses. The responses were downloaded and anonymised using unique identification codes known only to the researcher. The downloaded data was then inputted into excel where the open-ended questions were extracted from the document and fed into NVivo 10 for coding. The remaining quantitative responses were then coded 1-5 and imported into SPSS where the data were analysed according to Braun & Clarke (2008).

To analyse the data, it had to be tested for conformance with parametric assumptions. As discussed in section 3.3.2, Field (2009) stated that there are four assumptions which must be met before a set of data can be analysed as parametric these are: 1) data is normally distributed 2) data is homogenous 3) data is measured at the interval level and 4) data is independent of each other (Interdependence).

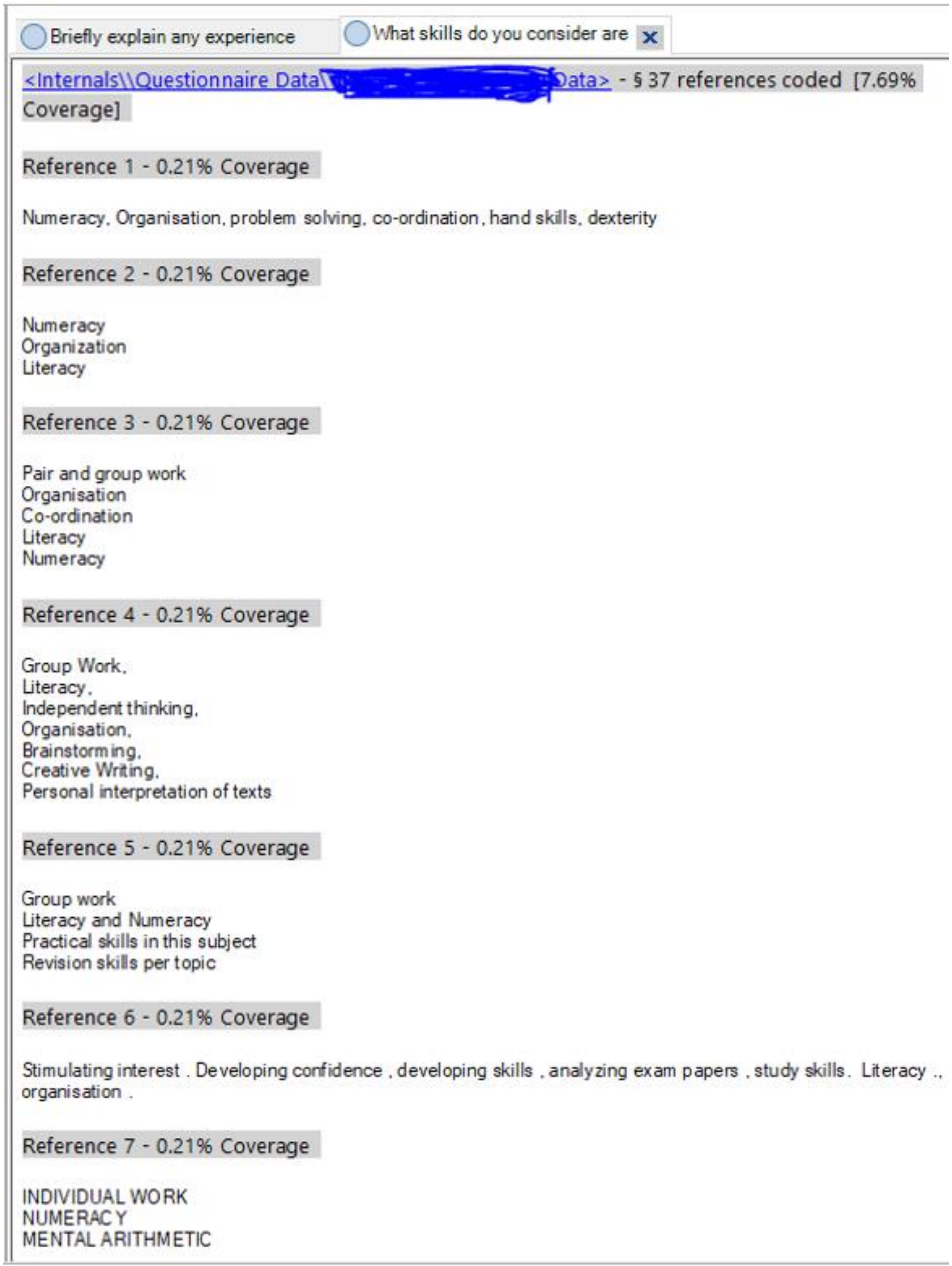
To test for normality a frequencies test was conducted on the data and the skewness and kurtosis were examined. It was found that only three items reached the skewness value of 1 indicating that the data set has failed to meet the first, and most important assumption (Field, 2009). Therefore, it can be concluded that the data is non-parametric. Non-parametric data works on the principle of ranking the data (Field, 2009). It has fewer assumptions than its parametric counterpart and as such has been regarded as having less power than parametric tests (Field, 2009). There are several statistical tests which could have been conducted however, the data in this thesis only satisfies the Kruskal – Wallis test, as such the procedure described in Field (2009, pp.562–564) was adopted. The data were entered into SPSS statistics 21, the data was analysed and tested for statistical significance between groups – male and female, subject department and ages. There was no statistical significance found between any items in any of these groupings. As a result, the data was then presented and analysed through a qualitative lens only.

The initial background survey contained nine open ended questions which were identified for coding. These questions can be found in table 3.2 below. The first three questions asked teachers to consider, rank and justify the skills they deem most important to the target cohort they identified earlier in the survey. The next pair of questions asks the teachers to recall a time where they used technology with the target cohort and detail what both the teacher and students did in this example. The next set of questions asks the teacher to detail any previous experience they have with respect to technology training while the final two questions ask the teacher to indicate how they use technology in a personal capacity and in planning lessons. These responses were collected on Google Forms and extracted from the raw data set. The questions were then brought into NVivo 10 package and the information was anonymised. Firstly, the responses were run through the auto coder function which allowed the data to be tagged by question, allowing for each teacher to be coded as the case and their responses appear in an itemised list of that question.

QUALITATIVE QUESTIONS FROM BACKGROUND SURVEY
What skills do you consider are important in your target cohorts subject?
With respect to your target cohort, please rank the previous skills in order of your perceived importance
Explain how you address your highest ranked skill in your target cohort
If you used technology with the target class, please outline what you did.
If you used technology in your target class, please outline what your students did
Briefly explain any experience you have with technology training
Briefly explain any experience you have with pedagogical technology training
Please indicate how you use technology for personal use
Please indicate how you use technology for planning a lesson

Table 3.2 Table of all qualitative questions in the background survey

Next, each response was coded for every question and the initial codes were generated. During this phase of the analysis, the codes were then organised into themes. These themes were used to identify potential talking points in the second workshop of case study one. In figure 3.5 each teacher is categorised as "*reference*" followed by a number. Under each reference are the skills they mentioned, for example reference 1 mentioned numeracy, organisation, problem solving, coordination, hand skills and dexterity. Figure 3.6 represents the questions asked in the survey. In figure 3.6 the third last question "*What skills do you consider important in your target…*" is highlighted. Clicking into this question would return the screen in figure 3.5. These responses were coded for their skill i.e. numeracy and then organised into themes to see which skills were represented the most.



Briefly explain any experience | What skills do you consider are

<Internals\\Questionnaire Data\[redacted]Data> - § 37 references coded [7.69% Coverage]

Reference 1 - 0.21% Coverage

Numeracy, Organisation, problem solving, co-ordination, hand skills, dexterity

Reference 2 - 0.21% Coverage

Numeracy
Organization
Literacy

Reference 3 - 0.21% Coverage

Pair and group work
Organisation
Co-ordination
Literacy
Numeracy

Reference 4 - 0.21% Coverage

Group Work,
Literacy,
Independent thinking,
Organisation,
Brainstorming,
Creative Writing,
Personal interpretation of texts

Reference 5 - 0.21% Coverage

Group work
Literacy and Numeracy
Practical skills in this subject
Revision skills per topic

Reference 6 - 0.21% Coverage

Stimulating interest . Developing confidence , developing skills , analyzing exam papers , study skills. Literacy ., organisation .

Reference 7 - 0.21% Coverage

INDIVIDUAL WORK
NUMERACY
MENTAL ARITHMETIC

Figure 3.4 Examples of the NVivo auto-coding by question – example: "What skills do you consider are important in your target cohort?"

Questionnaire Data (Open Codes)

Name	Sources	References
Briefly explain any experience you have with pedagogic	1	37
Briefly explain any experience you have with technology	1	37
Explain how you address your highest ranked skill in yo	1	37
If undecided, please explain why	1	37
If you used technology in your target class, please outli	1	37
If you used technology with the target class, please outli	1	37
Please give full title of degree(s)	1	37
Please indicate how you use technology for personal us	1	37
Please indicate how you use technology for planning a l	1	37
Please indicate which subjects you teach at Junior Cycle	1	37
What skills do you consider are important in your target	1	37
Which of the following do you currently hold	1	37
With respect to your target cohort, please rank the previ	1	37

Figure 3.5 The results of NVivo's auto coding by question.

3.5.3 Teacher Workshops

After data from the background survey was collected and analysed, two workshops were facilitated with teachers mostly in the format of focus group discussions. The first one focused on extracting teachers' wishes and wants for integrating technology in their lessons. For this, teachers were split into a morning and afternoon group where they were organised by their teaching subject groups. Where teachers taught more than one subject, the subject that the teacher selected in section B of the background survey was chosen as their subject grouping. This two-hour discussion hosted by the researcher and his two supervisors consisted of four questions which teachers answered individually and then as a subject group. The questions were as follows:

Q1. What do you want your students to take away from your subject?

Q2. What does it mean to be good at your subject?

Q3. Identify topics/areas which students in your subject struggle with.

Q4. How can technology help with these topics/areas?

Once individual responses were collected, the teachers then shared their answer with their subject colleagues. As a department, they were then tasked with collecting the individual responses into a subject response. This allowed the researcher to track what individual teachers thought were important and how these responses were reflected in not only the other individuals in the department, but how and which responses transferred onto the subject responses as well as which subject responses were found in none of the individual responses. Finally, at the end of each question section the group would share their answers with the other groups and the responses were written on the whiteboard. This process allowed other departments to understand the difficulties throughout a range of subjects and realise that some issues transcended the subjects and were in actuality a common problem throughout the school. The same procedure was repeated for the afternoon group and by the end of the day all teachers and subject responses were collected to be analysed over the summer months in preparation for the second workshop held at the beginning of the next school year when the teachers returned to school.

The responses were coded at the descriptive level (Bazeley, 2013) in order to develop ideas around what types of technological tools can be implemented by the teachers to possibly address the issues identified in their responses to questions three and four and how these tools fit into what teachers want their students to take away from their subject and how it address "*being good*" at their subject (Richards and Morse, 2012). The coding of the data then represented a way of fracturing the data and reconstructing it into categorical information which lead to the development of the idea of analysis (Bazeley, 2013). For questions one and two, codes were generated to see what aspects of their subjects' teachers deemed important for the student to know but also what makes the student good at their subject. An example of this is in question one. One of the highest coded responses was "*appreciation of the subject*". This was coded for any instance where the teacher makes a reference to the student having an appreciation of a) the subject as a whole, b) an aspect of the subject or c) the relevance of the subject in real life. In figure 3.8 we can see an example of such coding. In the first of the two images the text "*appreciation of subject*" is highlighted, this represents the typed theme created by the researcher. The second image is linked to the "*appreciation of the subject*" text and shows the teacher's response, which was coded as "*Appreciate that science is everywhere in everyday life*".

Questions three and four were coded and used to identify several tools which were extensively tested out on the devices for compatibility, so they could be used in school by the teachers. The tools which were deemed appropriate were then placed into a document given to the teachers in the second workshop along with an evaluation worksheet and operating instructions for each tool.

10 Commandments	1	1
Ability to make connections	1	1
Accounting Techniques	1	1
Application of Content Knowledge	1	1
Applying content in other subjects	1	1
Applying Content to Life	9	10
Appreciation of the subject	17	21
Assessing their own moral values	1	1
Assimulation of sourced material	1	1
Aurally and visually identify instruments	1	1
Awareness of content in life	2	2
Become more socially conscious	1	1

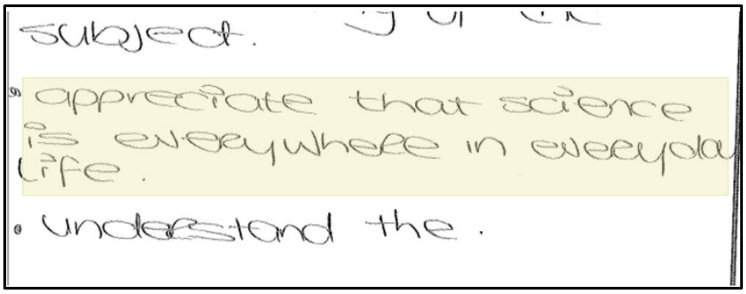


Figure 3.6 Examples of coding in question one. Highlighted text reads "appreciate that science is everywhere in everyday life"

At the next workshop teachers received their group responses from workshop one as well as the list of technology tools which were vetted for their subjects. The teachers were asked to examine one tool from the list and complete an evaluation form on their chosen tool. This form focused on drawing out the teachers' conceptions of the tool such as what were their impressions, what did they liked/disliked, how they believed it could address an area of difficulty the students have and outlined how it they could integrate the tool into a lesson. Teachers were given some time to play with the tools and complete the evaluation form before convening with their subject group and share their insight with the rest of the group. The department would then discuss each tool and decide which one tool would be most appropriate for integration. Once decided, the teachers were then asked to develop a lesson plan which focused on integrating this tool into their teaching. This lesson would serve as the first teacher observation for case study one.

In case studies two and three the workshops took a different approach. In case study two, since there were a smaller number of participating teachers the workshop could be conducted over a whole day. Using the tools identified for the subject groups in case study one, teachers in case study two used and evaluated these. However, due to the small sample size there were no subject departments and as such the group discussed their tool to the whole group. In case study three, which focused on pre-service teachers, the workshops were altered into practical university tutorials. The concept of evaluating and sharing ideas on ICT tools was integrated into the PST module and each week the pre-service teachers were asked to critique one tool and share this with their classmates.

3.5.4 Teacher Observations

There were two styles of classroom observations conducted throughout this research, the once off pilot classroom observations and the final classroom observations. Both of these observations are discussed below.

Pilot Observations:

Following on from workshop two in case study one, teachers were asked to develop pilot lessons for observation. The teachers developed and implemented pilot lessons which were video recorded and used by the researcher to develop teachers' confidence in planning, developing, implementing and evaluating technology enabled lessons and tools. It became clear that teachers required significant assistance to develop these lessons and as such nine teachers indicated their interest in developing these lessons with additional input from the researcher. The researcher spent a week in the company of these teachers and developed a lesson plan which would be observed the following week. In total nine lessons were observed from a range of subjects such as Spanish (1), Mathematics (1), Business (1), Science (3), Geography (1) and Home Economics (2). Following on from these observations, a further four lessons were observed three of these teachers were previously observed in the last round and one was a new teacher. The objective in this round of observation was to further develop the teachers' integration of technology, this time utilising a tool chosen by them as individuals rather than as a subject group.

For these observations, an unstructured approach framework was taken (See figure 3.8). Once the lessons were recorded and uploaded to the NVivo file, they were coded for examples of uses of technology, teacher and student interaction, general classroom observations and anything specific regarding the use of one-to-one devices. A brief introduction to each of the observations was written to provide the reader with some context to the lesson being discussed. At this stage of the research the observations were not developed into themes. The purpose of these observations was to gauge teachers current use of technology after the workshops.

	Level of Integration	Teaching Method	Level of Interaction	Notes
LP1				
LP2	Replacement	Investigative	Mixed	Teacher assigns students the task of finding recipies for different cheeses. Teacher provides them with the webiste to use and students just click the recipie tab
LP3	Replacement	Investigative	mixed	Teacher assigns task to find common cheese making steps

Figure 3.7 Unstructured observation protocol used in initial observations

After these observations, it was decided that teachers should plan and reflect on the lessons in which they integrated the devices. The teachers would complete a short one-page lesson plan with minimal guidance and once completed, upload it to a secure Google Drive file which was accessible to both teacher and researcher. The lesson plan was added to the NVivo data base and coded for areas of interest. After analysing these observations, it was determined that the unstructured nature and lack of coherent framework was limiting the development of the rich data that was obtained. As such, this approach was refined, and it was this new framework that was used throughout the three case studies. Therefore, these observations are contained only in chapter four of this thesis and not as part of the case study one chapter.

3.5.5 Final classroom observations

The refined structure for the teacher observations was developed when findings from the initial observations were lacking richness. A new framework was developed which drew upon the work of Hughes' (2005) technology support pedagogy, Bilici's (2013) Technological Pedagogical Content Knowledge (TPACK) Framework, Bloom's Taxonomy (1956) and the identification of classroom interactions. This new analysis framework was able to determine teachers' level of technology integration (substitution, amplification or transformation) while also providing information on their attainment in the areas of TPACK and finally position this information with context of the interactions occurring in the classroom. The framework consisted of three dimesons:

1. Interaction (Classroom interactions)
2. Integration (Hughes and Bloom's)
3. TPACK (Bilici)

Teachers in case studies one and two were asked to develop three lessons over the course of three months, implement these lessons, record them with a video camera and asked to complete a reflection sheet after the lesson. This documentation would then be shared with the researcher and feedback would be given to support the development of the next lessons. Fifteen in-service teachers in school one and school two planned and developed lessons for observation. In case study three, ten pre-service teachers were to co-develop a twenty-minute lesson which integrated technology. The lessons were recorded, and the same analysis methods as outlined above were utilised.

To support the implementation of the video recordings, teachers were provided with a wide-angle camera, several micro SD cards, a tripod mount and carry case to ensure the equipment could be transported easily. Some teachers were not comfortable with operating the camera and as such were shown how to use the device by the researcher or asked to arrange a specific class where another cooperating teacher or principal could set up the camera for them. Once all the videos were collected from the research sites, they were anonymised and analysed. Since there were several tools being implemented for these observations, analysis required multiple watch throughs. The first watch through allowed the researcher to identify divisions in the lesson based on changes in classroom interactions. Detailed notes were made about these episodes such as the work allocated, the topic and content, who was talking and for how long etc. After the first watch through, a classroom interaction chart and judgement on the level of integration could be made.

Figure 3.9 shows both the detailed breakdown of interactions and the classroom interaction chart for teacher one in school two. The detailed report provides information on the length of interaction, the type of interaction and a synopsis of the interaction that took place. There were five categories of interactions identified in this research to which all teachers were coded. These were:

- Teacher whole group – Twg: Where the teacher is addressing the whole class
- Teacher individual student – Tis: Where the teacher is working with students on an individual level
- Student group work – Sgw: Students are placed into groups and asked to work together.
- Student individual work – Siw: Students work independently on their own
- Discretionary time – Dt: Time used by the teacher for administration or where there is not teaching or learning

11:52:53	11:55:48	0:02:55	Twg	Lesson begins with teacher introducting the topic which is to put togteher a presentation on the earth, rivers and economy. Students to include ten slide, diagrams, video clips etc and teachger has provided the syccess criteria. Teacher then goes through the criteria for the river presentation. Teachert hen goes through the primary economic things (fishing etc). Students are
11:55:49	11:56:34	0:00:45	Sgw	Students begin task in their groups, creating the presentations. Teacher is walkinh
11:56:41	11:56:42	0:00:01	Twg	Teacher interupts class to let students know they are working in this lesson and another and will present in the third lesson.
11:56:44	12:01:33	0:04:49	Sgw	Students begin task again.
12:01:35	12:01:46	0:00:11	Twg	Teacher interupts class again to remind students of task. It should be good enough so students could revise with iut for their christmas exams
12:01:48	12:06:00	0:04:12	Sgw	Students continue with their task
12:06:01	12:07:00	0:00:59	Twg	Teacher asks students to ensure they save all their work. Then teacher gives students the email addresas to which the students are to send the final presentation.
12:07:00	12:12:05	0:05:05	Sgw	Students go back to task

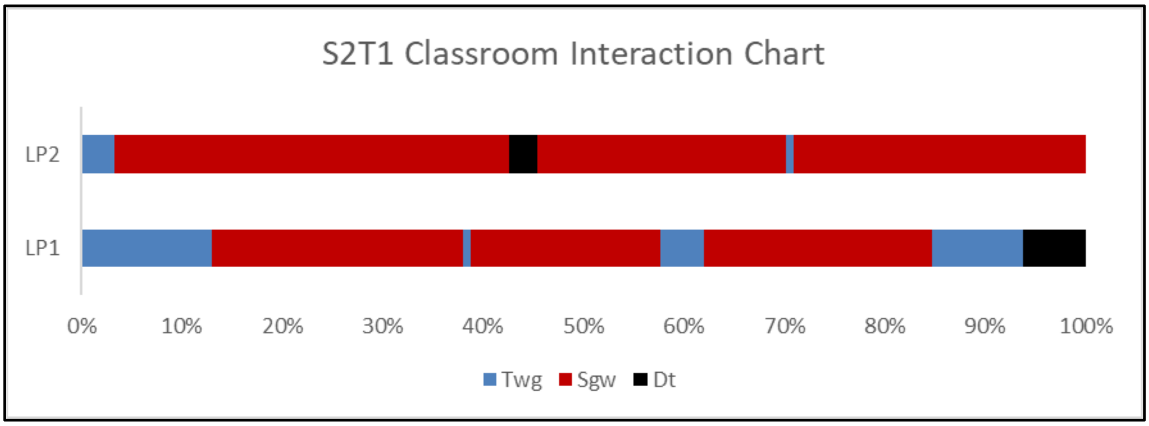


Figure 3.8 Example of teacher interaction and detailed summary of interaction

The second image of figure 3.9 shows the interaction chart of S2T1 (Geography). From this chart determinations can be made about the interactions during the lesson and whether the teacher favoured student or teaching centred methods.

The second method used in this framework was integration. While the use of Hughes (2005) framework provided data on the level of teacher's technology integration, it proved difficult to adequately distinguish between the levels without taking into consideration the level of cognition required by the learners. Therefore, the activities were also described using Bloom's Taxonomy of learning classification to provide further distinction between the levels of integration.

Hughes (2005) put forward three categories from which we can define the use of a certain technological scenario, these are: Replacement, Amplification and Transformation.

1. Replacement: Where technology is used to simply replace an activity or purpose. These scenarios are easily recreated without the use of technology. For example, a teacher using PowerPoint instead of paper notes to deliver the content of their topic. S1T2 (Home Ec.) (Geo) would be an example of replacement use of technology.
2. Amplification: Where technology is used in a more efficient manor i.e. using online documents to accomplish synchronous and asynchronous group work
3. Transformation: technology is used in innovative ways to encourage and engage students. For example, using data recording equipment in science class to record results, previously unobtainable without the use of technology

During analysis of the teachers lessons it was recognised that integration was somewhat abstract to not only the analysis, but in relating technology usage to the teachers' lessons. An earlier and discarded aspect of the data analysis examined teachers' activities for levels of Blooms. It was from this the original analysis that the concept of comparing technology integration with blooms taxonomy came about. As part of his study on integrating web 2.0 tools and social studies Diacopoulos (2015) created a table aligning specific web 2.0 tools with the National Council for Social Studies guidelines for effective use of technology. To do this, the author partnered with social study teachers and together identified as many web 2.0 tools as they could and aligned them with the guidelines. The guidelines specify four social domains for technology use, these are: planning and designing learning environments and experiences, teaching, learning and the curriculum, assessment and evaluation and social, ethical, legal and human issues. The study conducted in this thesis followed a similar course of action. However, there were several key differences. Firstly, since the study examined teachers from a wide range of subjects, a subject specific set of guidelines could not be used. Secondly and closely related to the first issue, use of certain web 2.0 tools may vary in the subjects. Therefore, it would be imprudent to align, for example, YouTube in the teaching, learning and the curriculum domain, as a language teacher may use it for assessment and evaluation. Instead, the researcher aligned the resources according to the pedagogical support methods outlined by Hughes (2005). This would provide a much wider view on the use of specific resources over a range of subjects as well as providing some insight into the level of effectiveness in the use of technology.

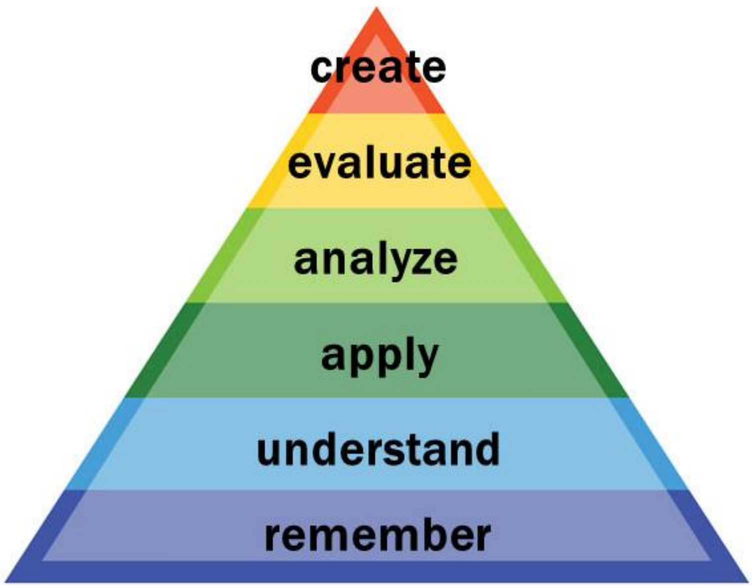


Figure 3.9 Blooms Taxonomy

The Bloom's model used was the 2001 revised taxonomy by Anderson and Krathwohl (2001) whose work involved the inclusion of the domain of cognition – seen in figure 3.10. Bloom's taxonomy was selected for this study mainly because of Irish post primary teachers' familiarity with the taxonomy.

The third method utilised in this framework involved examining the lesson via a modified version of Canbazoglu Bilici *et al.*, (2016) Technological Pedagogical Content Knowledge Observation Protocol (TPACK OP). Several modifications were made to the protocol including: a) adapting some of the terminology to make the protocol more universal in scope i.e. could be used for all subjects rather than science only and b) clarify certain levels within the key ratings. Originally designed to determine pre-service science teachers level of TPACK, the TPACK OP consists of eight ranked items categorised in five domains:

1. Goals and Purposes: The teacher's goals and purposes of teaching the subject guide/frame the development and implementation of the lesson.
2. Teacher's knowledge of assessment: Assessment methods aim to evaluate important dimensions.
3. Teachers knowledge of student's assessment: Students complete assessment that require them use critical, in-depth, higher order thinking, e.g., organize, interpret, evaluate, or synthesize complex information, and/or develop alternative solutions, strategies, perspectives or points of view.
4. Prior Knowledge: The teacher is aware of students' prior knowledge, learning difficulties and common alternative conceptions of the particular subject matter
5. Multiple Modalities: Using multiple modalities (e.g., kinaesthetic/tactile, oral/verbal, written, numerical, graphic, pictorial, tabular) allows students to feel as though they and all their peers (with different gender, ability, etc.) have had their needs met.
6. Multiple Representations: The lesson allows students to engage in representations (e.g., illustrations, models, or analogies) and activities (e.g., problems, demonstrations, simulations) that can facilitate their learning in a specific topic.
7. Context of curriculum: The teacher demonstrates an understanding of the goals and objectives for students in a particular topic that they are teaching, and that is addressed in the national curriculum.
8. Relevance of instructional materials: The instructional materials are relevant to teaching a particular domain of the subject matter and the general learning goals of the curriculum.

These eight key indicators were then grouped according to their component of TPACK. Item one was captured in the "*orientation toward teaching with technology*" component while items two and three came under knowledge of assessment. Items four and five referred to the knowledge of students' understanding of subject specific knowledge while item six referred to the knowledge of instructional strategies. Finally, both items seven and eight fell under the knowledge of curriculum and curriculum materials.

Before any analysis could be conducted using the TPACK-OP, a validity and reliability test was conducted. To do this, one other researcher was asked to co-mark a set of pre-service teachers' technology enabled microteaching lessons. The two researchers marked the students independently and compared results at the end of the session. Overall there was strong agreement between the researchers'. However, for one of the items in the TPACK-OP the researchers did not agree on the marks. In Item two "*assessment methods aim to evaluate import areas*" the researchers' found it difficult to differentiate between a three and a four. A score of three was awarded when "*all assessment methods are somewhat aligned with learning objectives to evaluate students' learning in a particular topic*" while a score of four was awarded when "*all assessment methods are aligned with learning objectives to evaluate students' learning in a particular topic*". The cause of disagreement stemmed from the lack of a middle ground, instead, the researchers elected to incorporate blooms taxonomy. Now the scores were awarded based on the teachers' use of higher or lower levels of blooms assessment. The researchers once again independently scored the students on item two and compared marks.

These results were entered into Excel and these scores were then placed on a chart to visualise the attainment of each teachers TPACK. This chart was known as the TPACK displacement chart and an example of S2T1 (Geography) can be found below in figure 3.11. While the word displacement may elicit negative connotations, it is a positive measure. The reasoning for choosing the word displacement was it reflect the nature of a teachers journey through the lens of TPACK. The researcher assumed that all teachers were starting from zero in terms of TPACK. As such, the movement from zero in any direction can be thought of as the displacement, as it has a direction and magnitude. Additionally, the word displacement was chosen as it reflected the terminology currently used within the EdTech sector i.e. disruptive technologies. In this context, it is assumed the technology is disruptive to the participants normal classroom practice. As such, the TPACK Chart can be thought of as a measure to gauge how aligned this disruption is with best practices. That is not to say however, that a lower score was a determent to the teaching and learning of the lesson. Particularly, some teachers may find low-tech methods better serve the purpose of that specific lesson. The TPACK displacement chart shows the teachers' attainment of the five domains of TPACK while the summary table provides information on the teacher's scores in each individual item. The items include text to help the researcher distinguish between the different rankings within each indicator, as such the measure of each ranking could be justified. Several items had to be changed to reflect the multi-disciplined nature of the subject being observed and as such, several lessons were observed independently by the researcher and their supervisor to test for interrater reliability.

3. *Students complete assessment that require them use critical, in-depth, higher order thinking, e.g., organize, interpret, evaluate, or synthesize complex information, and/or develop alternative solutions, strategies, perspectives or points of view.*		
Criteria	**The use of technology rich assessment tools**	**Evidence**
A "1" means that the assessment asked mostly for facts, straightforward answers.	NA/DK Yes/No 1 2 3 4	**No occurrences of assessment in this observations**
A "2" means that the questions required application in a slightly different situation, one higher order thinking questions asked, mostly lower higher order thinking questions.		
A "3" means that the questions involved synthesis and analysis and/or presented a new situation, two higher order thinking questions asked., mix of higher and lower order thinking questions (See lower half of Blooms)		
A "4" means that the questions used evaluation and/or higher order thinking, three or more higher order thinking questions asked. (See higher half of blooms)		

4. *The teacher is aware of students' prior knowledge, learning difficulties and common alternative conceptions of the particular subject matter*		
Criteria	**The use of technology**	**Evidence**
A "1" means that the lesson is somewhat aligned with students' prior knowledge, alternative conceptions and learning difficulties but teacher isn't knowledgeable to overcome alternative conceptions and difficulties.	NA/DK Yes/No 1 2 3 4	**The lesson asked students to develop a powerpoint based on prior knowledge which could be used by future students as a revision tool.**
A "2" means that the lesson is somewhat aligned with students' prior knowledge, alternative conceptions and learning difficulties but teacher is somewhat knowledgeable to overcome alternative conceptions and difficulties.		
A "3" means that the lesson is substantially aligned with students' prior knowledge, alternative conceptions and learning difficulties and teacher is somewhat knowledgeable to overcome alternative conceptions and difficulties.		
A "4" means that the lesson is substantially aligned with students' prior knowledge, alternative conceptions and learning difficulties and teacher is knowledgeable to overcome alternative conceptions and difficulties.		

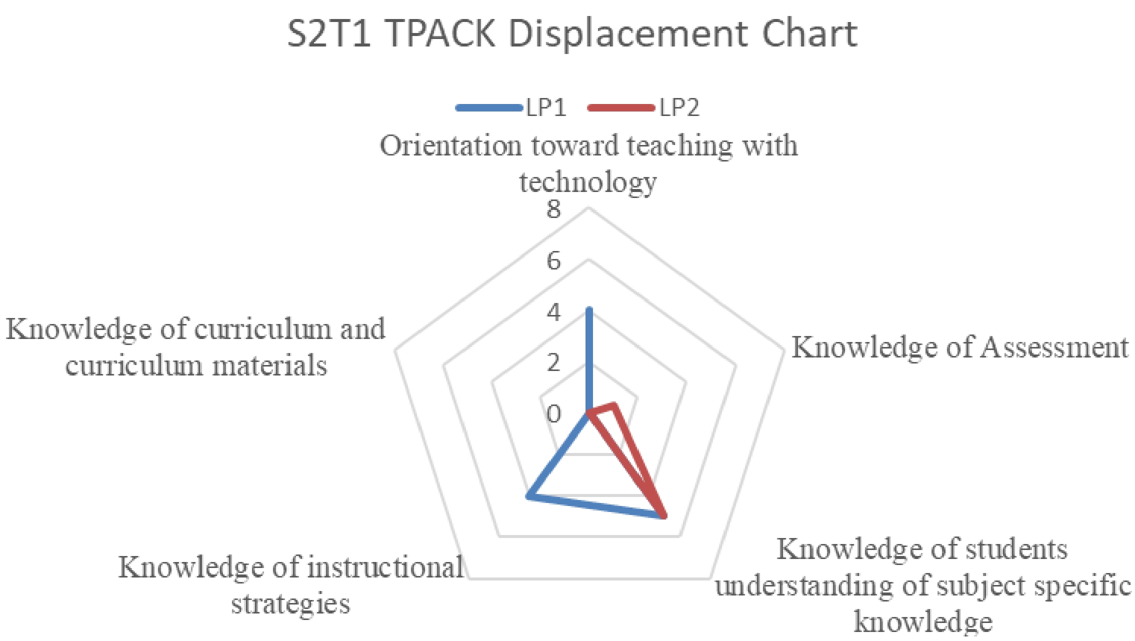


Figure 3.10 Examples of lesson summary (left) and TPACK-OP ratings of key indicators

3.5.6 Teacher Interviews

After the completion of the teacher observations, an interview was held with the teachers to gather information on their experiences developing technology enabled lessons as well as their recommendations not only for themselves, but for other teachers and schools who may be interested in integrating technology into their lessons. These interviews were conducted individually and the time for each interview lasted between 20 to 40 minutes. The interviews were semi-structured, and participants were asked 11 core questions from which others may have been asked. These interviews were audio recorded and later transcribed verbatim so that thematic analysis could be conducted on the transcripts. The thematic analysis conducted on these interviews was identical to the analysis method conducted in section 3.5.3.

3.6 Ethical Approval and Considerations

Ethical approval was sought and approved by the Research Ethics Committee in Dublin City University in October 2013. Further ethical approval was sought and approved in March 2016 in relation to the addition of School two and the inclusion of pre-service science teachers as well as extend the ethical approval previously approved in 2013.

Ethics plays a vital role in not only the formation of a piece of research, but also in the protection of the researched (Felzmann, 2009). Felzmann (2009, p.102) identified three key areas of consideration for every school-based research project. These were: informed consent, confidentiality and harm. Since two of the three case studies took place in post-primary schools with students, extra precautions had to be considered. Within the school context, achieving informed consent can be difficult due to the multiple stakeholder present, for example, teachers, students and management. Additionally, the majority of students in school are minors and therefore, further ethical and legal requirements are placed on the researcher. The researcher collected informed assent from the participating student as well as informed consent from their legally recognised guardian. Furthermore, the informed assent must recognise that the students may not have the cognitive ability to fully understand what is being asked of them. Therefore, every effort was made to ensure correct and age appropriate language was used, while also ensuring the student could discuss any questions or concerns they have with the researcher. With regards to the power of consent and assent, it is generally accepted that consent trumps assent while refusal trumps acceptance (Felzmann, 2009, pp. 1–2). Therefore, the researcher followed these guidelines:

- when both legally appointed guardian and child consented/assented, the child became a participant
- when the child assented but the legally appointed guardian refused, the child was not included in the research.
- When the child did not assent, no further steps were taken, and the child was not included in the research

In addition to these measures, there is also one other major ethical concern. Since the students were asked for assent during school time they were most likely with their peers in a classroom setting. Therefore, some students may have felt pressured to assent to the research. To deal with this, students were asked to return their assent forms to the principal within the week at their own discretion. This provided students with power over their own decision making. One final consideration the researcher made was on the management of participating and non-participating students. The researcher considered the options available, including a separate breakout room for the students to conduct comparable supervised activities. However, this was not needed as consent and assent for the students in the participating teachers' classes were received in full.

The next group of participants were the in-service and pre-service teachers. As this cohort of participants were all over 20 years of age, informed consent only was sought. Much of the same considerations were made such as the potential of group influence on decision making. Ultimately, consent was given from all participants. In the plain language statement, which all participants received, participants were informed of the aims, objectives and methods of data collection involved in this research. Each participant read and signed a plain language statement and consent form to be included in this research. Participants were informed of the legal limits of confidentiality and the risks associated with small scale qualitative research.

The second ethical consideration was confidentiality. Confidentiality requires that the researcher does not divulge any information gather from or related to the research activity without the expressed consent of the participant (Felzmann, 2009). In this research data was collected only on the participating teachers. However, since students would be observed in the video recorded observations, steps had to be taken to ensure confidentiality – such as limiting the viewership of the observations to just the researcher and the participating teacher. However, in the case of minors, the researcher was compelled by law to breach the confidentiality in extreme cases in which the minor may have been put at risk. This legal requirement was clearly stated to all participants in the plain language statement and assent/consent forms.

The final ethical consideration was risk to the participants physical, social or psychological health. Felzmann (2009) states that in school based research the risk of physical harm is significantly reduced. However, psychological and social harm are not uncommon. Some psychological risks include:

- Confrontation with particularly emotionally evocative material
- Confrontation with age-inappropriate material
- Confrontation with sensitive topics
- Confrontation with topics related to personal difficulties or difficult life experiences triggering of traumatic memories (Felzmann, 2009, p. 107)

Social risks may include: becoming isolated from peer group, being perceived differently within peer group or loss of status (Felzmann, 2009). To reduce the potential for harm, the data collected was only shared with the specific participant. However, participants were made aware of the limitations of confidentiality in the context of small scale qualitative research. Every effort was made to ensure data was anonymised and presented anonymously in any publications to reduce the potential of any social, physical or psychological harm.

3.7 Conclusion

This chapter presented the selected methodology chosen to answer the chosen research questions. Case study methodology was discussed at length before a statement on this project methodological framework was presented. The theoretical underpinnings of the researcher were then presented. A pragmatic approach has been adopted as the researcher wished to explore the experiences of teachers integrating one-to-one technology, utilising a variety of methodologies and analytical strategies. The research consisted of three main studies which took place in school one and school two as well as in a University with second year undergraduate science education students. School one was a 3-year study which collected several forms of data such as surveys, observations, workshop responses and lesson planning documentation. School two was a short replication study based on the experiences gained from school one. This study focused on teachers first time experiences with integrating technology into their teaching. All qualitative data except for the observations were analysed using the thematic analysis methodology outlined by Braun & Clarke (2008). At several stages throughout the project the data was coded and sorted into themes in order to advance the project however, at the end of the study in school one, all data collected over the three years was placed into a data pool and recoded to generate themes throughout the life of the study.

In summary, the case study methodology was adopted from Yin (2009). Qualitative data was analysed using the thematic analysis guidelines developed by Braun and Clarke (2008) or in the case of video observations, using the observational framework developed by the researcher. Case studies one, two and three contained the same methodological procedure, except for the background data that was captured in school one prior to the commencement of case study one.

Chapter 4 School One - Background

4.1 Introduction

This chapter presents the background to school one prior to the commencement of case study one in this school. School one was awarded a set of 1:1 tablet devices for their entire first year cohort and teaching staff in 2013. The data in this chapter is presented to provide an overview of the school, their policies and management structures, the Intel SMARTCLASS award and its promises and outcomes. It should be noted the collected findings from this data were used to develop the case study methodology used in the later chapters 5, 6 and 7.

School one is a co-educational post-primary community school located in rural north-west Ireland. Community schools are independently owned by the Education and Training Boards of that county and offer a wider range of programmes to its students', such as vocational education and adult education to its community (Citizens Information, 2016). Enrolment figures at the time indicated that 53% (402) were boys while 47% (361) were girls in School one (School Days, 2016). The official website for School one indicated that at the time data was collected in this study there were 51 teachers employed in the school.

The school is equipped with several dedicated computer rooms, purpose-built materials technology workshops, several science laboratories as well a science demonstration room, several home economic kitchens, art and music facilities and over 40 classrooms and prefabrication rooms. At lower second level students are enrolled into 10 core subjects consisting of: Irish, Mathematics, Civic, Social and Political Education (CSPE), Social, Personal & Health Education (SPHE), French or Spanish, Science, Geography, History and Physical Education. In their first-year students' get to sample all eight optional subjects and in second year chose two to continue studying, these subjects include: Art, Craft and Design, Woodwork, Technical Graphics, Home Economics, Business Studies, Music, Technology and Metalwork. After completion of their terminal examination at the end of third year, students' then have the option to enrol into an optional 4th year known as Transition Year (TY) or, continue into the traditional Leaving Certificate programme. There is also the option for students' who are more interested in developing practical work skills to enrol into the Leaving Certificate Applied Programme (LCA).

In 2012 a whole school inspection was conducted, and the findings of the report indicate that School one enjoys very good ICT provisions and the quality of teaching was "*generally good*" with a small number of lessons observed as "*exemplary*" (p. 1). Recommendations made by this report include developing literacy and numeracy strategies and attention should be given to increasing teachers' engagement with continuous professional development (CPD) which has a particular focus on key teaching and learning areas. The report also found the school support and management structures as well as the relationship between them and staff were very positive.

The school operates a no phone and no media player policy except during lunch time and after school activities to include school tours. There is a good relationship between both management and their staff. Management were always visible in the school throughout the day and have a good rapport with the students'. In order to communicate with staff, a television was placed in the staff room displaying messages from both management and staff through PowerPoint.

4.2 Participants

The participants in this study were the collective teaching staff of 51 members. As expected, these teachers have diverse backgrounds, experiences and subjects. This section aims to provide some context to who these participants were.

The teachers were all based in a mixed community secondary school in rural Ireland. Of the 51-teaching staff 66% were female. All teachers held a bachelor's degree at a minimum while nine teachers held either a taught or research-based masters. In terms of experience the lowest number of years teaching post degree was 3 years, while one had a full 40 years' service and was retiring that year.

4.3 Smartclass Initiative

4.3.1 Aims, objectives and initial set up.

SMARTCLASS was an initiative run by Intel Ireland whose focus is on creating the 21st century classroom by changing from a content based system to a skill based teaching model (Intel Ireland, 2011). In August 2011, Intel partnered with the Education Company of Ireland and Steljes to host a national competition which awarded one post-primary school a technology package for their entire first year cohort of students'. This technology package included a Fizz book laptop for each first-year student, a complete booklist of digital books provided by the Educational Company, Intel's own Smart software as well as teacher CPD to be provided by Steljes and Intel. As part of the project award, a programme of independent evaluation was carried out over the course of the project and Dublin City University (DCU) was selected to conduct this research and have an active role in supporting teachers in their integration. The challenge set out by Intel was to create an e-book which depicted the Smart Class of the Future – 2025. Within this book the entries must consider how technology in the class could change the ways of thinking, the ways of working, the tools for working and the ways of the living in the world. In November 2011 the prize was awarded to the school for its entry written by a final year student. The school was required to invest in the upgrading of its wireless infrastructure system. Once this was completed the Fizzbooks were deployed for the incoming first years of the 2012/13 academic year. To assist the school and its teachers a full time IT technician was employed by school one.

4.3.2 Fizzbook implementation

In September 2012 the teachers and incoming first year students received their Fizzbooks devices. The devices were preloaded with all the relevant software and eBooks by Steljes. Issues occurred instantly with the Fizzbooks as they were not updated with the latest firmware and the eBook accounts were not set up for the students'. The technician installed all the relevant service packs and setup the eBook accounts, but it took a whole month before the students got their Fizzbooks again. Any initial wave of enthusiasm was washed out by the limiting factors of the Fizzbook such as the start-up speeds and their general slowness in handling basic operations such as opening the eBooks and entering text in word processing software. A survey was conducted to gather information on the students' experiences with the devices to date. Results showed major dissatisfaction with the Fizzbooks (61%) and a majority of students had preference to using physical books over the Fizzbooks (69%) while 48% identified the loading of the eBook pages as being "*too slow*". When asked if they felt the Fizzbooks had enhanced their learning compared to traditional textbooks, over 4/5ths of students' stated *No*. As a result of the feedback gathered the devices were upgraded from 1GB of random access memory (RAM) to 2GB. However, this upgrade was not noticeable to some students' as quite a few of the Fizzbooks were fitted with a standard Hard Drive Disk (HDD) whole others had a Solid State Hard drive (SSD) installed. This meant that only those fitted with a SSD saw a benefit from the increase in RAM.

The devices were then tested by a local Institute of Technology and found that on average the devices took between 2-3 minutes to open from sleep mode with an additional minute and a half to open an eBook from the desktop. Later that school year, all Fizzbooks were fitted with the 2GB of RAM, space was freed up on the hard drive and logical issues with some devices were resolved. At the end of the school year another student's survey was carried out and the results still showed that the Fizzbooks were not fit for purpose as eBook readers, but both teachers and students reported some success in using them for projects and research at home.

At the end of the school year teacher interviews were conducted to evaluate the success of the Fizzbooks and the first year of the Smartclass initiative. Teachers from each subject department were interviewed and their responses were recorded and collated into table 4.1

An examination of table 4.1 suggests that teachers were overwhelmingly negative in their view of the Fizzbooks and this is mirrored in the interviews as the majority of the interview time was taken to discuss how slow or unfit these devices were. However, there were a few encouraging points made by teachers such as teachers' feeling the Fizzbooks were a great additional resource for research and project-based assignments, pursuing new opportunities that teachers could not before, and a number of teachers believed the devices allowed the students to become more independent learners. It was clear from the interviews however, that the teachers did not believe the devices were capable of being used in the classroom and refused to use them in the next year. With these points in mind it was two recommendations were made. Firstly, teachers receive professional development to expand their usage of the technology. Secondly, the Fizzbooks be collected and a new device should be selected and rolled out to the school in the next academic year. The Fizzbooks were collected back from the teachers and students' and were replaced with the Asus T100 Transformer Book as the selected device.

Subject	**Device Usage**	**Negative Feedback**
Science	Used as eReader Online activities Edmodo	Time consuming Revision difficult for the students' Teachers found using the Fizzbooks daunting. Teachers are unsure if students are focusing on the lesson when looking at the screen. Difficult to read pages based on the screen size
English	Used as eReader	Fizzbooks are an obstacle to learning Fizzbook is outdated Teachers' felt they had to teach IT as well as their usual English class.
Irish	Used as eReader only Used as an oral aid	Students' prefer using notebooks.
Mathematics		Can't view more than half a page at a time Students' keep coming up new excuses for not bringing in their devices
Business Studies	Helps stronger students become independent learners Used only as an eReader	Can't underline on the eBook Too slow to load Teacher feels students' have a negative opinion of the Fizzbooks
Geography	Used as an eReader Has been used for short assignments Edmodo is used for setting assignments	
Civic, Social & Political Education	Have been used for setting assignments	
Art	Used for researching topics Students' becoming more independent learners First time students got to experience graphics designing	Problem connecting to the internet
Social, Personal & Health Education.		Books take too long to load Batteries are often dead
History	Used for research Students' have the chance to become independent learners Students' have completed project work Students' enjoy working independently	Opening the eBooks is time consuming Discipline was an issue at the start Weaker students' make up excuses to get out of work when the Fizzbooks are being used
French	Students' have created PowerPoints and sent them to the teacher through Edmodo	Fizzbooks are not up to standard Too slow to load The pace of the learning is slowed

Music	Used interactive website	Teacher tried allowing the students to type up their notes but found they typed too slowly and took much longer Students' are more easily distracted
Spanish	Fizzbooks are mostly used at home for homework Suits weaker students at home when doing activities Students' are becoming more independent	eBook are too slow
Religion	Used as a research tool Edmodo also used for uploading of project work Students' knowledge of subject has expanded	
Technical Graphics	Used only as eReader in classroom Students' complete homework in MS word and email it to the teacher.	Units are cumbersome
Home Economics	Video practical work Students' becoming independent learners	Devices are too slow to use

Table 4.1 Teachers collated responses to interview at the end of the 2012/2013 academic year.

4.3.3 Asus Implementation

By half way through the academic year all students' and approximately 30 of the staff had received their new device. During the deployment of the new devices (Asus T100s), Wriggle, who replaced Steljes as a new technology partner provided all staff and students with a 90-minute workshop covering the basic operations of their new devices including accessing the eBooks. This time around all devices were imaged with the latest updates and student accounts were created beforehand so each student was given their own username and login for both the device and the eBook accounts. In subsequent informal discussions, teachers were becoming increasingly more engaged with technology, excited by the prospect of the new device and the possibilities it could bring. The use of devices was mostly as eBooks.

4.3.4 Teacher Workshops

It was decided that students' and teachers should be given a few months to grow accustomed to their new devices before the roll out of two workshops with teachers at the end of the year. These workshops were focused on determining teachers' wishes and wants with technology, providing teachers with several examples of technological tools available to their subject and providing them time to engage with these tools and discuss as a subject group the opportunities and challenges each of these tools presented.

At the first workshop teachers were divided into two groups which were facilitated in the morning and afternoon. The groups were compiled from each subject department and arranged so that there were some cross curricular links between all subject groups present in the sessions. To begin this workshop, teachers were asked to answer four questions: Q1) what do you want your students to take away from your subject i.e. what is the essence of your subject? Q2) what does it mean to be good at your subject? Q3) identify topics/areas which students' generally struggle with/ Q4) How can technology help? The teachers responded to each question individually before consulting with their subject group to provide an overall subject answer. The individual and group responses were collected and analysed. Using their responses, tools, software etc. were carefully selected by the researcher and tested for compatibility with their devices. At the second workshop which took place three months later, the teachers returned in their original morning and afternoon groups and were presented with a list of tools and software for each of their subjects. Teachers were asked to select one item from the list and explore it for half an hour. When the time was up, all teachers within that subject group shared their experiences and discuss the opportunities and challenges presented by each tool. Teachers were then given some time to explore particular technical tools. They were then asked to select one or two of these tools as a subject department that they would then plan and implement into a lesson in October.

4.3.5 Pilot Observations

Following from the second workshop, teachers were asked to develop lessons in which they integrated the tool chosen by their subject department. One teacher from each department was selected to develop a lesson and implement it while being observed by the researcher. In total, eight teachers were observed from a range of subjects including Spanish (1), Science (3), Mathematics (1), Geography (1) and Home Economics (2). During this round of observations, the researcher sat at the back of the classroom and took field notes during the lesson. At the conclusion of these observations it was recommended that teachers needed vast amounts of support and as such, five teachers were invited to collaborate further with the research to develop more student-centred technology enabled lessons.

Following directly after the first round of observations a group of five teachers worked closely with the researcher to develop technology enabled lessons. During this two-week period, five teachers engaged with the researcher in developing one pilot lesson which integrated technology beyond the teachers' regular usage. The findings from these two rounds of observations were that working closely with a small group of teachers provided more meaningful integration.

4.4 Findings from teacher background survey

The next sections of this chapter will discuss the results obtained from the attitude and beliefs survey, the teacher workshops and some general observations noted during the teaching observations.

All 51-teaching staff were asked to complete an online Google Forms survey within a two-week period prior to the commencement of the first teacher workshop. Of the 51 staff, 37 (74%) completed the survey. The purpose of this survey was to gain information on teachers' background and their attitude and beliefs towards teaching and technology. The OECDs Teaching and Learning International Survey (2013) was used as a source of questions on teachers' attitude and beliefs. The TALIS 2013 survey was prepared via a consortium of 23 countries. The survey item itself was developed and construct validity and confirmatory factor analysis were conducted to ensure the survey tool was both valid and reliable. A full copy of the survey which was sent out to teachers can be found in appendix A of this thesis. The participants data was downloaded into excel and the data was anonymised. Once anonymized, the data was then manipulated so as to be readable in SPSS 23 statistical package. Using the parametric assumptions set out by Field (2009) and as discussed in chapter 3 of this thesis, it was found that the data did not meet the any of the parametric assumptions and as such non-parametric tests were conducted. Results from these tests showed no significant statistical differences and as such the data was then analysed using a qualitative lens. Below are the results from each section of the survey.

4.4.1 Teachers' Attitude Towards Teaching

Figure 4.1 shows the distribution of responses of the 37 teachers to question ten and eleven. For simplicity, the questions are referred to in their short hand, for example, question 10 a asks the teacher for their level of agreement with the following statement "*I use lecture style presentations*", this is presented in figure 1 as 10a. A full list of expanded questions can be found in table 4.2, as well as subsequent tables in the preceding sections.

Question 10 a to h, inquire about a teacher's specific usage of certain teaching methods such as lecture style presentations, group work, assessment methods and individually. While the set of questions eleven ask about the type of assignments the teacher allocates to the classes they teach. The questions were asked on a five-point Likert scale with the options in question ten being: 0) not at all, 1) a quarter of class time, 2) half of class time, 3) three-quarters of class time and 4) all of the time.

The results from question ten show that the majority of teachers indicated they tended to use lecture style presentations between a quarter to half of the total lesson time. Question 10h, "*I check by asking questions whether the subject matter has been understood*" had the highest proportional response to "*All the time*", with a total of 23 teachers suggesting that teachers tended to ask students questions on whether they understood the content all of the time throughout their lessons. For the majority of responses in question ten, teachers tended toward the middle i.e. fifty percent of class time. Question 10g "*I allow students' to work in groups based upon their ability*" had the lowest number of zero or "*not at all*" responses. This question asked if teachers grouped their students' according to their ability levels, in total seventeen teachers stated that they do not do this in any of their lessons.

Question eleven shows the teachers' typical usage of assessments or assignments. The majority of teachers do not use essay style questions as a form of assessment, which is not surprising, given that only a handful of teachers were language teachers while the rest were from more practical based subjects. It can also be seen that the most common form of assessment used by these teachers was the administration of a test. 26 teachers used these at the end of every topic. Apart from these two questions the general trend is that other forms of assessment were used quite infrequently.

Q10 a	I use lecture style presentations
Q10 b	I present a short summary of the previous lesson
Q10 c	I prompt students to recall specific knowledge
Q10 d	I facilitate individual students' learning
Q10 e	I allow students to work individually with the worksheet/textbook
Q10 f	I allow students to work in small groups to come up with a joint solution to a problem or task
Q10 g	I allow students to work in groups based upon their ability
Q10 h	I check by asking questions whether the subject matter has been understood
Q11 a	I assign my students' projects that require at least one week to complete
Q11 b	I ask my students to write an essay in which they are expected to explain their thinking or reasoning at some length
Q11 c	I hold a debate where students argue for a particular point of view which may not be their own
Q11 d	I administer a test or quiz to assess their learning

Table 4.2 Full list of questions: 10 (a-h) and 11 (a-d)

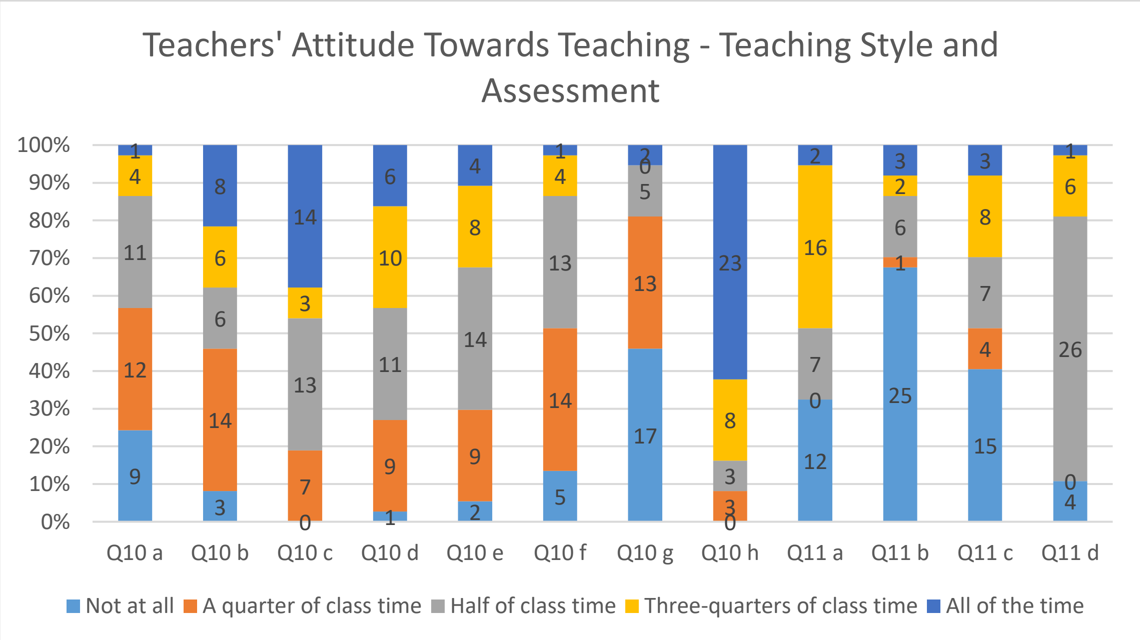


Figure 4.1 Stacked bar chart representing the results of teachers' attitudes towards teaching – teaching style and assessment

4.4.2 Teachers' Attitude Towards Teaching in Specific Classroom Situations

The teachers' responses to questions pertaining to their attitudes towards teaching in specific classroom situations are shown in figure 4.2 and table 4.3 below. Classroom situations such as how they react to a wrong answer from a student, managing classrooms where students were doing different activities, how they react to not knowing the answer to a students' question, relating their content in a broader context and their comfortability to ask questions to which they themselves were unsure of the answer. The results indicate that teachers would most likely not provide the students with the correct answer immediately if they were incorrect. Table 4.3 shows that the majority of teachers' disagree in some capacity with the statement "*I am uncomfortable with asking questions in my class where I am unsure of the answer myself*" which is encouraging as it shows the teachers' do not perceive themselves as the typical sage on the sage (Van Ast, 1997). More encouraging results can be found in the responses to "*I am unsure how to ask students' higher order questions that promotes thinking*" and "*I find it difficult to manage a classroom where each student group is doing different activities*" where the majority of teachers, to some extent, disagree with those statements.

Q24 a	If a student gives an unexpected answer/result I immediately tell the students', the right answer/result
Q24 b	I am unsure how to ask students' higher order questions that promotes thinking.
Q24 c	I find it difficult to manage a classroom where each student group is doing different activities.
Q24 d	If I don't know the answers to students' questions I feel inadequate as a teacher
Q24 e	I am uncomfortable with asking questions, in my class, where I am unsure of the answer myself.
Q24 f	I often show students' the relevance of my subject in a broader context
Q24 g	I think a quiet classroom is generally needed for effective learning

Table 4.3 Full list of questions: 24 (a-g)

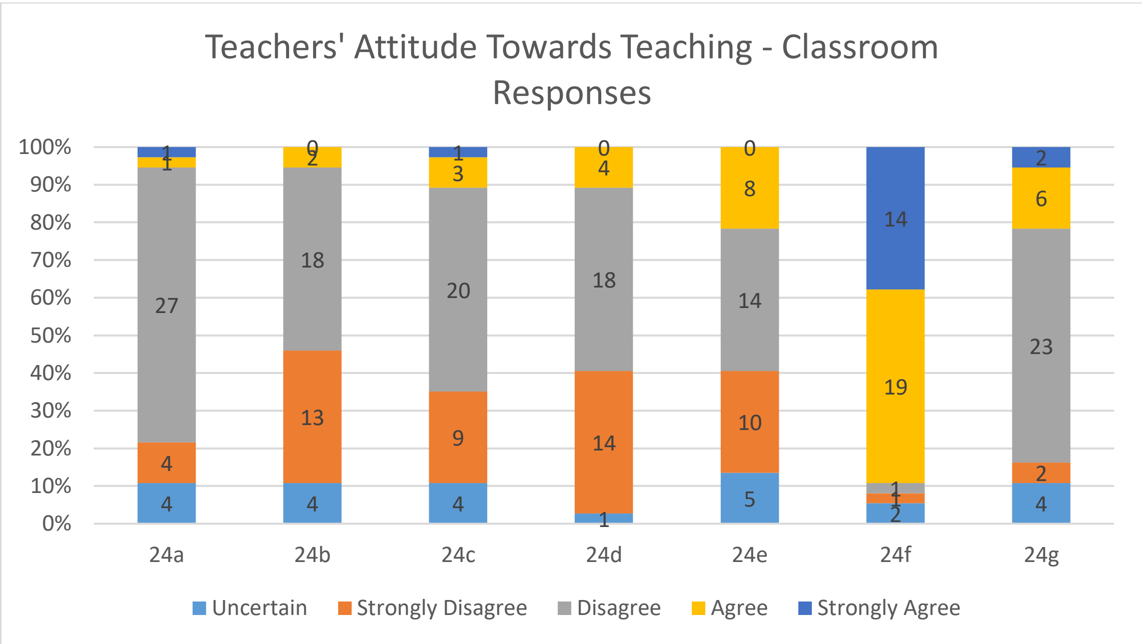


Figure 4.2 Stacked bar chart representing the results for teachers' classroom responses as found in questions 24 (a-g)

4.4.3 Teachers' attitude towards technology

The next section collected teachers' response to their attitude and beliefs towards teaching with technology, the results of which can be found in table 4.4 and figure 4.3 below.

Question 19a "*The use of technology is appropriate to achieving the aims of the curriculum*" asks teachers' if they believe the use of technology is appropriate to achieving the aims of the curriculum, and it is disconcerting that over 30% of teachers surveyed were uncertain. However, other responses were more reassuring for example, all but two teachers believed that teaching with technology is not just suitable for very capable students' but for all abilities of student (19b). While all, but two teachers agree that they were willing to develop their TPK and TK (19f and 19g). The last two questions ask whether the teachers' believed there were sufficient professional development opportunities for them to develop their technological knowledge and technological pedagogical knowledge (19h and 19i). The results showed that a significant portion of teachers were uncertain, while 14 and 17 teachers respectively, believed that there were not enough professional development opportunities.

Q19 a	The use of technology is appropriate to achieving the aims of the curriculum.
Q19 b	Teaching with technology is only suitable for very capable students'
Q19 c	I think technology takes up too much time for me to implement.
Q19 d	Technology and ICT skills are not needed in my teaching
Q19 e	I need more training in technology and ICT skills
Q19 f	I am interested in developing my technology skills
Q19 g	I am interested in developing my Technology Pedagogical Knowledge (TPK)*
Q19 h	There are sufficient Professional Development Courses available for Technology and ICT skills.
Q19 i	There are sufficient Professional Development Courses available for Technology Pedagogical Knowledge

Table 4.4 Question stems to questions 19 a to i

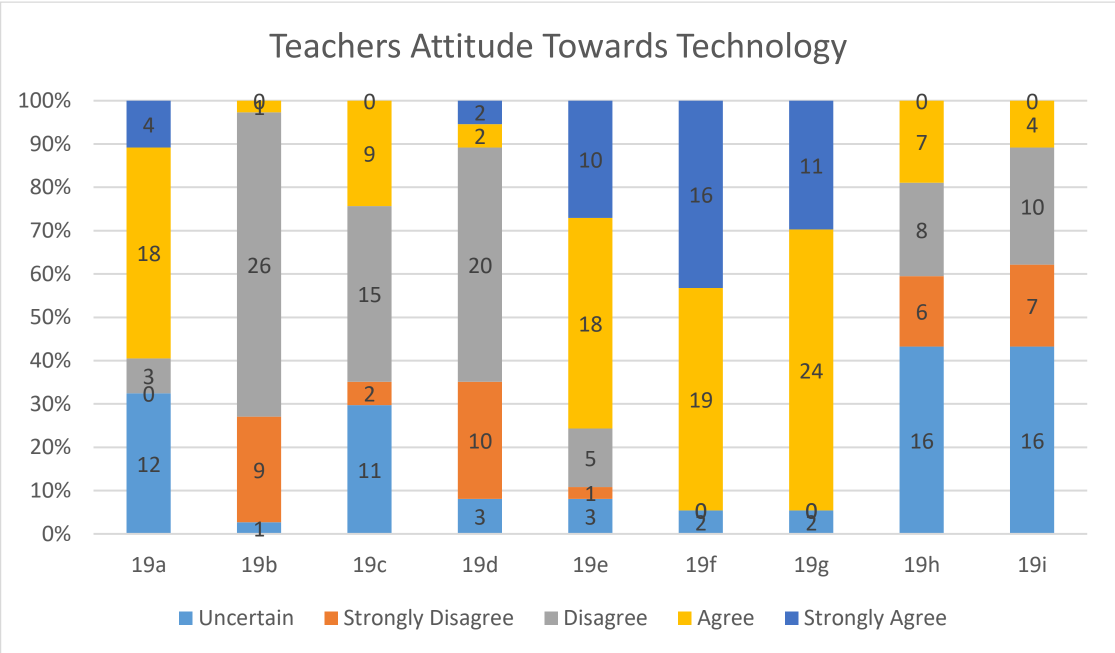


Figure 4.3 Results of the responses to teachers' attitudes towards technology contained in question 19 (a-i)

The overall findings of this survey indicated that the teachers were generally quite positive in their beliefs of technology. They identified a need for more professional development in technological domains such as TK, TCK and TPK.

4.4.4 Open Ended Response

As part of the survey, there were several open-ended questions for the teachers to answer. These questions asked teachers' to either justify a particular answer or comment on specific aspects of technology, teaching or training. Figure 4.7 contains a table with all the open-ended questions.

The first question to be examined was teachers' previous experience with any Technological Pedagogical training. This question asked if teachers had previous professional development on subject specific technology use or workshops detailing how to use specific teaching methodologies with technology. In total 20 teachers (54%) were recorded as stating they had no previous experience with this type of professional development or training. Six out of the 37 teachers responded that they had attended some training on specific tools or websites, while a further five highlighted that the only training they had received was the tablet specific one provided by Steljes as part of this study. The remaining teachers all noted that they had received training in college during their undergraduate or more recently during a master's qualification.

The next two questions asked the teachers to recall specific examples of when they used technology in their teaching with respect to the target cohort identified earlier in the survey. Firstly, teachers were asked to recount what their students did and then discuss what they themselves did during this lesson. In total, sixteen teachers were identified as using technology as a revision tool in the form of completing online quizzes or assignment or developing PowerPoints or as a research tool often asking the students to find information online or video examples. Seven teachers stated they have never used technology at least with that target cohort. The remaining teachers offered a wide variety of different experiences of classroom practice but most however, focused on prescribed student work. One teacher did discuss how they have an online pen pal system with a school in Spain and provides some examples of what they do in their class such as blogging, video calling and completing tasks and worksheets developed by the cooperating school. In the teacher section of this question the majority of responses were to do with research and revision. Teachers stated they would show students' a PowerPoint, give them tasks and correct them, or in the case of revision work assign them a task and walk around checking their progress.

When asked to outline how they use technology in their free time, surfing, emails, shopping, social media and news were all popular responses. Other responses included preparing lessons, watching online video services, listening to music and online banking, however most of these responses were only recorded once or twice by individual teachers. Not surprisingly, the most popular use of technology was to plan their lessons in PowerPoint and Word documents. Another popular response was finding YouTube videos and designing worksheets. There was one teacher however who said they do not use technology at all to assist with planning their lessons.

If you used technology with the target class, please outline what you did
Please indicate how you use technology for personal use
Please indicate how you use technology for planning a lesson

Table 4.5 List of open ended questions contained in the survey

4.5 Teacher Workshops

Two whole school workshops were held throughout the duration of this study. The purpose of these workshop was to allow the researcher to identify target areas for development with technology in each teacher's subject. To achieve this, teachers were asked four central questions:

1. What do you want your students to take away from your subject by the end of Junior Cycle?
2. What does it take to be good at your subject?
3. What topics/areas do students' struggle with?
4. How can technology help in teaching your subject?

The first workshop ran for two and a half hours where the staff were organised into their subject groups. While this session took place a parallel session with wriggle on the classroom management suite took place. In the researcher led workshop the teachers' answered each question individually before consulting with their subject group and presenting a final group answer. Throughout the workshop teachers had a chance to share their answers with the group. Teachers' found that some issues which they felt were isolated to their subject were in fact widespread in all subjects. coded according to Braun & Clarke (2008) and as described in chapter three of this thesis. The answers were collected and entered in NVivo 11 according to the subject groups.

4.5.1 Question One: "What do you want your students' to take away from your subject by the end of Junior Cycle."

Question one asked the teachers' what do you want your students to take away from your subject by the end of Junior Cycle? On the individual level, three major themes were identified. These were; Skill development, appreciation of the subject/world around them and understanding and applying the content. In terms of skill development there were twenty-two instances where a teacher made a specific reference to developing a skill, i.e. problem solving which was cited eight times, communication cited nine times, creativity (6), working in groups (5) literacy (4), lifelong learning (3), critical thinking (2) and independent thinking (2). Appreciation of the subject/world around them was mentioned by 17 teachers and was quite often explicitly mentioned for example, teacher 31 (T31) of school one (S1) who was coded as S1T31 (English) stated "*Develop an interest or appreciation for the world around us*". The final theme was understanding and applying content knowledge which was cited 40 times making it the largest theme of the three. Originally coded as three separate codes named content knowledge, applying content to life and understanding of content, they formed the major theme. Examples include "*To make use of home economics in their life*" (S1T2 (Home Ec.), "*How to manage money*" (S1T12 (Business), "*using the language*" (S1T18 (Spanish), "*understanding of colour theory*" (S1T4 (Art) and "*good subject knowledge*" (S1T34 (PE). During this workshop, when teachers had finished answering question one they were asked to provide some examples to the group. Teachers were then asked to answer question one again but as a subject group. There were twelve subject groups present throughout the day, six in the morning session and six in afternoon session. These results were analysed in the same way and it was found that there were two emergent themes, appreciation of subject matter and skill development. Six subject groups made some reference to the appreciation of their subject, these were: English, Irish, Mathematics, Music and Art, Science and Technologies. An example of what was coded can be seen in the English teachers' group, they wrote; "*Appreciation of what they read write",* while the Irish teachers wrote "*A love for the language & culture*". The science group had a few comments linked under the heading "*appreciation of: scientific method, human body, nature, everyday applications*". The second theme was skill development which encompassed 23 unique skills and generated 32 codes. The skills were all coded individually first before being condensed into the skill development theme, the majority of the 23 skills were unique to each subject, however, six of the skills were coded across two or more subjects. These were: lifelong learning, problem solving, self-confidence, communication, creativity and reflectivity.

4.5.2 Question Two: "What does it take to be good at your subject?"

In question two the teachers were asked to think about what it means for a student to be good at their subject. In total four themes were identified and a total of 102 codes were generated with 84 instances of these codes between all the teachers. The four themes were 1) skill development, 2) application of content knowledge 3) higher order thinking ability and 4) developing and maintaining an interest in the subject. The first theme skill development was coded in two ways firstly with subject specific skills for example, S1T2 (Home Ec.) stated "*Culinary Skills*" or secondly with general skill development as in the case of S1T17 who stated "*Skills – research etc*." and "*Well organised*". Skill development was mentioned 14 times by 12 different teachers. The next theme was application of content knowledge which contained codes such as application of knowledge, recall of knowledge and being knowledgeable. For example, one of the history groups response was "*be knowledgeable*" while the geography teachers' responded with "*recall*". Higher order thinking ability was the next theme and was one of the more populated themes containing 18 of the codes generated by the teachers. In this theme teachers focused on students' ability to process content via higher order abilities such as synthesis of information and presenting balanced viewpoints. Other codes within this theme included visualisation, independent thinking, evaluation, peer learning and more. The last theme identified from the data was developing and maintaining an interest in the subject. Teachers' felt that students needed to be "*motivated and enthusiastic*" (home economics) about the subject in order to be good at it. While other subject groups also felt that students' need to be able to "*persevere*" and "*achieve their potential*"

4.5.3 Question Three: What topics/areas do students' struggle with?

In this question teachers were asked to think of the topics or areas of their subjects which students' typically find difficult every year. To analyse these results, the data was grouped and coded according to their subject group to ensure that the specific difficulties of each subject could be tracked. Below are a series of tables labelled 4.6 to 4.16. These tables provide details on the number of teachers within a specific subject group, represented as n=x, where x is the number of teachers. It also provides information on the number of teachers' who were coded for a certain response. These were represented as percentages. For example, in table 4.6 which represents the two physical education teachers, 50% were coded as saying "*coordination*", meaning only one teacher provided this response.

In table 4.6 (top left) it can be seen that in the group of two PE teachers there were no common difficulties identified by both teachers. The areas of difficulties identified were: coordination, dance, gymnastics, learning the rules of games, multitasking, reporting and technique. Likewise, in the art department there were two teachers, however, this time there were some overlapping topics or areas of difficulty. These areas were originality and time management. Other areas included brain storming, terminology, understanding content, art history and exam preparations.

The modern language subject group comprised of four teachers. In their responses there was one response which was coded for each teacher, "*Aural Skills*". While grammar was coded for three of the teachers and pronunciation and spelling were coded for two teachers. Other areas of difficulty included students' unwillingness to speak in the target language, their oral skills, disinterest in the subject and their self-beliefs.

The home economic teachers, of which there were three, did not have full responses coded for any of their six identified areas of difficulty. Three areas, deadline, evaluation of skill and sowing skills were all coded by two teachers while textiles theory, knowing when something is cooked, and terminology were all coded for by one teacher. Of the two business studies teachers there was generally good coverage of the areas of difficulties between them. Terminology, double entry accounts, calculating income and defining key terms were all areas of difficulty identified by both teachers while applying previous experience to new problems and ratios was only coded for one teacher.

The three English teachers' did not offer any unanimous responses and these teachers' provided many unique codes including: Difficulty in expressing themselves logically and coherently, Technical Difficulties, forming observations, Lacking Structure, Responding, Originality, Poetry, writing in paragraphs, forming their own opinions, giving reasons for their opinions, Literacy, Comparative studies, Organisation and structure of responses, planning applications and realising the relevance of literature. The two response which were identified by two different teachers were students' resistance to poetry and their difficulty in sustaining an argument over an extended essay.

Of the four Irish teachers one response was coded for by each teacher, grammar. Two teachers stated that mixed ability teaching is a common area of difficulty for students', while each of the following had just one response: essay writing, making curriculum links, oral, avoiding use of google translate, websites, utilising resources, conversation, independent thinking and prepositions. Between the four mathematics teachers', algebra was unanimously found to be the area that students' struggle with the most according to these teachers'. While word problems and fractions were also areas in which three of the teachers' felt their students struggled with too. Financial mathematics, numeracy and revision were areas highlighted by two of the teachers while trigonometry, grasping patterns from previous questions, the change in syllabus and the sheer amount of content were also identified by one teacher.

Agreement was only reached with two of the three science teachers on areas such as using formulas, the concept of electricity, bonding and the project work assigned to students' in the third year of their study. Other areas of difficulty included photosynthesis, graphing, equations, calculations and being able to think independently. The majority of the responses collected by the three geography teachers were unique to each individual teacher with the exception of climate depression which was cited by two teachers. Other answers included imagining different regions in the world, drawing accurate diagrams, applying content knowledge, conducting field research and the whole area of physical geography.

The four history teachers cited many problem areas and topics that their students' often find difficult. Three of the four teachers cited students' often mixing the achievements of Cumman Na Ngaedheal and Fianna Fail (two early Irish political parties). Two teachers also cited the counter reformation, war of independence and remembering the names of the political parties as other common areas where students' find difficulty. Other issues identified by the teachers included: detecting bias in sources, the different burial customs, key historical dates, the Irish revolution, Hitler's policies and the outbreak of world war two and why Fianna Fail won the 1932 general election.

When asked to gather responses as a group there was almost no overlap of issues between the subjects. Seven items were identified from the coding to have been responded across subjects, these were: Terminology with four subject groups, time management with three subject groups, financial mathematics with two subject groups as well revision, self-belief, originality and understanding content knowledge also with two subject group responses.

PE (n=2)	
Coordination	50%
Dance	50%
Gymnastics	50%
Learning Rules of Games	50%
Multitasking	50%
Reporting	50%
Technique	50%

Art (n=2)	
Originality	100%
Time Management	100%
Brain Storming	50%
Terminology	50%
Understanding Content	50%
Art History	50%
Exam Preparations	50%

Modern Languages (n=4)	
Aural Skills	100%
Grammar	75%
Pronunciation	50%
Spelling	50%
Unwillingness to Speak	25%
Oral Skills	25%
Disinterest in subject	25%
Self Belief	25%

Irish (n=4)	
Grammar	100%
Mixed Ability Teaching	75%
Essay Writing	25%
Making curriculum links	25%
Oral	25%
Avoid Google Translate	25%
Websites	25%
Ulilising Resources	25%
Conversation	25%
Independent Thinking	25%
Prepositions	25%

Home Economics (n=2)	
Deadlines	100%
Evaluation of skills	100%
Sewing Skills	100%
Textiles Theory	50%
Knowing when something is cooked	50%
Terminology	50%

Mathematics (n=4)	
Algebra	100%
Word Problems	75%
Fractions	75%
Financial Mathematics	50%
Numeracy	50%
Revision	50%
Trigonometry	25%
Grasp patterns from similar questions	25%
Large amount of content to cover	25%
Project Maths	25%

Business Studies (n=2)	
Terminology	100%
Accounts (Double Entry)	100%
Calculating Income	100%
Defining Key Terms	100%
Applying Previous Experience to New Proble	50%
Ratios	50%

Science (n=3)	
Formulae	100%
Electricity	100%
Coursework B	100%
Bonding	100%
Photosynthesis	50%
Independent thinking	50%
Graphs	50%
Equations	50%
Calculations	50%

English (n=2)	
Resistance to poetry	100%
Sustaining an argument over an extended es	100%
Difficulty expressing logically	50%
Technical Difficulties	50%
Forming observations	50%
Lacking Structure	50%
Responding	50%
Originality	50%
Poetry	50%
Writing in paragraphs	50%
Forming their own opinions	50%
Giving reasons for their opinions	50%
Literacy	50%
Comparative studies	50%
Organisation and structure of responses	50%
Planning apps	50%
Relevance of literature	50%

Geography (n=3)	
Climate Depressions	100%
Imagining different regions in the world	50%
Accurate diagrams	50%
Application of knowledge	50%
Field research	50%
Physical Geography	50%

History (n=4)	
Mixing up Irish political parties	100%
Name of leaders of political parties	67%
The Counter Reformation	67%
War of Independence	67%
Detecting bias in sources	33%
Key Dates	33%
Burial Customs	33%
Hitlers policies and outbreak of ww2	33%
Why Finna Fail won 1932 election	33%
Irish Revolution	33%
Too much detail in Irish history	33%
Confuse eras	33%

Table 4.14- 4.15 table displaying the proportion of teachers' responses by subject group

4.5.4 Question four: "How can technology help in teaching your subject?"

The final question asked of teachers was to identify how technology could help in the teaching of their subject. It was hoped that after completing the previous three questions the teachers would be more susceptible to creating strategies for which technology may improve their teaching and learning. However, due to time constraints only the afternoon cohort of subject groups completed this section of the workshop. Their responses can be found below in table 4.17.

From table 4.17 it can be seen that there were several occurrences of YouTube as well as quiz and game-based learning applications. Edmodo and virtual learning environments were also cited multiple times. It appeared that these teachers' viewed technology as a means to either improve the efficiency of a lesson and the learning or, as a tool to bring a more visual aspect to the learning.

Subject	How technology can help
Business Studies	Excel Video creation Interactive quizzes YouTube
Geography	Research project YouTube Animations Learning Tool
History	YouTube Interactive History Website Edmodo
Art & Music	Online learning Environment YouTube Organiser Games Concept mapping Online file manager
Religion	Research project Presentations
Technology	Efficient planning Student tasks and timetables Electronic templates Assistance from the special needs department

Table 4.16 Table of technologies which teachers believe may help improve their teaching and learning

After all the data from this first workshop was collected, the data was analysed, and potential technology tools were identified for inclusion in teaching. These tools were tested on the devices for full compatibility. A second workshop was organised to provide teachers with the time to test these tools in a controlled environment, where feedback and troubleshooting could be provided instantaneously. Teachers were asked to select one tool from a list of potential tools suitable for their subject and test them for 45 minutes. Once time was up, teachers then convened to discuss the opportunities and challenges these tools presented. Further time was given for all teachers of that subject to test the chosen tool(s). Teachers were then asked to develop one lesson each where they integrate the chosen tool into their teaching which were observed by the researcher later that year.

4.6 Teachers' trialling of technology in the classroom

During the conclusion of the second workshop, teachers were asked to select one of the tools they had been trialling and to develop a lesson which integrated this tool into their teaching. Teachers were to plan these lessons which were observed by the researcher. The school was notified of the upcoming observations and was asked to remind staff of these observations. A notice was placed in the staff room which included a sign-in sheet for staff to put their name forward for observation and an email reminder sent to all staff from the researcher.

4.6.1 Initial Pilot Observations

During the week of observations eleven teachers had signed up for observations and of these eleven teachers, none had planned a pilot lesson. Instead, this week was used by the researcher to act as a cooperating teacher in these lessons. Teachers were asked to integrate technology to the best of their abilities and should issues arise during the lesson the researcher would solve the issues so as not to impact on the teaching and learning. It was observed during this week that there were still issues with devices connecting to the internet and when they did the speed was insufficient and prolonged the duration of non-active teaching time. It was also observed that even though students were reminded to bring their devices into school for the lesson a lot of students' either forgot to bring them from home or likely did not sufficiently charge their device. However, teachers were still able to adapt and were continued with a modified version of their lesson or activity. In post lesson discussions with the teachers, they highlighted these issues as common practice and due to their persistence, technology was seldom integrated into their teaching. During the lessons it was noted that teachers tended to use tools and resources which were not cognitively demanding of the students' such as matching exercises, fill in the blank quizzes or general world wide web browsing. Overall, the lessons were very teacher directed and, in the opportunities, where students had the chance to take control of their learning, the tasks were simple recall of content. In one of the lesson students were informally asked by the teacher how they felt about using the devices. Some of the positive comments include: "*more for than taking note*", "*quick*" and "*we*(sic) *learn more*". Some of the negative comments include how the tablets were both "*awkward*" and "*frustrating*" to use while also being "*unreliable*". One student felt that the tablets are "*not a great study tool*" and it ultimately meant "*more work for revision*".

It became clear that teachers required a significant amount of support to assist in the development of their technology integration. As such, a week of support was provided to all participating teachers. During the week of support, the researcher worked closely with the teachers individually and discussed several important factors including: the topic of the lesson, the teaching methods to be employed and how to align technology appropriately, what resources were needed and if not available how could they be created etc.

4.6.2 Further Pilot Observations

Five teachers were asked to participate in further observations which included on call support from the researcher. However, during the observation week one teacher fell ill and could not participate in the observation. One of the teachers had a clear focus for their lesson and required little to no extra assistance. It became clear that the other teachers' felt they did not have the time to devote to developing a lesson and locating resources. So, it fell onto the researcher to develop the lesson plans, resources and develop worksheets and any other additional materials. Once these were gathered they were discussed with each teacher who then provided their expertise as subject matter experts to the content of the lesson i.e. ensuring the questions were correct and in line with the curriculum and current teachers' progress. These lessons were not recorded as an observational protocol had not been established and since the researcher was an active participant in these lessons the field notes which were taken were limited. The following sections, 4.6.3 to 4.6.6 present a summary of each teachers' lesson.

4.6.3 S1T26 – Music Teacher

S1T26 (French/Music) wanted to cover the classical ballets in this lesson. S1T26 (French/Music) stated that they typically would show students' a video of Swan Lake or other ballets and ask the students' questions at the end regarding the video in question. S1T26 (French/Music) had no previous experience with technology and as such was not comfortable with using technology or even allowing the students to use it in their lesson. In response, the researcher asked the teacher to locate the videos to be used in the lesson and write out a series of questions which they would like to ask. A local copy of the video was created the questions were embedded as annotations in the video. These annotations appeared at key times where the question was relevant such as "*what is the instrument playing the harmony now*?" etc. The teacher watched these videos and agreed on the placement of the questions. The purpose of this activity was to allow students' control over their own learning. Each student had their own tablet, access to the local copy of the video and a set of earphones so there was no cross-sound interference. The researcher assisted the teacher in ensuring every student was able to access the video and had a set of earphones for playback. A significant portion of the lesson was used by the students' in answering these questions and for those who could not finish the questions within class time the video link was on Edmodo and could be completed as homework. Feedback gather at the end of the lesson showed that students enjoyed the freedom to work independently and at their own pace and the teacher felt more confident in allowing students to use technology the lessons.

4.6.4 Mathematics Teacher – S1T18

The mathematics teacher wanted to cover Pythagoras theorem and for this lesson S1T18 (Spanish/Maths) had a PowerPoint and website they usually used. The teacher did not make use of the available support but did ask for assistance in the classroom during the lesson. The lesson was very teacher directed with much of the focus being on the teacher and their use of PowerPoint. The students did have an opportunity near the end of the lesson to play the game for solving the length of either the opposite, adjacent or hypotenuse of a right-angled triangle using Pythagoras theorem. No student feedback was received in this lesson due to time constraints.

4.6.5 Geography Teacher – S1T5

The Geography teacher sat down with the researcher and wanted to know what could be done to integrate technology into a lesson about industrial regions in Europe. After some discussion it was agreed that the students would use prior knowledge and research to create a video of specific industrial regions using Animoto. The teacher had some previous experience with Animoto from the second workshop and was comfortable with using it in the lesson so long as the researcher was present in the classroom. During the pilot lesson the researcher handed out extra devices to students' whose devices were not charged or left behind at home. There were very few issues during this lesson, the majority of issues were caused by a slowing down of the broadband which could not be solved in the classroom. The teacher spent the first ten minutes of the lesson introducing the students to the task. The teacher provided the students with a list of industrialised regions and assigned each student a region to research. The rest of the lesson was spent with the teacher facilitating students' learning while the students developed the Animoto video resource. Once or twice during the lesson the teacher would call for the students' attention to provide some tips or look for some interesting facts found by students' so far. Feedback received by the students at the end of the lesson found that they favoured this lesson compared to typical lessons as it gave them control over their learning.

4.6.6 Science Teacher – S1T21

The final lesson observed was by one of the science teachers. This teacher needed a lot of support and relied on the researcher's background as a science teacher to develop the lesson. The teacher told the researcher what subject they would be covering and left it to the researcher to develop a lesson. As this was the students' first experience with the topic of electricity and since it was an area of difficulty identified by science teacher, it was decided to try and teach the topic using animations. A guided inquiry lesson was developed with accompanying worksheet. The whole lesson was spent with students' engaging with the simulations and following the worksheet. To avoid connectivity issues the simulations were downloaded onto the tablets prior to the lesson. Students' reported a preference to using the simulations over physical circuits as it removed the physical challenges to their learning. Students' also noted how it easily enabled purposeful revision. However, some students remarked that it was still important to be able to manipulate physical circuits and cautioned against replacing physical circuits with simulations completely.

4.6.7 Outcomes from the observations

While no formal interviews were held with the teachers a few observations were made throughout this two-week period. Firstly, these teachers needed a vast amount of support in order to implement these pilot lessons, support which is not realistically available for everyday teaching. However, teachers' felt more motivated to use technology after the positive experiences with their pilot lessons. Secondly, working with a small cohort of teachers was much more successful than working with a large group of staff. Thirdly, even though there were some issues with connectivity the issues were not as prominent as previously reported. What was an issue however, was the students' lack responsibility on bringing the devices into school and keeping them fully charged?

With these three points in mind a meeting was held with Intel, the researchers and the management of School one. During this meeting is was agreed that several interventions were required during the next stage of this project. These were:

- transfer ownership of the student devices back the school and to implement a system of class sets of devices on a mobile basis for use by all staff
- work with a small group of teachers' willing to provide the time necessary to commit to the development of several technology enabled lessons and
- provide remote support via telephone, email and physically where needed.

Given that the teachers whom previously participated in the observation were now involved in terminal examination preparations it was agreed that the project would delay starting this new phase until the following academic year. In the interim time, the school were responsible for retrieving the devices from the current cohort of students' and conducting all necessary repairs, updates etc to ensure they were available to all staff at the start of the new academic year. The findings of these observations suggested that teachers, when supported, could implement technology integration in classroom practice and that an observational framework is necessary to capture their practice.

4.7Conclusions

The findings from this study showed that in general, the 51 participating teachers in this school were not ready to use technology in their lessons. They struggled to plan a lesson that used the 1:1 devices despite each of their students' having a device, and each of the teachers been given a device. Additional, the teachers were provided external support from the researcher in the form of lesson study designing, IT technical support whom was hired on a government jobs initiative and priority support from the book publishing company to address any issues identified with their eBooks.

Thirty-seven teachers responded to the survey on attitudes and beliefs. The results of the survey showed positive deposition towards a technology supported pedagogy. However, from the observations it was clear that teachers were not comfortable implementing pedagogies which facilitate effective technology integration. Instead, teachers resorted to teacher directed learning methods such a chalk and talk. However, there was a small cohort of four teachers, who were able with substantial support, to develop lessons with effective technology replacement methods. Through focused support progress was made in fostering a willingness to engage with technology with this cohort of teachers. Following a review of this phase of the research, it was agreed with school management that a small group of teachers should be selected to work closely with the researcher to develop technology enabled lessons. These teachers agreed to develop several lessons and could avail of support from the researcher at any time. Selection of these teachers was between school management and the researcher highlighting those teachers with positive technology beliefs and attitudes and whom were willing to dedicate the time necessary for the development and implementation of these lessons. In this school, teachers and management felt that a student owned device policy was ineffective and usually created issues within the lessons such as devices not being charged or being left at home. Therefore, school management made the decision to recall all the devices and carry out all the necessary maintenance to develop three class sets of tablets for mobile use in the school.

The findings of the supported observations showed that the teachers were able to develop technology integrated lessons with some support. It was found that the unstructured observational approach provided no meaningful data beyond superficial information regarding the general running of the lesson. Therefore, it was decided that an operational framework for conceptualising teachers' technology integration should be used in further studies. The next chapter will present and discuss the work conducted in case study one which was conducted in school one.

Chapter 5 Case Study One: School One

5.1 Introduction

This chapter discusses the lessons developed and implemented by the nine participating teachers from school one who agreed to take part in the recording of their technology enabled lessons. As discussed in chapter four, background data was collected from 37 of the teachers over a range of subjects. Of these 37 teachers, eleven were asked to develop three lessons in which technology was used in a way which they had never tried before. Of these eleven, ten teachers recorded lessons, however, one of the teachers recorded only a snippet of their lesson and as such could not be used for analysis. The final nine teachers came from a range of subject areas, which can be seen in the summary table below in table 5.1 and a more detailed table including lesson summary which is contained in appendix B.

Data collected from each teacher consisted of a summary of the observed lesson(s), a detailed analysis from the observational framework, planning and reflection documentation and transcribed exit interviews. This chapter will present the results from these data collection tools. Firstly, each teacher's background is briefly introduced. Secondly, an examination of teachers' classroom interactions under specific categories will be presented. This will be followed by the level of technology integration achieved in each lesson as well as the assessment of each teachers' attainment of technological pedagogical content knowledge (TPACK). Finally, the outcomes of each teacher will be presented based on the data obtained in the self-reflection and exit interviews. Background

5.1.1 Study motivation

The purpose of these data collection methods and analysis was to try and answer the two in-service specific research questions, namely:

1. How do in-service teachers with minimal experience of technology integration, use technology in their classroom practice?
2. What support do in-service teachers need in order to improve their technology integration in class room practice?

As discussed in chapter four, background data and some initial observations were conducted with the teachers in school one. However, there were issues with the data such as the lack of a valid and reliable framework to capture technology integration. To address this concern the researcher conducted literature review to assess the viability of existing frameworks. As discussed in chapter three section 3.3.3 while there are several research-based observation protocols, none – in the opinion of the researcher - captured the multifaceted nature of teaching and learning in a technology enabled classroom. Therefore, a secondary aim of this case study was to determine the viability of a new operational framework for capturing technology integration. Below a short literature review is presented on one of the most prominent technology integration frameworks known as SAMR and why TPACK was chosen instead.

5.1.2 Technology integration framework

In 2006 there were two technology based frameworks, one was a four level taxonomy which was designed for selecting, using and evaluating technology in primary and secondary level education (Puentedura, 2006), the other was framework which described the types of knowledge a teacher needed in order to integrate technology effectively (Mishra and Koehler, 2006).

The framework proposed by Puentedura (2006) was comprised of four levels known as Substitution, Augmentation, Modification and Redefinition (SAMR). These four levels were split into two hierarchical categories known as enhancement (SA) and transformation (MR). These four levels closely align to Hughes technology supported pedagogies (2005) with exception of modification and augmentation. Puentedura (2006) defined the four levels as follows:

- Substitution: Technology acts as a direct tool substitute, with no functional change (p. 3)
- Augmentation: Technology acts as a direct tool substitute, with functional improvement (p.4)
- Modification: Technology allows for significant task redesign (p.5)
- Redefinition: Technology allows for the creation of new tasks, previously inconceivable (p.6)

Since 2006, SAMR has received considerable attention in the research with Hamilton, Rosenberg and Akcaoglu (2016) noting a 44 times increase in the number of references to SAMR in the ISTE conferences between 2006 and 2015. However, this increase of scholarly attention was worrisome not because it shifted researchers attention to one specific aspect, but because there was no scholarly work, process or review behind the model itself (Hamilton, Rosenberg and Akcaoglu, 2016). In fact, in their review of SMAR, Hamilton, Rosenberg and Akcaoglu (2016) found now peer-reviewed literature citing this lack of theoretical explanation. The first attempt to draw attention to this issue was in 2013 via blog post which was constructed as an open letter to Puentedura inviting further open dialogue and discourse. Furthermore, the authors detailed a scenario where Puentedura (2014) shared the results of Mueller and Oppenheimer (2014) claiming them to be a good example of substitution. In their work, Mueller and Oppenheimer (2014) investigated the effects of typing on a computer versus writing longhand on paper on student learning. Their results not only showed that typing had a negative impact on student learning, but also argued against substitution, raising further questions on the validity of SAMR. Another major concern surrounding the SAMR model however, is its focus on technology, suggesting that simply using technology in any teaching scenario enhances education (Bayne, 2014; Hamilton, Rosenberg and Akcaoglu, 2016). Therefore there has been a call in recent years for a framework which is not only based on peer-reviewed, scholarly work, but is technologically decentralised (Hamilton, Rosenberg and Akcaoglu, 2016).

The Technological Pedagogical Content Knowledge Framework (TPACK), first proposed by Mishra and Koehler (2006), attempted to explain technology integration not as a function of technology, but as a result of teachers' inherent knowledge. The TPACK framework was based on Shulman's (1986) Pedagogical Content Knowledge framework and extended this further by introducing a third knowledge domain, technological knowledge. At the intersections of these three domains lie the extended domains of knowledge. These were: Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK) and Technological Pedagogical Content Knowledge (TPACK) as well as the main constructs of Technological Knowledge (TK), Pedagogical Knowledge (PK) and Content Knowledge (CK). Since it is based on PCK, it has its own inherent issues, namely the fuzziness between constructs (Gess-Newsome, 1999). Unlike SAMR, TPACK was developed on evidence based theoretical underpinnings such as ICT-related PCK (Cochran, Deruiter and King, 1993), technological content knowledge (Slough and Connell, 2006), Electronic Pedagogical Content Knowledge (Franklin, 2004) and Technological Pedagogical Content Knowledge – web (Lee and Tsai, 2010). Not only does TPACK have significant theoretical underpinnings, it has also received significant attention to make valid and reliable to great effect (Schmidt *et al.*, 2009b; Sahin, 2011; Kabakci Yurdakul *et al.*, 2012). Addressing the concerns of Hamilton, Rosenberg and Akcaoglu (2016), TPACK offers a technologically decentralised framework by focussing on the knowledges of the teacher and its effect on technology, rather than the effect technology has on the teacher. However, from the perspective of the researcher, TPACK does not fully capture all the nuances of teaching and learning, specifically, it does not provide detail on the interactions which take place during instruction, nor does it provide information on the level of technology being integrated. Therefore, the researcher used two theoretical frameworks which were integrated into TPACK to provide this additional context, these were Bloom's Taxonomy (1956) and Hughes (2005) technology supported pedagogy. This new framework was used to determine technology integration of the participating teachers via observations. The next section will describe how the data from this tool was captured, coded and analysed to form the conclusion reached in this, and subsequent chapters.

5.1.3 Data collection, coding and analysis of TPACK observation framework.

Data was collected via video recording for the classroom observations. This was to minimise the time commitment that was placed on the researcher during face to face observations in the background study of school one. The principal and teachers were instructed on how to set up the video camera to ensure a good quality of recording while also keeping students' anonymity. This was achieved by placing the video recorder at the back of the class facing the teacher with only the back of the students' heads being filmed. Once recorded the video camera was handed to the IT technician who uploaded the files to a secure folder which only the researcher had access to once upload was completed. To conduct analysis on these videos each was watched twice. The first time was to determine time segments of interactions and provide a summary of what occurred during that period. The second watch through was to complete the TPACK Observation Protocol (Canbazoglu Bilici, Guzey and Yamak, 2016) assigning scores of 1 – 4 for each of the knowledge domains. Finally, a judgement was made to categorise the overall lesson in terms of Bloom's taxonomy and assign a level of integration according to Hughes (2005) technology supported pedagogies. Presented below, is an overview of how each aspect of data collection was analysed and where appropriate, validated and checked for reliability.

During each observation a record was kept on the type of interaction(s) most prominent as well as the length of time this interaction lasted. In their article, Ohlberger & Wegner (2013) discussed seven types of classroom interaction of which three were most prominently observed in this study. These were: teacher – student talk, student – teacher talk and group talk. Teacher– student talk typically occurs at the introduction of a lesson where it is categorised by a high amount of teacher talking either to individual student or the whole group. The converse then represent student – teacher talk interactions, where the teacher takes a backseat offering the students' a greater share of the talking. Group talk occurs when the students' share information with other peers, while the teacher often assumes the role of supporter. While these definitions offered a starting point, it was important to utilise them for the purpose of this study. Therefore teacher-student talk was divided into two subsections: teacher - whole group talk and teacher - individual student talk. A new interaction, Student Individual work was added to account for when students were tasked with completing learning or activities on their own. A final interaction was added; this was known as discretionary time and was created to account for any lulls in the lesson where no teacher or student interactions were occurring. For example, when the whole class is asked to put equipment back into storage, this was accounted for as discretionary time. In total, five categories of interaction were recorded throughout all observations, these were: Teacher Whole group (Twg), Teacher individual student (Tis), Student group work (Sgw), student individual work (Siw) and Discretionary time (Dt). To make the determinations of classroom interactions valid and reliable a set of rules were developed to instruct researchers on how to ensure a specific type of interaction occurred, these rules can be found below in table 5.1. The rules were simple in nature by provide clear instruction, for example, Teacher whole group interactions occur when the teacher, regardless of position in the classroom calls to attention the entire student cohort, examples of words or phrases teachers used were "*all right everyone*", "*Listen up*", "*okay lads*", "*Look up here for a second*" etc. To ensure validity and reliability, the researcher and his supervisor conducted two independent reviews of the same observations to determine the validity and reliability of each data collection tool. In the case of classroom interactions there were no inconsistencies between the researchers.

Type of Interaction	Rule	Examples
Teacher Whole Group (Twg)	Teacher whole group interactions occur when the teacher, regardless of position in the classroom calls to attention the entire student cohort	"*all right everyone*", "*Listen up*", "*okay lads*", "*Look up here for a second*" Homework correction, introduction, conclusion, corrections etc.
Teacher individual student (Tis)	The teacher is working closely with individual students' assuming the role of a facilitator of knowledge	Teacher works closely with one particular student Most often will occur during student individual work interactions
Student group work (Sgw)	Students' are working in pairs or more to complete tasks assigned by teacher	Project work, presentations, demonstrations etc.
Student individual work (Siw)	Students' are assigned classwork to complete on their own, often noticeable by quiet classroom	Classwork, research, assignments etc.
Discretionary time (Dt)	There is no learning occurring during this time. The time is being used to fulfil some administrative duties.	Attendance, cleaning up, storing devices away, interruptions from other staff or announcements.

Table 5.1 Rubric of rules for determining the type of classroom interaction.

The second data collection tool used was a combination of technology supported pedagogies (Hughes, 2005) and Bloom's Taxonomy (1956). While the use of Hughes (2005) framework provided data on the level of teacher's technology integration, it proved difficult to adequately distinguish between the levels without taking into consideration the level of cognition required by the learners. Therefore, the activities were also described using Bloom's Taxonomy (1956) of learning classification to provide further distinction between the levels of integration.

Hughes (2005) put forward three categories from which we can define the use of a certain technological scenario, these were: Replacement, Amplification and Transformation.

1. Replacement: Where technology is used to simply replace an activity or purpose. These scenarios are easily recreated without the use of technology. For example, a teacher using PowerPoint instead of paper notes to deliver the content of their topic. S1T2 (Home Ec.) (Geo) was an example of replacement use of technology.
2. Amplification: Where technology is used in a more efficient manor i.e. using online documents to accomplish synchronous and asynchronous group work
3. Transformation: technology is used in innovative ways to encourage and engage students'. For example, using data recording equipment in science class to record results, previously unobtainable without the use of technology

To use this tool, the researcher had to make informed decisions based on what was observed in the lesson. To do this, the researcher and his supervisor had several discussions identifying examples the different levels of technology integration. Fortunately, the majority of videos observed were captured in replacement and the distinction between levels was clear to both researchers. For Bloom's taxonomy, the two researchers watched two observations and were asked to make a judgement on the overall level of Bloom's achieved in that lesson. This meant that we coded for the highest example of Bloom's achieved during the lesson. The only issue that arose was in assigning the creation domain, particularly for subjects such as Art. The issue was due to how the subject focused on the creation of images etc and whether this should be seen as achieving the highest level of Bloom's. After some discussion, it was agreed that any example of creation would stand, so long as the work being produced was original and unique to the student and not a reproduction of an image or piece of work.

The final data collection tool used was the TPACK Observation Protocol developed by Canbazoglu Bilici, Guzey and Yamak (2016). This tool was discussed in great detail in chapter three section 3.5.5. Here, a short summary is presented to remind the reader of the process behind how each score was determined for each of the knowledge construct. The TPACK-OP was comprised of eight areas which represented the domains of knowledge. These were:

1. Goals and Purposes: The teacher's goals and purposes of teaching the subject guide/frame the development and implementation of the lesson.
2. Teacher's knowledge of assessment: Assessment methods aim to evaluate important dimensions.
3. Teachers' knowledge of student's assessment: Students' complete assessment that require them use critical, in-depth, higher order thinking, e.g., organize, interpret, evaluate, or synthesize complex information, and/or develop alternative solutions, strategies, perspectives or points of view.
4. Prior Knowledge: The teacher is aware of students' prior knowledge, learning difficulties and common alternative conceptions of the particular subject matter
5. Multiple Modalities: Using multiple modalities (e.g., kinaesthetic/tactile, oral/verbal, written, numerical, graphic, pictorial, tabular) allows students to feel as though they and all of their peers (with different gender, ability, etc.) have had their needs met.
6. Multiple Representations: The lesson allows students to engage in representations (e.g., illustrations, models, or analogies) and activities (e.g., problems, demonstrations, simulations) that can facilitate their learning in a specific topic.
7. Context of curriculum: The teacher demonstrates an understanding of the goals and objectives for students' in a particular topic that they are teaching, and that is addressed in the national curriculum.

8. Relevance of instructional materials: The instructional materials are relevant to teaching a particular domain of the subject matter and the general learning goals of the curriculum

Each of these dimensions were presented in rubric form with a rating scale from 1 to 4. Each dimension had its own differentiation between the levels, which can be found in table 5.2 below. In domain one, goals and purposes of the lesson the levels depended on the amount of active learning within the lesson. A score of one was awarded for lessons which focussed on the transmission of facts while a four was awarded for lessons which involved defining, investigating and presenting problems/data in some form or another. Domain two centred on assessment and alignment of assessment to the important dimensions of the subject, the levels of differentiation ranged from assessment being used but not to evaluate student learning to all assessment methods used being aligned with the learning objectives and to evaluate the student learning. Domain three then examined the specific types of assessment used ranging from fact checking with straightforward answers to questions which promote higher order thinking in three or more instances. Domain four focussed on teacher's awareness of their student prior knowledge and ranged from being somewhat aligned to substantially aligned but also incorporated teacher's ability to address and overcome misconceptions. The fifth domain examined teacher's use of different modalities in their classroom practice and were rated according to the number of modalities observed. The sixth domain examined the number of times the teacher used representations for demonstrating their knowledge as well as allowing their students to participate in activities during the lesson. Domain seven evaluated the teacher's linking of the lesson objectives to the national curriculum and other subject areas. The four scale ratings in domain seven ranged from presenting interesting but inconsequential facts to presenting concepts substantially aligned to the broad curriculum. The final domain examines the teacher's use of instructional materials such as PowerPoints, worksheets etc. The rating scales in this domain ranged from the materials were inconsequential to the lesson and its objectives to the materials were sustainably aligned to the objectives of the lesson.

Domain	Criteria
The teacher's goals and purposes of teaching science guide/frame the development and implementation of the lesson.	"1" means that the lesson centres around transmitting the fact of the science. "2" means that the lesson asks students' to engage in activities to develop science process skills. "3" means that the lesson provides opportunity for students' to engage in hands on activities. "4" means that the lesson asks the students' to define and investigate problems, do and/or design an experiment, and present the data to others for debate, discussion, and/or evaluation.
Assessment methods aim to evaluate important dimensions of science learning.	"1" means that all assessment methods aren't used to evaluate students' learning in a particular topic. "2" means that some assessment methods aren't aligned with learning objectives to evaluate students' learning in a particular science topic. "3" means that the all assessment methods are somewhat aligned with learning objectives to evaluate students' learning in a particular science topic. "4" means that the all assessment methods are aligned with learning objectives to evaluate students' learning in a particular science topic.
Students' complete assessment that require them use critical, in-depth, higher order thinking, e.g., organize, interpret, evaluate, or synthesize complex information, and/or develop alternative solutions, strategies, perspectives or points of view.	"1" means that the assessment asked mostly for facts, straightforward answers. "2" means that the questions required application in a slightly different situation, one higher order thinking questions asked, mostly lower higher order thinking questions. "3" means that the questions involved synthesis and analysis and/or presented a new situation, two higher order thinking questions asked., mix of higher and lower order thinking questions. "4" means that the questions used evaluation and/or higher order thinking, three or more higher order thinking questions asked.
The teacher is aware of students' prior knowledge, learning difficulties and common alternative conceptions of the concepts	"1" means that the lesson is somewhat aligned with students' prior knowledge, alternative conceptions and learning difficulties but teacher isn't knowledgeable to overcome alternative conceptions and difficulties. "2" means that the lesson is somewhat aligned with students' prior knowledge, alternative conceptions and learning difficulties but teacher is somewhat knowledgeable to overcome alternative conceptions and difficulties. "3" means that the lesson is substantially aligned with students' prior knowledge, alternative conceptions and learning difficulties and teacher is somewhat knowledgeable to overcome alternative conceptions and difficulties. "4" means that the lesson is substantially aligned with students' prior knowledge, alternative conceptions and learning difficulties and teacher is knowledgeable to overcome alternative conceptions and difficulties.
Using multiple modalities (e.g., kinaesthetic/tactile, oral/verbal, written, numerical, graphic, pictorial,	"1" means that 1 modality is used in the lesson presentation. "2" means that 2 or 3 modalities are used in the lesson presentation.

tabular) allows students to feel as though they and all of their peers (with different gender, ability, etc.) have had their needs met.	"3" means that the lesson is presented using 4 modalities. "4" means that the lesson uses multiple modalities (more than 4) in an integrated way to achieve for students' understanding of science.
The lesson allows students engage in representations (e.g., illustrations, models, or analogies) and activities (e.g., problems, demonstrations, simulations) that can facilitate their learning in a specific-science topic.	"1" means that the teacher uses a limited range of representations and activities that are not appropriate to learning objectives of topic. "2" means that the teacher uses a limited range of representations and activities that are somewhat appropriate to facilitate students' learning in a specific-science topic "3" means that teacher uses multiple representations OR activities that are appropriate to facilitate students' learning in a specific-science topic "4" means that teacher uses multiple representations AND activities that are appropriate to facilitate students' learning in a specific-science topic
The teacher demonstrates an understanding of the goals and objectives for students' in a particular science topic that she is teaching is and that is addressed in the national and state level frameworks.	"1" means that there might be some interesting facts, but they are trivial or inconsequential. "2" means that main concepts are presented and somewhat aligned with the broader concepts of science curriculum goals and objectives at the grade level "3" means that main concepts are presented and substantially aligned with broader concepts of science curriculum goals and objectives at the grade level. "4" means that main concepts are presented and substantially aligned with broader concepts of the science curriculum goals and objectives, and spiral structure of the curriculum.
The instructional materials are relevant to teaching a particular domain of science and the general learning goals of the national and state level frameworks	"1" means that the teacher uses some materials, but they are trivial or inconsequential. "2" means that the teacher uses a limited range of materials and materials are somewhat aligned with learning objectives of topic. "3" means that the teacher uses a limited range of materials and materials are substantially aligned with learning objectives of topic. "4" means that the teacher uses most of materials and materials are substantially aligned with learning objectives of topic.

Table 5.2 Table containing the eight domains of TPACK-OP and their 1-4 rating criteria

The TPACK-OP was found to be valid and reliable in Canbazoglu Bilici, Guzey and Yamak (2016) study. For this reason, reliability needed to be established in the context of this study, particularly, since the instrument was used across multiple subjects and not science as originally intended for TPACK-OP. Reliability was established as it was with the previous two tools, the researchers independently watched two lessons and scored them with TPACK. One issue was found in the ratings of domain four, prior knowledge. The researchers felt, that it was quite difficult to determine in one lesson if the teacher was aligned with prior knowledge. This issue was compounded further in other subjects which were outside the expertise of the researchers i.e. science. Therefore, it was agreed that ratings in domain four would be scored based on obvious examples of using prior knowledge and explicit call outs. If these were not seen a not applicable score was given.

The final piece of data that was analysed was the exit interviews. These were coded using Braun and Clarke's (2008) thematic analysis methodology. A detailed breakdown of the methodology used can be found in chapter 3 section 3.3.2. In this section, the transition from data to conclusions is made explicit. During the exit interviews, the teachers were asked questions from an interview script in a semi structured way. The researcher typed up the interviews verbatim and uploaded the file to NVivo 10. Each transcript was read through once before any initial coding took place. On the second read through sentences were highlighted and codes were generated which summarised the meaning(s) of the sentence. On a third read through the codes were further refined to capture the meaning(s) in as little words as possible. These codes were then paired with similar or identical codes. A read through the sentences which were coded was conducted to ensure each code was homogeneous within the theme and heterogeneous with the other pairings (Patton, 1990). Once the codes were internal homogeneous and external heterogeneous, the researcher assigned these as theme which were then used to form the talking points for the conclusions.

5.2 School one participating teachers

This section describes each of the nine-participating teacher's background, subjects, why they were involved in the project and an overview of their observed lessons. Table 5.3 presents a summary of the participating teachers' details: the year group, subject observed, the length of time for each observation and the learning objectives for each lesson. Appendix B provides a further breakdown of these observations.

Teacher	Observed Cohort	Time (mins)	Lesson Objectives
S1T29 (History)	2nd year History	27	1. Identify the meaning of selective breeding. 2. Analyse the difference before and after. 3. Identify new inventions during the industrial revolution. 4. Analyse the impact of these inventions. 5. Why were these inventions necessary?
		29	To gain insight into the industrial revolution using data from online primary sources. • To compare and contrast the living and working conditions in Industrial England with Rural Ireland
		33	To gain insight into the industrial revolution using data from online primary sources. • To compare and contrast the living and working conditions in Industrial England with Rural Ireland
S1T12 (Business)	1st year Business Studies	20	1. To learn what is insurance 2. To understand how insurance works 3. To identify the different types of household insurance
		25	1. To identify the different types of insurance available for households 2. To improve IT skills by communicating information on a poster

		23	1. To understand the forms of business ownership available to businesses 2. To distinguish between limited and unlimited liability
S1T2 (Home Ec.)	2nd year Home Economics	68	[redacted]
		34	
S1T4 (Art)	2nd year Art	66	
S1T34 (PE)	2nd year Physical Education	31	1. Demonstrate the skills of basketball to each student's best ability. 2. Work together to ensure each student is able to create a movie clip that best demonstrates their basketball skills. 3. Make the best use of the tablet in recording and then observing, analysing and refining their individual work. 4. To assist the students' both in the best use of the tablet during the class.
S1T26 (French)	2nd year French	28	1. To reinforce vocabulary of "les meubles/pieces" (furniture/rooms) in French. 2. That pupils (in pairs) will create a word document containing each item in French / images and cost for a particular room in the house.
		26	1. To reinforce vocabulary of "Les Prépositions" in French. 2. That pupils (in pairs) will create a video dialogue to further encourage conversational skills and understanding of key words...
		27	1. To review and reinforce the vocabulary "Les Pièces" 2. That pupils (in pairs) will create a poster displaying 'Une Maison Idéale" (as an A4 WORD document)
S1T18 (Spanish)	1st year Spanish	31	1. Recognise and interpret new words and phrases in Spanish 2. Express/communicate ideas related to 'I like/ I don't like' using some new words and phrases
		25	1. Recognise and interpret phrases that use the verb 'tenner' 2. Be able to express/communicate ideas that use 'tener' using some new words
S1T13 (Irish)	2nd year Irish	13	1. Search the internet and select pictures for movie. 2. Create a drobox account. 3. Save pictures onto drobox. 4. Order pictures
		34	[redacted]
S1T31 (English)	1st year English	27	1. Become competent in the use of tablets to access Google Images 2. Competent in Word Document 3. Use prior knowledge of Media Studies to create a front cover template 4. Successfully create a front-page cover for a newspaper independently
		29	1. Become competent in the use of tablets to access the Camera function 2. Work in pairs to create the report 3. Confident in the recording and storage of their activity 4. Use prior knowledge of Media Studies to create a news report to record 5. Successfully create a TV ready news report

Table 5.3 Summary table of participating teachers' and their observed technology enabled lessons

5.2.1 S1T29 – History Teacher

S1T29 teaches History, Religion, Irish and Civic Social and Political Education. For the purpose of this project S1T29(History) chose to focus on developing lessons for their first-year history class. During the course of this project S1T29(History) was pursuing a master's degree which introduced them to new teaching methods and as such S1T29(History) felt more comfortable trying to find new ways to improve the teaching their lessons. S1T29(History) had two main foci throughout the three lessons. Firstly, they elected to develop students' research skills throughout the three lessons. To achieve this, the teacher presented students with questions regarding the topic at hand, in this case, the industrial and agricultural revolutions and asked the students to use primary sources online to find the answer. Secondly, they intended to further develop the students' content knowledge by integrating the content using their first method.

In the first lesson, S1T29(History) tasked the students' with identifying what factors led to the industrial and agricultural revolutions. Students' not only had to find research their answers online, but they also had to put their answers into a PowerPoint and often incorporated images to support their assertions. As the lesson develops S1T29(History) offers students to opportunity to show their work so far on the teacher's projector. This is then used as a focal point from which the teacher examines the students' understanding of the content thus far. The second lesson was structured very similarly to that of lesson one. Students' were presented with a list of questions and tasked with finding the answers online. The focus of this lesson however was on the impact both revolutions had on the life of those who lived through them. One of the questions S1T29(History) posed during the middle of the lesson was for students to examine the mortality rates during this time. The students were able to identify and discuss the trend of child mortality rates increasing up to 1910 and then steadily declining. The third and final lesson was again, structured similarly to that of lessons one and two. The students' task during this lesson was to research and construct a narrative regarding the day to day living of a worker during the industrial revolution. At one point during the lesson, S1T29(History) calls upon a student to transfer some image files to the desktop computer. S1T29(History) then showed these on the projector and asked students to justify if the image was of industrial England or rural Ireland. The students were successful in identifying and justifying their answers.

5.2.2 S1T12 – Business Studies Teacher

S1T12 (Business) is a business studies and mathematics teacher. S1T12 (Business) had previous experiences with using technology in their lessons, but felt it takes up too much time to use on a daily basis. For their three lessons, S1T12 (Business) wanted to introduce students to insurance, what it is, the many forms of insurance and what they cover. The first lesson focused on introducing the students to insurance and in particular household insurance using an online lesson designed by skool.ie. Their second lesson was a continuation on the topic of insurance. However, it was not a direct continuation as a week had elapsed between the lesson and as such some other content was covered in between. The purpose of this lesson was for the students to create a poster showing the different types of insurance. Unlike the previous lesson, this observation took place inside the computer room where each student had their own desktop computer. For their final lesson, which again took place a week after the previous observation, S1T12 (Business) developed a lesson on the forms of business ownership and the importance of liability in business. To achieve this, the students' were directed to use www.businessstudiesonline.co.uk where they were able to access quizzes to test their knowledge.

5.2.3 S1T2 Home Economics Teacher

S1T2 (Home Ec.) is a home economics and science teacher. S1T2 (Home Ec.) has some experience with using technology during their teaching. For example, they have used interactive lessons from Skool.ie and created questions which students would answer based on that lesson. S1T2 (Home Ec.) has also used online games and presentations but found that constant problems with internet connectivity had put them off using technology. S1T2 (Home Ec.) remarked in their survey that in college they covered some content regarding teaching with tablets and also received some specialised training on specific software but does not use it. During the observational period, S1T2 (Home Ec.) conducted three technology enabled lessons. However, only lessons two and three were recorded. No lesson plan was submitted for both lessons two and three either and as such it was not possible to determine the teacher's objectives for those lessons. The two recorded observations focused on cheese: the types of cheese and how it is made. The first lesson took place over a double class period while the second lasted for a single period.

S1T2 (Home Ec.) first lesson focused on what cheese is and the different types. The majority of this lesson took place in traditional talk and chalk methods. Using mostly PowerPoint, the students were asked to take down notes and answers into a separate hand out the teacher has prepared for them. For their technology activity, the students used the devices in groups of two, to find six recipes which include cheese as a major ingredient. The students were also given the opportunity to research which countries produce what cheese. For the second lesson, the teacher utilised an online video which shows the cheese making process. The students were given a hand out which contained questions relating to the video. Before watching this video however, students were tasked with researching the common steps involved in cheese making. The rest of the lesson revolved around the transmission of facts and recall questioning.

5.2.4 S1T4 Art Teacher

S1T4 (Art) is the Art and design and social, personal and health education teacher. S1T4 (Art) has ample experience using technology as their art room is kitted out with Macintosh desktop computers which were generally used by the students' when designing projects. S1T4 (Art) also uses eBooks the majority of the time and even conducts photography classes with Transition Year students'.

S1T4 (Art) did not provide lesson plans to any of their lessons. According to S1T4 (Art) exit interview, two lessons were developed for the project and only one was recorded. The recorded lesson introduced students to design and typography using an online tool called Pixlar. During the observation students were tasked with designing their own typography of their name using laptops. S1T4 (Art) didn't use these lessons to further their use of technology, because they already have a lot of activities and resources which were used frequently. However, they teacher does still maintain a somewhat negative perception of technology and this showed in their exit interview. However, the students were engaged in the lesson and the use of technology was of a high standard.

5.2.5 S1T34 Physical Education Teacher

S1T34 (PE) is one of two physical education teachers in the school and also teaches mathematics and CSPE. S1T34 (PE) use of technology in mathematics lessons is limited to presentations and GeoGebra. For this project, S1T34 (PE) wanted to integrate technology into their physical education lessons. S1T34 (PE) planned and conducted two lessons, however, only one of these were recorded for observation.

Even though the first lesson was not recorded, in their exit interview, S1T34 (PE) spoke very highly of their first lesson. They asked students to perform a set of gymnastic skills and record themselves doing so. The students then had to review the videos and correct any mistakes or bad habits that were evident in their recording. Based on how successful the first lesson was, S1T34 (PE) decided to model the second lesson identical to the first. This time however, a different year group was used and as such, a different sport. The second lesson saw students' recording themselves displaying four key basketball skills: dribbling, layups, bounce passes, and chest passes. The teacher opened the lesson by introducing the students to the task and then asking them to collect one device between each group. Then the teacher spent some time discussing the task with each individual group. The majority of the class was then spent by students' displaying their key skills whilst being recorded. All groups could be seen recording, reviewing and rerecording where necessary. The teacher had an extension activity planned with another teacher in a different class. This teacher had the students' edit the videos and compile a new video which shows their key skills in one video. This teacher was not part of this study, but the teacher received support from the researcher for this lesson.

5.2.6 S1T26 – French Language Teacher

S1T26 (French) is one of several French teachers in school one. Before participation, S1T26 (French) had no prior experience with using technology in their teaching and as such was asked to participate in the project in order to gain some experience while there was some in school support available. For the three observed lessons, S1T26 (French) wanted to develop the students' vocabulary and immerse them in the target language. To achieve this, S1T26 (French) designed two lessons to complement each other (lesson 1 and 3) while the other lesson developed the students' spoken ability in French.

The first lesson asked students to design a room using the IKEA France website. To do these students had to select one (or more) rooms and find suitable furniture for said room i.e. bedside lockers, lamps, bed etc. for a bedroom. The items were then written down in a word document with the French word for the item and the price. In their second lesson, S1T26 (French) asked the students to pair up and get one tablet between them. Students' had to record themselves speaking the prepositions and then review the video to see where improvements could have been made in their spoken ability. For their final observation S1T26 (French) built upon the work students completed in lesson one. In this lesson, the students designed a poster of a room using the images from the IKEA website and vocabulary that they learned in lesson one. Students' were also asked to price all the furniture to give an overall cost for the room that they designed. S1T26 (French) generally kept to the same structured format- the lesson opened with the roll call and a brief introduction to the task, all while conversing in the target language. Then the students were given time to work on the task before the teacher called them to attention again either to give them a countdown or to clarify some issues. The class normally concluded with the teacher asking students to complete the task for homework.

5.2.7 S1T18 Spanish Teacher

S1T18 (Spanish) is a Spanish and science teacher. From the very beginning of the study S1T18 (Spanish) was identified as the teacher with the highest probability of utilising technology in their teaching. In their responses to the survey, S1T18 (Spanish) highlighted how they set up an eTwinning program with a school in Spain where both sets of students kept a live blog, interacted with each other via games and problem-solving activities and completed individual and group projects together. S1T18 (Spanish) also displayed a more positive disposition towards technology and teaching with technology. The main focus of S1T18 (Spanish) two observed lessons was the development of students' vocabulary and this was achieved by using online games and resources.

In the first lesson S1T18 (Spanish) had put work for the students on the Edmodo page. The students completed a series of online tasks from the LanguagesOnline.org.uk website. All of these activities focused on developing the students' understanding of the terms I like/I don't like. The second lesson was similar to the first in that the teacher asked students to complete resources on the languagesonline.org.uk website. This time however, the students were learning a new verb "*to have*". During the lesson S1T18 (Spanish) finds an image on Google which contains all the syntax of the verb. Students' then use this as their means of completing the tasks. S1T18 (Spanish) was asked to score their lessons out of ten where one was very bad and ten was excellent. Interestingly, in the exit interview S1T18 (Spanish) scored this lesson a seven out of ten, while they rated the first as a two or three due to network issues and this sentiment was echoed in their self-reflections.

"*Two of them were below a 3 (out of 10), I would give them a 2 because the network basically didn't work for those lessons and only a handful of students' benefitted. The middle lesson was fairly successful, I would give that probably a 7 in that most students were engaged, and I felt that they benefitted from it.*"

Yet, during the observation no major issues were recorded. Some devices were removed from the students' due to poor connectivity or being unable to access the user account. Whether these issues were downplayed during the lesson or S1T18 (Spanish) is being too harsh remains unclear.

5.2.8 S1T13 Irish Teacher

S1T13 (Irish) is an Irish language and Mathematics teacher. S1T13 (Irish) was considered one of the more accomplished technology experts as were one of the few members of staff to have some official technology training, e.g. European Computers Driver Licence (ECDL). However, in their survey, S1T13 (Irish) indicates that they do not believe technology skills are not needed in their teaching. The general technology use by S1T13 (Irish) favours online resources, eBooks, YouTube and GeoGebra. Before agreeing to participate in this project, S1T13 (Irish) had indicated informally that due to the lack of Irish language technology resources, they had not been able to integrate technology in their Irish lessons. The focus of S1T13 (Irish) lessons therefore, was on the development of activities which did not require such curated Irish content. Instead, students would be the curators of this content. In the Irish syllabus, students are now required to sit an oral exam at their junior certificate examination. Students' are also required to have some knowledge of a particular set of Irish poetry. Therefore, it was decided that these lessons would focus not only on developing students' spoken skills, but also their understanding of the prescribed poetry. To achieve this, S1T13 (Irish) planned three lessons where students would record themselves speaking a particular piece of poetry, import this audio file into Windows movie maker and then design a video to accompany the audio. Only two of these three lessons were recorded, and to avoid excess noise and disturbances, the students were required to record the poetry at home. The two recorded lessons focus on the students' developing the videos for their piece of poetry.

The first of these two lessons were a short recording, possible due to it being a small part of the main lesson, or due to other factors which are not known to the researcher. In the short second lesson, the teacher spent the majority of their time showing students' how to locate and download the files from their drobox folder. Many of the students cannot locate their files in Dropbox. The teacher had to help each student individually and this meant no actual work was achieved during the lesson. The third lesson opens up the same as lesson two in which students were asked to open drop box and windows movie maker to begin their task. During this lesson, students had to line up their audio recording with the picture sequence they had created. During the lesson S1T13 (Irish) circulates the room ensuring all students were on task and keeping up with each other. Students' were asked to complete the rest of the work at home.

5.2.9 S1T31 English Teacher

S1T31 (English) is an English, Business Studies and Geography teacher. As a result of recent changes to the English Junior Certificate curriculum, S1T31 (English) felt it was the perfect time to integrate technology into their teaching. As part of this reform, media studies and English oral assessments were added to the curriculum. As such, the focus of S1T31 (English) two lessons was on the development of students' media skills I.E. newspaper front cover designing and spoken ability. S1T31 (English) first lesson introduced students' to designing the front page of a newspaper. A discussion at the beginning of class reintroduced students to the key aspects of a front page. The teacher spent a considerable amount of time walking students' through how to locate and open Microsoft word on the tablets. Students' were then shown an image of a front-page cover from which to use as a frame of reference. Students' were allowed to copy and paste images found from Google image searches. The second lesson was a major departure from the first. In this lesson students were required to record a news report/segment with their partner. To do this, all other students had to be silent in the class while the recording group were delivering their news report. At the end of each report the teacher gave some feedback to the group and asked them to silently review the video in order to highlight areas for improvement. The last nine minutes of the lesson were dedicated to deleting the videos off the tablets. Before the recording finished the teacher asked students to rerecord their videos outside the classroom based on the areas they identified for improvement.

5.3 Classroom Interactions

5.3.1 Teacher whole group (Twg)

Teacher whole group interactions were defined by teacher led activities such as introducing the lesson, questioning, detailing a task, delivering a lecture style presentation and any other situations in which the teacher took control of the lesson and addressed the whole class group. Examination of figures 5.1 – 5.9 shows, that the majority of teachers include some Twg interactions mostly at the beginning and end of the lesson. Most of the Twg interactions generally occurred when the teacher was introducing the lesson and detailing the objectives for the lesson. However, some teachers such as S1T29(History), S1T12 (Business) and S1T26 (French) would interrupt in the middle of an activity to either tell the group how long is left for a certain task, or more commonly to use this time as an opportunity to checkpoint their students' knowledge so far. In total, teachers spent three hours, twenty-two minutes and thirty-two seconds in teacher whole group interactions, or thirty-four per cent of available class time. S1T2 (Home Ec.) accumulated the most time spent in Twg interactions. In fact, S1T2 (Home Ec.) spent over 60 per cent of the available class time in teacher led interactions, which is not surprising given in their survey response, S1T2 (Home Ec.) stated they spend 75% of class time in lecture style presentations.

5.3.2 Teacher individual student (Tis)

Similarly, to teacher whole group, teacher individual student interactions were defined by teacher led activities with a particular focus on helping one particular student. Naturally, this occurs when the teacher becomes the facilitator in group work or individual activities. However, S1T13 (Irish), the only teacher with this interaction had spent seven minutes ensuring students were fully briefed with the activity. Why this is different to group work interactions is due to the lack of work being conducted by the students' during this time. The teacher had yet to set out the task and as such students were sitting idly by until they were seen by the teacher.

5.3.3 Student group work (Sgw)

Student group work interactions were defined as student centred activities where more than one student worked together collaboratively to complete the task set by their teacher. This could include tasks such as project work, completing online fill in the blank questions, crosswords, video creation etc. Certain teachers tended to implement group work more regularly than others. For example, Figure 5.1 shows that S1T26 (French) tends to favour group work over any other methods, spending 80.8% of the available class time over the three observations in group work situations. Interestingly, S1T26 (French) explained in their exit interview why the students were put into pairs:

"*…in those three lessons putting them in pairs because I thought it would be easier instead of doling out one individually*"

A more telling example however, of how S1T26 (French) beliefs influenced their decision to implement group work can be found in a slightly later interview question. When asked how they viewed their role as a teacher S1T26 (French) replied:

"*Supporting and there to answer a question or if they weren't sure where to look up something…. so, you were more of an assistant rather than the dominating force in the room."*

5.3.4 Student individual work (Siw)

Student individual work was defined by student centred interactions where the students were expected to complete tasks on their own. Examples of how student individual work was implemented include: research, completion of online quizzes and video creation. The majority of participating teachers in this study utilised Siw in their lessons, however, both S1T29(History) and S1T12 (Business) accumulated the highest proportion of class time in Siw interactions. S1T29(History) utilised Siw for student research. The students were provided with a set of questions which they then had to research online for the answer. S1T12 (Business) on the other hand used their Siw time to provide students with the opportunity to complete an online lesson on insurance, as well as develop a poster on the different types of insurance.

5.3.5 Discretionary time (Dt)

Discretionary time was defined as any non-teacher student interaction where no learning, active or passive was occurring. Generally, this occurred when a teacher was distributing the tablets or putting them back into their storage, as seen in figure 5.2. Another example of Dt occurred in S1T31 (English) second lesson. The students had all completed the task and the teacher asked them to delete the videos from the devices. The following nine minutes were then spent by the teacher going around to individual students' ensuring the video was deleted.

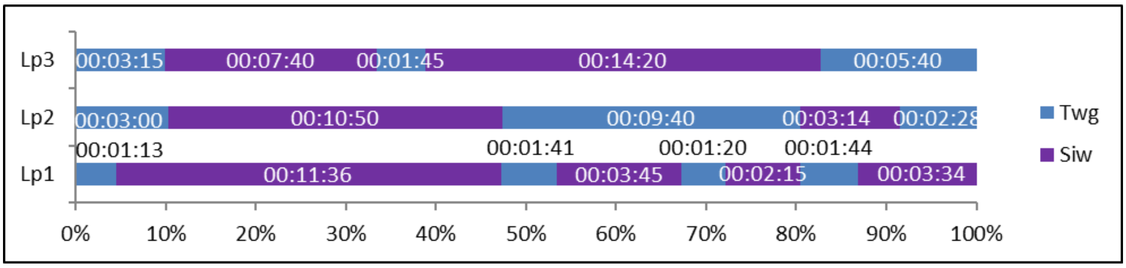


Figure 5.1 Classroom interaction chart for S1T29 – History

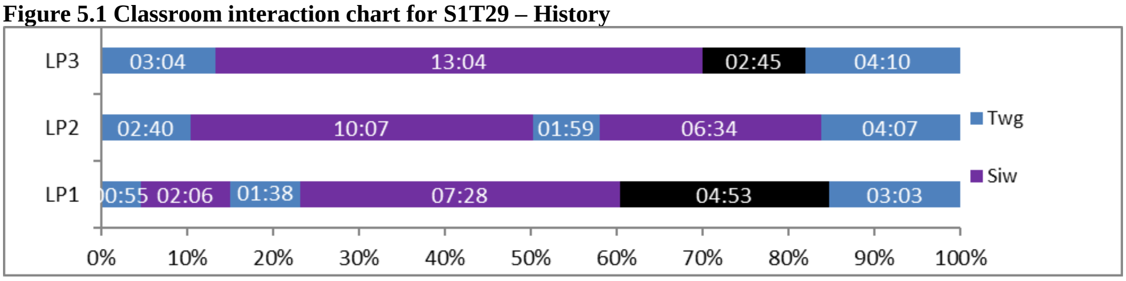


Figure 5.2 Classroom interaction chart for S1T18 – Business

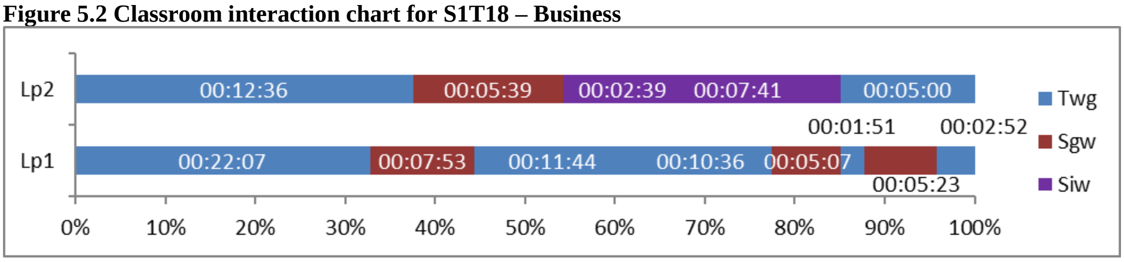


Figure 5.3 Classroom interaction chart for S1T2 –HE

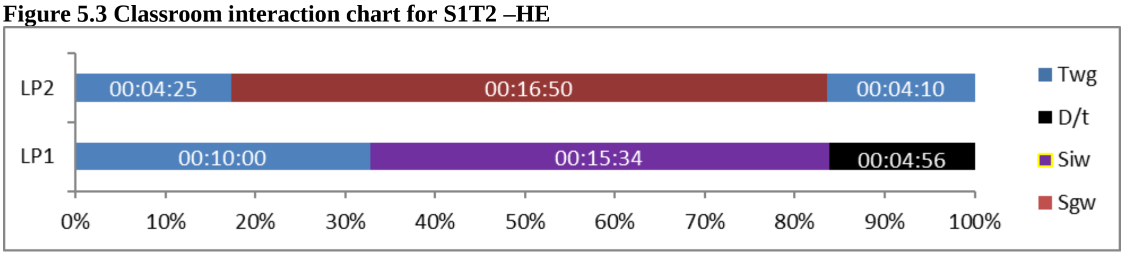


Figure 5.4 Classroom interaction chart for S1T18 – Spanish

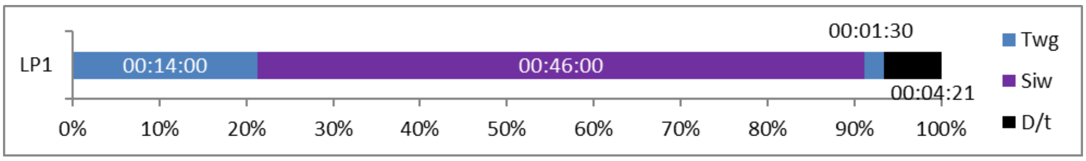


Figure 5.5 Classroom interaction chart for S1T4 - Art

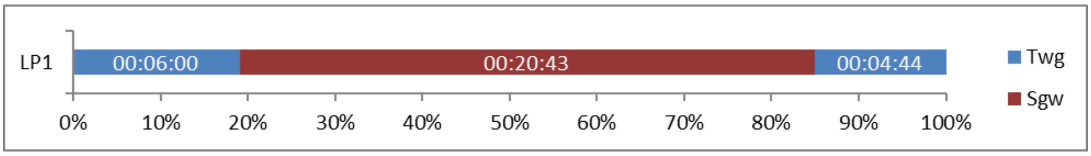


Figure 5.6 Classroom interaction chart for S1T34 - PE

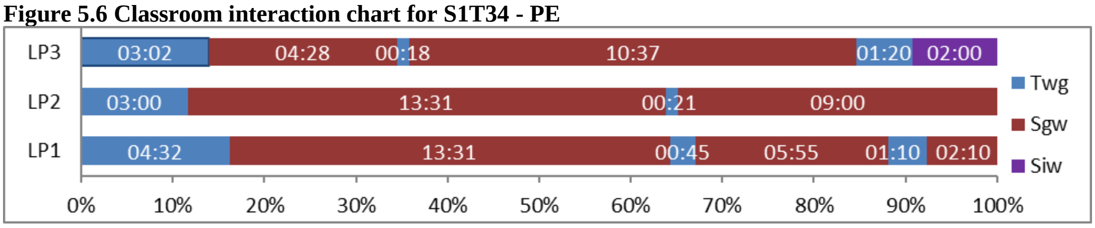


Figure 5.7 Classroom interaction chart for S1T26 - French

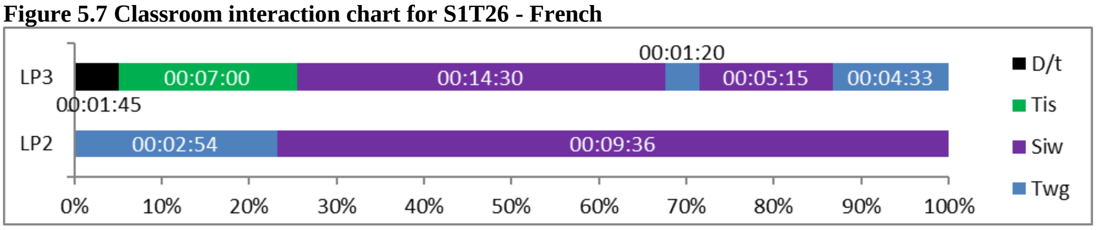


Figure 5.8 Classroom interaction chart for S1T13 –Irish

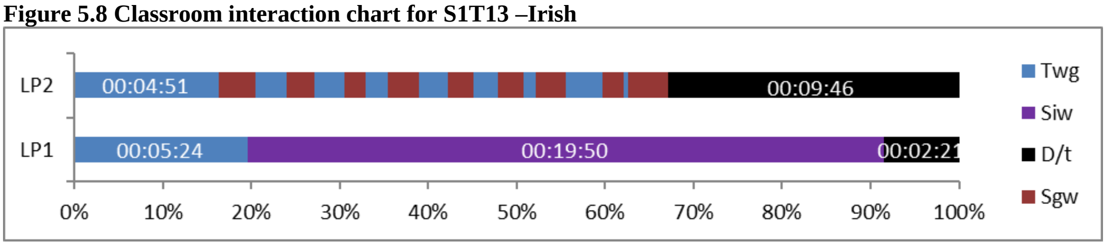


Figure 5.9 Classroom interaction chart for S1T31 –English

To examine the interactions in each of the lesson it was important to define categories through which they could be studied. It was determined that the main focus of the lesson as identified by the observer should be the defining category. From this, two categories of lessons were developed: 1) development of content knowledge and 2) development of subject specific skill(s).

5.3.6 Focus on the Development of Content Knowledge

Four teachers' lessons were identified as focussing on the development of content knowledge, these were: S1T29 (History), S1T12 (Business), S1T2 (Home Ec.) and S1T18 (Spanish). In S1T29 (History) lessons, the students were presented with questions regarding the industrial and agricultural revolution and asked to research the answers online. In business studies lessons one and three focussed on using online resources to develop students' understanding of insurance. The second lesson asked students to develop a poster on the different types of insurance. In home economics, S1T2 (Home Ec.) utilised a variety of tools to introduce students to cheese, how it's made and the origins of certain cheeses while also recapping the subject with a video with accompanying questions. Finally, in the two lessons of Spanish, the students were introduced to new verbs and asked to use them to complete online quizzes and fill in the blank style questions to develop their vocabulary and mastery of the language.

Examination of figures 5.1 and 5.2 show an interesting observation, both were nearly identical. S1T29 (History) and S1T12 (Business) both start their lessons with Twg interactions lasting between one to three minutes. Students' were then individually set on their task for roughly ten minutes before the teacher would interject and either check their progress or reassign the task. S1T29(History) repeated this cycle more so than S1T12 (Business), however, both teachers ended their lessons with a Twg interaction consisting mostly of recap or recall questioning. Similarly, to S1T29(History) and S1T12 (Business), S1T18 (Spanish) followed a similar interaction structure, the only key difference being that no Twg took place in the middle of the lesson to break up the student interactions. Interestingly, S1T2 (Home Ec.) follows a similar lesson pattern but utilises both individual and group work in their lessons. However, S1T2 (Home Ec.) has a much higher accumulation of Twg interactions than both S1T12 (Business) and S1T29(History). However, the first lesson of S1T2 (Home Ec.) observations was a double class and therefore would naturally accumulate higher percentages of interactions.

Another somewhat interesting observation was discovered from the data on these four teachers. All of their accumulated Twg interactions were within the same range, 32 – 36 per cent of the available class time. And this is examined further in section 5.5.2

5.3.7 Focus on the Development of Subject Specific Skills

The remainder of the teachers' observations could all be categorised as a subject specific skill development lesson. These included: S1T4 (Art), S1T34 (PE), S1T26 (French), S1T13 (Irish) and S1T31 (English).

The overall interactions of these teachers' lesson do not appear widely different, however, there is clearly less emphasis on Twg interactions, which have mainly been used to introduce the topic/task at hand or, in the case of S1T4 (Art), introduce a completely new topic and provide some background information. An examination of figures 5.5 to 5.9 clearly highlights this trend. All Twg interactions tend occur at the beginning of each teachers' lesson while some have instances of Twg later in the lesson, these were often minor interruptions to the students' work, rather than a complete stopping of the task.

In these lessons there is a clear focus on the development of subject specific skills for example, in S1T26 (French) lessons, the teacher wanted to focus on vocabulary development as well as oral language skills. Similarly, both S1T31 (English) and S1T13 (Irish) also focused on oral language skill development, and this can somewhat be seen in the interactions of the lessons. In particular, the second lesson plans of both S1T26 (French) and S1T13 (Irish) were identical, which is not surprising considering both lessons focussed on oral skill development. It can be taken one step further to include S1T4 (Art)'s art lesson. Even though there was some discretionary time and Twg at the end of the lesson, the majority of the lesson is identical to that of S1T26 (French) and

S1T13 (Irish) second lessons. These lessons clearly have a set out structure which these teachers believed enabled their students' to successfully develop their subject specific skills.

Just as it was pointed out at the end of section 5.3.2, there is a common occurrence in these lessons, that is, in relation to overall accumulation of Twg, these skill lessons were in the range of 19-29 %. After investigating the teachers' classroom interaction, the next step in analysing the data was to examine the teacher level of technology integration.

5.4 Technology Integration

5.4.1 Teachers' level of integration

All nine teachers' videos were analysed and where technology was used, notes were made detailing the usage, who was in control of the technology and what was the main purpose of the technology being used at the time. This information was then used to decide what level of integration, then independently, the level of Blooms which was achieved in that lesson. Tables 5.4 to 5.6 detail the levels achieved by each teacher.

Table 5.4 presents the lower level of integration (replacement) achieved by teachers S1T18 (Spanish), S1T2 (Home Ec.) and S1T12 (Business). It can be clearly seen from the information presented above that all of these lessons involved very limited use of technology, mainly as a tool to find information or as a method to answer questions. In any of the lessons included in table 5.4 the technology could have easily been replaced with a non-technological alterative. For example, in home economics lesson two, the students were asked to watch a video and answer questions relating to that video. This could have easily been replicated with a piece of written text or through general recall.

These lessons were also rated in the lower levels of Blooms taxonomy, with both of S1T18 (Spanish) lessons being somewhat an exception as they lie in the middle of Bloom's taxonomy.

Level of Integration	Teacher and Lessons	Classroom Activity	Level of Bloom's
replacement	S1T18, Spanish, LP1, 2	Apply verb in new situations	Apply
replacement	S1T2, Home Economics, LP1	Research information	Understand
replacement	S1T12 (Business), Business studies, LP1, 3	Recall information	Remember
replacement	S1T2, Home Economics, LP2	Answer questions from a video	Remember

Table 5.4 Level of Technology Integration - Replacement

Table 5.5 displays the teachers who achieved the amplification rating for their level of integration. The table shows that the majority of participating teachers' achieved amplification in their lessons, with five of the nine teachers' achieving this rating. In these lessons we can see that the teacher use technology in ways which cannot be easily replicated without technology and while it could be argued that students' can create a poster without technology, the definition of amplification specifies efficiency as a key component in the technology enhanced teaching and learning process. For example, in S1T13 (Irish) Irish lesson three, the students were asked to create a video combing their previous recordings of an Irish poem alongside some apt images for the theme of the poem. There is a clear trend in what qualifies as amplification most of the activities below were of a designing nature, i.e. designing a front page or poster. Similarly, to the replacement lessons, there is a somewhat clear blooms level bias which can be associated with amplification lessons. Four of the six teachers were coded for apply lessons while two were coded as understand. This is a clear increase in the level of Bloom's achieved compared to the replacement lesson previous described in table 5.5.

Level of Integration	**Teacher and Lessons**	**Classroom Activity**	**Level of Bloom's**
amplification	S1T3, English, LP1	Design front page	Apply
amplification	S1T13, Irish, LP3	AV representation of poem	Apply
amplification	S1T18, Business, LP2	Poster of types of insurance	Apply
amplification	S1T26, French, LP3	Poster of vocab	Apply
amplification	S1T26, French, LP1	Identify translated words.	Understand
amplification	S1T29, History, LP 1, 2, 3	Research questions and discuss, report their research	Understand

Table 5.5 Level of Technology Integration – Amplification

The teachers' and their lessons presented in table 5.6 were those which were coded as achieving transformative levels of technology integration. In total four teachers achieved this ranking in one of their lessons: S1T26 (French), S1T4 (Art), S1T31 (English) and S1T34 (PE). A common aspect between each of these lessons is the control given to the students' learning. In these lessons the students become autonomous learners and have complete control over the pacing and sequence of their learning. For example, in S1T26 (French) second lesson, the students were asked to create a video where they speak a sentence which includes the use of one of the five prepositions. The students had complete free reign over the video and their sentences and what transpired was a classroom where each student was fully engaged and focused on the task. Students' could be seen moving objects on top of desks, under desks etc. just too visually show their sentence. One student even picked up their English to French dictionary to find the right word. In each of these lessons the teacher became the facilitator, even where the teacher had high instances of Twg interactions, as in the case of S1T31 (English) second lesson. These interactions often were only used to re-establish order in the lesson or present the task to the students'. In these lessons, the use of technology vastly increased the students' engagement with the content and in turn their understanding or appreciation of the content. Just as it was observed in both tables 5.4 and 5.5, the higher the levels of integration, the more instances of higher order blooms were observed. Interestingly, all but one of these lessons included some form of video recording/analysis.

Level of Integration	**Teacher and Lessons**	**Classroom Activity**	**Level of Bloom's**
transformation	S1T26, French, LP2	Create videos	Create
transformation	S1T4, Art, LP2	Design type font	Create
transformation	S1T31, English, LP2	Record self and critique	Evaluate
transformation	S1T34, Physical Education. LP2	Appraise & critique, Show their skill	Evaluate/Apply

Table 5.6 Level of Technology Integration - Transformation

This section has highlighted several findings. Firstly, from the participating teachers we can determine that there was a wide variety of technology integration displayed. Secondly, there is link between the level of integration and the level of Blooms taxonomy. For these teachers it can be shown that the lower the level of technology integration the lower the level of Blooms taxonomy achieved.

5.5 TPACK Observations

A TPACK-OP was completed for each lesson a teacher recorded. To complete the TPACK-OP, the researcher watched each lesson twice, once to make general field notes and a second time to take more detailed notes including time stamps and interaction notes, all of which have been discussed above. After viewing the lesson, a second time, the researcher then provided a rank for each item of TPACK-OP. Each of the items can be rated between 1 and 4 and not applicable. For each item, the researcher also had to indicate whether or not technology was used by the teacher or student this is indicated by a red colouring in the TPACK summary table which can be found at the end of section 5.7. This data will be discussed later for each teacher.

5.5.1 Orientation toward teaching with technology

Orientation toward teaching with technology is the first domain to be discussed. This domain consists only of item one "*The teacher's goals and purposes of teaching the subject guide/frame the development and implementation of the lesson*". Table 5.7 shows that on average this group of teachers achieved a subject knowledge score of 2.37. This indicates that the teachers have a relatively good knowledge of their subjects' goals and objectives. However, no teacher scored a maximum level, the researcher believes this is due to two factors. Firstly, the researcher is only subject expert in Science not all subjects, secondly, the criteria for which achieving a four is still heavily focused towards a science lesson. The methods proposed in a four may not present themselves in other subject areas. Overall however, the majority of teachers were rated as a three. Those lessons which were scored a one mainly focused on content delivery and either lecture style presentations or weakly integrated technology.

	Item 1: The teacher's goals and purposes of teaching the subject guide/frame the development and implementation of the lesson.	
	Criteria	**TPACK-OP**
0	Not Applicable	0
1	The lesson centres around transmitting the facts of the subject.	4
2	The lesson asks students to engage in activities to develop process skills.	4
3	The lesson provides opportunity for students to engage in "hands on" activities.	11
4	The lesson asks the students to define and investigate problems, do and/or design an "experiment", and present the data to others for debate, discussion, and/or evaluation.	0
	Mean ($\bar{x}$)	2.37

Table 5.7 Summary of TPACK-OP Scores across all teachers for item 1

5.5.2 Knowledge of Assessment

Items two and three which focus on teachers' knowledge of assessment strategies and their implementation of assessment were grouped under the domain of knowledge of assessment. Table 5.8 shows the total number of scores achieved by the teachers'. In item two, the teachers achieved a mean score 1.80. This suggests that the teachers' knowledge of assessment practices is quite low. However, there could be several factors which need to be considered. One factor we could consider is that a large number of teachers did not incorporate any form of assessment in their observed lessons and as such could not be scored. These not applicable scores were not included in the mean score calculation however. Therefore, in the lessons where assessment was included the teachers displayed a low level of assessment knowledge. Item three focused on the specific assessment utilised by the teacher. As discussed previously, this section caused some issue between the two raters and was adopted to include Blooms hierarchy of questioning. Again, a high proportion of teachers did not include any form of assessment in their lessons, those who did however were rated quite lowly. Teachers tended to focus on simple recall and lower order questioning.

Item 2: Assessment methods aim to evaluate important dimensions.

	Criteria	TPACK-OP
0	Not Applicable	9
1	All assessment methods aren't used to evaluate students' learning in a particular topic.	5
2	some assessment methods aren't aligned with learning objectives to evaluate students' learning in a particular topic.	2
3	all assessment methods are somewhat aligned with learning objectives to evaluate students' learning in a particular topic.	3
4	all assessment methods are aligned with learning objectives to evaluate students' learning in a particular topic.	0
	Mean ($\bar{x}$)	1.80

Item 3: Students' complete assessment that require them use critical, in-depth, higher order thinking, e.g., organize, interpret, evaluate, or synthesize complex information, and/or develop alternative solutions, strategies, perspectives or points of view.

	Criteria	TPACK-OP
0	Not Applicable	7
1	the assessment asked mostly for facts, straightforward answers.	8
2	the questions required application in a slightly different situation, one higher order thinking questions asked, mostly lower higher order thinking questions.	3
3	the questions involved synthesis and analysis and/or presented a new situation, two higher order thinking questions asked., mix of higher and lower order thinking questions (See lower half of Blooms)	1
4	the questions used evaluation and/or higher order thinking, three or more higher order thinking questions asked. (See higher half of blooms)	0
	Mean ($\bar{x}$)	1.42

Table 5.8 Summary of TPACK-OP Scores across all teachers for items 2 and 3

5.5.3 Knowledge of students' understanding of subject specific knowledge

Table 5.9 contains items number four and five, which focused on the teachers' knowledge of their students' understanding of subject specific knowledge. Item four examined the teachers' awareness of their students' prior knowledge and how knowledgeable the teacher was to overcome any misconceptions the students' may hold. Unsurprisingly, the majority of teachers were rated as a four, indicating that the teachers in this group were all quite knowledge in their respective subject areas. Where teachers were awarded a three it was to their being no instances of challenging and overcoming student misconceptions. While it may seem unfair to penalise the teacher as they may be knowledgeable enough, it would be unwise to assume this knowledge. Only one teacher was awarded a two, S1T13 (Irish), they showed a lack of knowledge regarding the use of a particular cloud sharing service. They were unable to locate drop box on the computers and failed to realise that drop box needed to be installed prior to locating it on any desktop computer. This caused a lot of confusion and cost the teacher a whole class trying to correct the issue. It is worth noting that in situations where a teacher has used technology (indicated by the black score) then the CK and TK domains were being observed and rated. Item five observed the number of modalities teachers used in their lessons. Overall the teachers generally used the same two or three modalities and apart from two teachers, each teacher generally stuck with the same variety of modalities too. By far the most common modality was oral/teacher talk closely followed by written and then pictorial. No teacher in this study used more than four modalities: conversely no teacher was rated as only using one modality either.

	Item 4: The teacher is aware of students' prior knowledge, learning difficulties and common alternative conceptions of the particular subject matter	
	Criteria	**TPACK-OP**
0	Not Applicable	3
1	the lesson is somewhat aligned with students' prior knowledge, alternative conceptions and learning difficulties but teacher isn't knowledgeable to overcome alternative conceptions and difficulties.	0
2	the lesson is somewhat aligned with students' prior knowledge, alternative conceptions and learning difficulties but teacher is somewhat knowledgeable to overcome alternative conceptions and difficulties.	1
3	the lesson is substantially aligned with students' prior knowledge, alternative conceptions and learning difficulties and teacher is somewhat knowledgeable to overcome alternative conceptions and difficulties.	4
4	the lesson is substantially aligned with students' prior knowledge, alternative conceptions and learning difficulties and teacher is knowledgeable to overcome alternative conceptions and difficulties	11
	Mean ($\bar{x}$)	3.63
	Item 5: Using multiple modalities (e.g., kinesthetic/tactile, oral/verbal, written, numerical, graphic, pictorial, tabular) allows students to feel as though they and all of their peers (with different gender, ability, etc.) have had their needs met.	
	Criteria	**TPACK-OP**
0	Not Applicable	0
1	1 modality is used in the lesson presentation.	0
2	2 or 3 modalities are used in the lesson presentation.	12
3	the lesson is presented using 4 modalities.)	7
4	the lesson uses multiple modalities (more than 4) in an integrated way to achieve for students' understanding of the content	0
	Mean ($\bar{x}$)	2.37

Table 5.9 Summary of TPACK-OP Scores across all teachers for item 4 and 5

5.5.4 Knowledge of instructional strategies

As can be seen in table 5.10, the majority of teacher scored less than a three for item six, engaging students' in multiple representations. The mean score achieved by this group was 2.30 which represents a lack of variety in the representations used by teachers. While it was found in the previous section that the majority of teachers' implement on average between three to four modalities, we can see here that these modalities often rehash the same representations or activities, for example dedicating a whole lesson to using online fill in the blank style questions.

	Item 6: The lesson allows students to engage in representations (e.g., illustrations, models, or analogies) and activities (e.g., problems, demonstrations, simulations) that can facilitate their learning in a specific topic.	
	Criteria	**TPACK-OP**
0	Not Applicable	2
1	The teacher uses a limited range of representations and activities that are not appropriate to the learning objectives of topic.	3
2	the teacher uses a limited range of representations and activities that are somewhat appropriate to facilitate students' learning in a specific topic	6
3	The teacher uses multiple representations OR activities that are appropriate to facilitate students' learning in a specific topic	8
4	The teacher uses multiple representations AND activities that are appropriate to facilitate students' learning in a specific topic	0
	Mean ($\bar{x}$)	2.30

Table 5.10 Summary of TPACK-OP Scores across all teachers for item 6

5.5.5 Knowledge of curriculum and curriculum materials

Table 5.11 showcases the TPACK summary scores for items seven and eight which are in the knowledge of the curriculum and curriculum materials domain. Firstly, teachers scored on average slightly below a three for item seven ($\bar{x} = 2.93$). This meant that teachers generally present the content substantially aligned with broader concepts of the curriculum. However, only two instances were observed where a teacher adapted aspects from the leaving certificate curriculum into their teaching, thereby challenging the students at a much higher level of understanding. The final item examined teachers' use of instructional materials such as PowerPoint's and hand-outs and their relevance to the subject matter and general learning goals of the curriculum. There were two issues with examining this during recorded observations firstly, without seeing the hand-outs it is quite difficult to determine the relevancy of them in relation to the learning goals and curriculum. Secondly, not a lot of teachers used instructional materials instead opting for web 2.0 tools or creation of content. For any lesson where the researcher felt they were inferring the instructional materials, the class was scored a not applicable. There were several lessons where the PowerPoint and instructional materials could be evaluated due to their presence on the video or the teachers' discussion of the hand-out. In the eight lessons where this evaluation was made the mean score was 2.25 indicating lower quality materials which were somewhat aligned with the learning objectives of the topic.

Item 7: The teacher demonstrates an understanding of the goals and objectives for students' in a particular topic that they are teaching, and that is addressed in the national curriculum.		
	Criteria	**TPACK-OP**
0	Not Applicable	4
1	There might be some interesting facts, but they are trivial or inconsequential.	1
2	Main concepts are presented and somewhat aligned with the broader concepts of the curriculum goals and objectives at the grade level.	1
3	Main concepts are presented and substantially aligned with broader concepts of the curriculum goals and objectives at the grade level.	11
4	main concepts are presented and substantially aligned with broader concepts of the subject goals and objectives at higher grade levels	2
	Mean ($\bar{x}$)	2.93
Item 8: The instructional materials are relevant to teaching a particular domain of the subject matter and the general learning goals of the curriculum.		
	Criteria	**TPACK-OP**
0	Not Applicable	11
1	The teacher uses some materials, but they are trivial or inconsequential.	0
2	The teacher uses a limited range of materials and materials are somewhat aligned with learning objectives of topic.	6
3	The teacher uses a range of materials and materials are aligned with learning objectives of topic.	2
4	The teacher uses a range of materials which substantially aligned with learning objectives of topic.	0
	Mean ($\bar{x}$)	2.25

Table 5.11 Summary of TPACK-OP Scores across all teachers for items 7 and 8

As stated previous, a summary of the TPACK-OP scores can be found below in table 5.12. This table includes the numerical score for each teacher, for each of their observations - noted as Lesson Plans (Lp), for each of the domains of the TPACK-OP.

	Components of TPACK	Orientation toward teaching with technology	Knowledge of Assessment		Knowledge of students' understanding of subject specific knowledge		Knowledge of instructional strategies	Knowledge of curriculum and curriculum materials	
		Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8
S1T29	Lp1	3	2	1	3	3	3	3	2
	Lp2	3	3	3	4	3	3	3	n/a
	Lp3	3	1	1	4	2	3	3	n/a
S1T12 (Business)	Lp1	1	1	1	n/a	2	n/a	1	2
	Lp2	3	1	1	3	2	2	n/a	n/a
	Lp3	1	1	1	4	2	n/a	n/a	2
S1T2	Lp2	1	1	1	3	3	1	3	3
	Lp3	1	3	1	4	3	1	3	3
S1T18 (Spanish)	Lp1	2	n/a	1	4	2	3	3	2
	Lp2	2	2	2	4	2	3	3	2
S1T4 (Art)	Lp2	3	n/a	n/a	n/a	3	3	3	n/a
S1T34 (PE)	Lp2	3	n/a	2	4	3	2	n/a	n/a
S1T26 (French)	Lp1	3	n/a	n/a	3	2	2	2	n/a
	Lp2	3	3	n/a	4	2	3	4	n/a
	Lp3	2	n/a	n/a	4	2	1	3	n/a
S1T13 (Irish)	Lp2	2	n/a	n/a	2	2	2	n/a	n/a
	Lp3	3	n/a	n/a	4	2	3	3	n/a
S1T31 (English)	Lp1	3	n/a	n/a	4	3	2	3	2
	Lp2	3	n/a	2	n/a	2	2	4	n/a

Table 5.12 Summary of TPACK scores from TPACK-OP

5.6 Overview of Teachers

This section reports on the two final pieces of data collected from the participating teachers, their end of lesson reflection and the exit interview. In this section, a summary of each teacher will be presented citing evidence from their reflections and interviews where appropriate.

As discussed in the previous sections, nine teachers were involved in this study and between them 19 lessons were observed. Each teacher was asked to complete a reflection at the end of each lesson. This reflection consisted of four sections, Areas of achievement, areas for development, specifics regarding areas for development and an overall score of the lesson. Not all teachers completed an end of lesson reflection and as such 14 out of a possible 19 reflections were received. Finally, eight of the nine participating teachers were available for an exit interview which was transcribed verbatim.

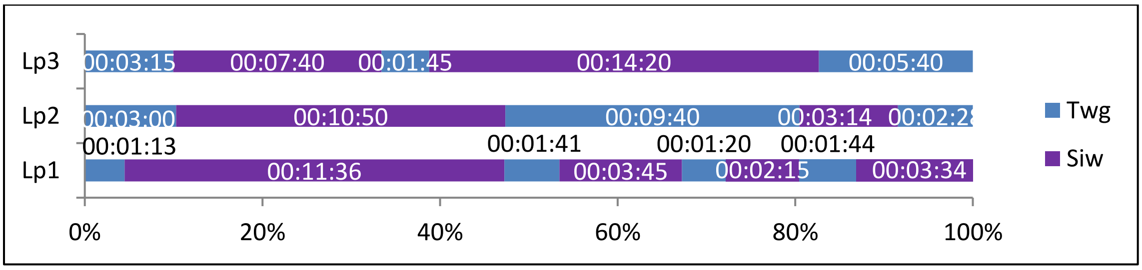
The following sections present the summary for each teacher, supported with evidence from the reflections and exit interviews.

5.6.1 S1T29 – History

Examining S1T29(History) interaction chart in 5.3.1 we can see that the majority of their interactions suggest they favour individual learning over group work. In general, the structure of the lessons was methodology and consistent across all three. The teacher would open the lesson with a brief introduction to the task and topic before assigning the student their task. Over the course of the three lessons, S1T29(History) spent 64 per cent of the available class time in student individual work interactions. In their reflection of the first lesson S1T29(History) stated how they had very little control over the direction the class took mostly due to the students' "*looking up very detailed site and copying and pasting information".* S1T29(History) continued by suggesting that due to the length of the lesson, they did not accomplish as much as they had hoped, and that for a while, the work produced by the students was not of a satisfactory standard:

"*By the time I got students' to show some examples, the class was almost over and the material they produced was not satisfactory. What works well topics such as these is I put a picture on the screen and we discuss it. I lead the direction of the lesson, but they come up their ideas which are accepted and appreciated.*" (S1T29, lesson two reflections)

The second sentence of the above quote from their second lesson is quite interesting. Going back to examine the interaction chart for S1T29(History) in figure 5.1, it can be seen that there is a considerable Twg section, in fact it is the longest Twg interaction of S1T29 by four minutes. This Twg interaction occurred when S1T29(History) presented the students with a series of photographs depicting industrial England and Rural Ireland, which aligns with their quotation above. So, if we sequence these events we can infer that when S1T29(History) finally got to examine students' work thus far, they were unhappy with the quality of work, decided to draw the students' attention to these images and conducted a classroom discussion. Within this discussion students were then refocused on the next section of the task. In their final reflection S1T29(History) expressed how this lesson was more successfully than the two previously. They felt this may have been due to the students' gaining some additional primary sources and context thanks in part to their field trip to a famine village.



Repeat of figure 5.1. Classroom interaction for S1T29 History's three lesson plans

Shifting focus to S1T29 TPACK displacement chart which can be found in figure 5.10 below, it can be seen that over the course of the three lessons S1T29(History) achieved reasonably high TPACK ratings in the domains of orientations towards technology and knowledge of instructional strategies. Only three indicators were recorded as not incorporating technology and two of these, knowledge of assessment, occurred in the same lesson. While S1T29(History) and their students mainly only used PowerPoint, it provided students with an opportunity to represent their research in ways appropriate to their learning styles. As the lessons progressed, S1T29(History) introduced new questions building upon the knowledge gained during a particular lesson and this often led to rich learning experiences. For example, in lesson two, while discussing the life of people during industrial England, one student began talking about working in factories. This led to S1T29(History) briefly talking about child labour after which S1T29(History) tasked students' with finding the mortality rates during this era. One student however, found the child mortality rate which the teacher used and was asked the students to identify the trends in the graph. The teacher's uses of technology were limited to putting questions onto a PowerPoint and asking students to put their slides onto the computer, therefore their integration scored quite low. On the other hand, students engaged in research and development of content using PowerPoint. However, one could argue these could be achieved by simply using the textbook or the teachers own notes, therefore the integration was rated as amplification.

S1T29(History) was the only teacher not available for an exit interview.

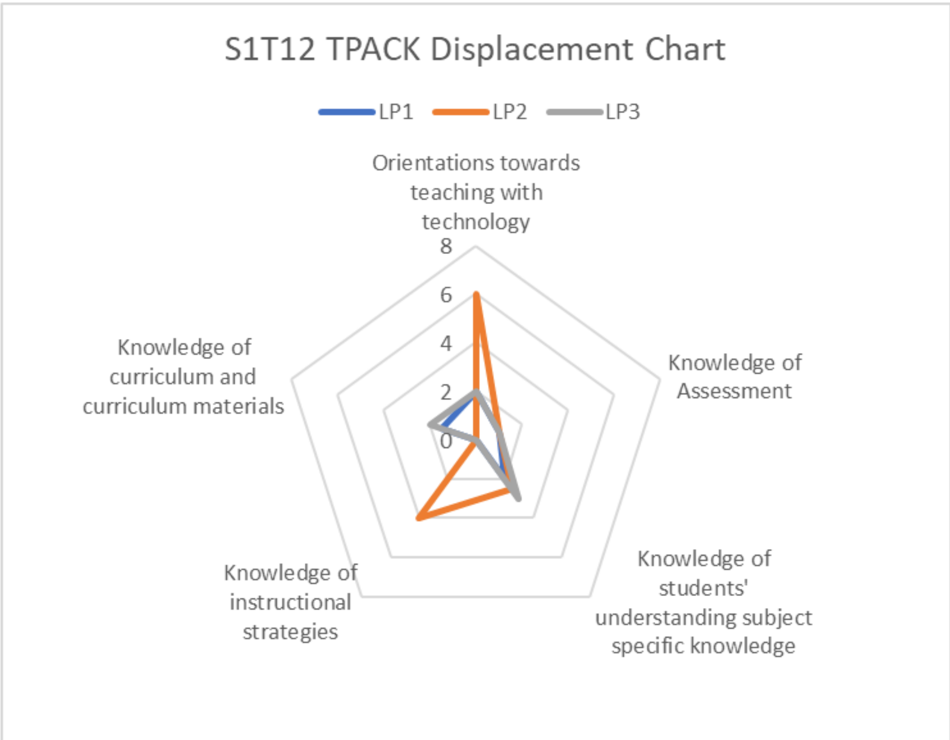


Figure 5.10 S1T29(History) TPACK Displacement Chart

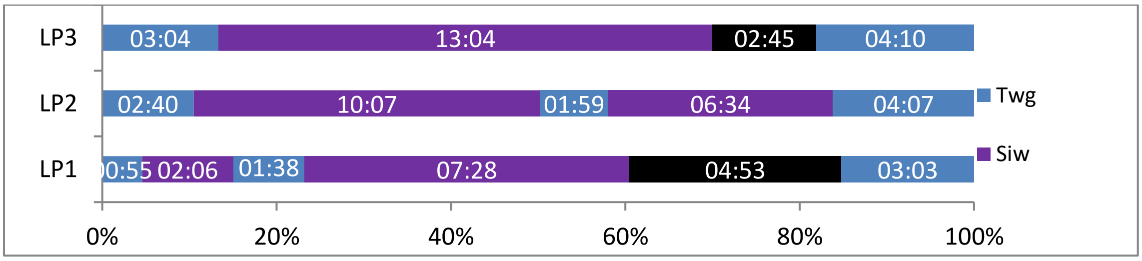
5.6.2 S1T12 – Business Studies

Figure 5.2 displays S1T12 (Business) interaction chart over the course of the three observations. Clearly, S1T12 (Business) prefers individual work over group work, spending over 57 per cent of the available class time on student individual work. S1T12 (Business) had a near identical classroom interaction structure to that of S1T29(History), i.e. teacher introduction followed by student work which is sometimes broken up with a teacher interruption before more student work is completed. S1T12 (Business) always ended their lesson with teacher whole group interaction which mainly consisted of a teacher led recall questioning sessions on key words covered in the lesson. During their exit interview S1T12 (Business) discussed how in their first lesson, issues with connectivity and putting the devices back on charger cost them a lot of class time. Figure 5.2 shows that in fact that almost five minutes were spent putting the devices back in the trolley. It should also be noted that there were no visible disturbances due to internet connectivity during the lesson. In contrast, S1T12 (Business) felt the second lesson which took place in the computer room was much better, even better than the third lesson. Examining figure 5.2 it can be seen the greatest amount of student work time was achieved in lesson two, over 16 minutes were observed. In lesson one nine minutes and 34 seconds were observed while just slight over thirteen minutes were observed in lesson three. When asked why they felt that both lesson one and three were not successful S1T12 (Business) stated:

"*... I wouldn't have been over satisfied because I felt so much time was given up getting organised, getting them from where they were stored, putting them back, that they really only had 10 or 15 minutes actually using them which they couldn't get an awful lot of information from the websites*" (S1T12 (Business), Exit interview).

No evidence was found during the exit interview to illuminate why S1T12 (Business) utilised individual work throughout these three lessons. However, it was clear from the interview that S1T12 (Business) mainly uses technology in their lessons for research purposes, research which could mainly be conducted by individual students':

"*I would say probably it is mainly used for research I would think*" (S1T12 (Business), exit interview)



Repeat of figure 5.2. Classroom interaction for S1T12 Business' three lesson plans

Examining TPACK displacement chart of S1T12 (Business) below in figure 5.11 it can be seen that overall the ratings were quite low. Their highest performing domains were orientations towards teaching with technology and knowledge of instructional strategies. S1T12 (Business) always ended their lessons with a low-level recall which is evident from their knowledge of assessment domain. Both lessons one and two did not include the use of technology for the assessments, technology was only used in lesson three for assessment. The use of technology for assessment was in the form of online word searches and crosswords. S1T12 (Business) main interaction was teacher whole class. This was because they did not spend much of the student individual work time with the students' in both lessons two and three. Instead they answered questions addressed to them openly to the whole class. However, in lesson one, S1T12 (Business) had to ensure each individual student was logged on and able to access skool.ie. Overall in terms of integration, the level was quite low with lesson two achieving the highest rating, mostly due to the use of PowerPoint to create a poster. In lessons one and three the students completed online tasks which could have been easily replaced with non-web-based alternatives.

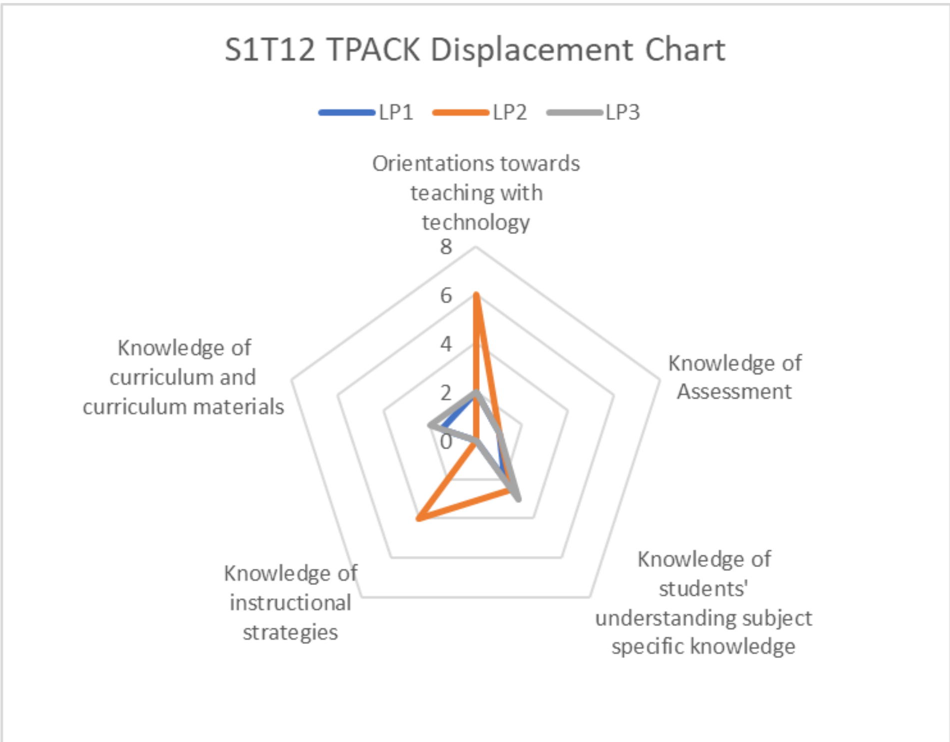
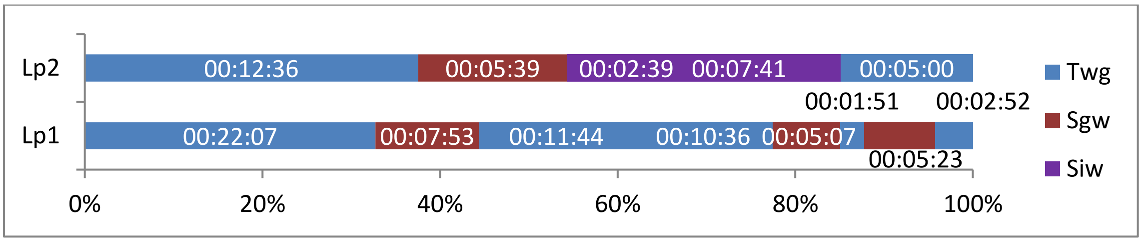


Figure 5.11 S1T12 (Business) TPACK Displacement Chart

5.6.3 S1T2 – Home Economics

If we examine the interaction chart of S1T2 (Home Ec.) we can see that the teacher spent the majority (68%) of the available class time in teacher directed interactions. Group work accounted for 24 per cent while individual work accumulated just 7%. This interaction chart comes as no surprise given that in their survey, S1T2 (Home Ec.) stated that they spent 75% of class time giving lecture style presentations. S1T2 (Home Ec.) was the only teacher observed to have used both individual and group work style interactions all other participating teachers general stuck to one type of student interaction for the duration of the lesson.



Repeat of figure 5.3. Classroom interaction for S1T2 Home Ec's two lesson plans

An inspection of S1T2 (Home Ec.) TPACK displacement chart below, in figure 5.12, reveals that technology was used infrequently, but also that they did not demonstrate any particular strengths in these two lessons. It can be seen that the main use of technology was around knowledge domains, and in the observations, it was seen that this use focused on information gathering which tasked the students' with finding recipes and the countries of origins for certain cheese. When asked during their interview what they would typically use technology for in their lessons S1T2 (Home Ec.) responded:

"*I suppose a lot of it sometimes can be information gathering, looking up information and that kind of thing. I have a website for doing games and stuff, but it is educational where you can input the notes and stuff, but they are actually playing a game and learning at the same time*" (S1T2 (Home Ec.), exit interview).

The teacher displayed a limited knowledge of assessment, mostly relying on recall and other forms of lower order questioning. Another point of interest is the teacher's apparent lack of instructional knowledge, as evident by the sole use of traditional talk and chalk style teaching.

During the exit interview S1T2 (Home Ec.) was asked what they believed a technology integrated classroom would look like to them. The teacher began by stating they have not seen technology being used well or at least as well as it could be, before discussing what they felt the two main uses for technology should be: communication with the students' and testing & assessment.

"*I think for testing their knowledge and stuff. I know we were supposed to [unclear 00:05:39] devices being able to communicate with the kids, but we haven't got that far, that is what we were supposed to have been doing. Or what was the purpose of them that we would be able to communicate? And then the lesson, we can very quickly assess their learning, wee quizzes or stuff like that. But I just think you will get a better idea of their learning by the end of class by using the technology possibly. But as I say I haven't been able to see that yet*" (S1T2 (Home Ec.), exit interview).

Another interview question asked the teacher if they thought the integration of technology into any teachers' lessons would be beneficial. This question was trying to draw out what worked for this teacher and if they felt those benefits could extend to others, not necessarily from their subject discipline:

"*With some of the technology that I use, where it wasn't them using, they were just watching, the videos and stuff for cheese making that I was doing, that was beneficial because I felt they learned from that and they could visually see because it is a hard-enough thing to learn off. And I did feel the next day that they were actually giving these answers for things that they didn't necessarily need to know but they had actually retained the information, that they wouldn't have been studying, it wasn't in their notes, but they had retained the information from the video the next day… Everyone was able to give an answer and they felt more secure giving the answer because they knew it was probably right*" (S1T2 (Home Ec.), exit interview).

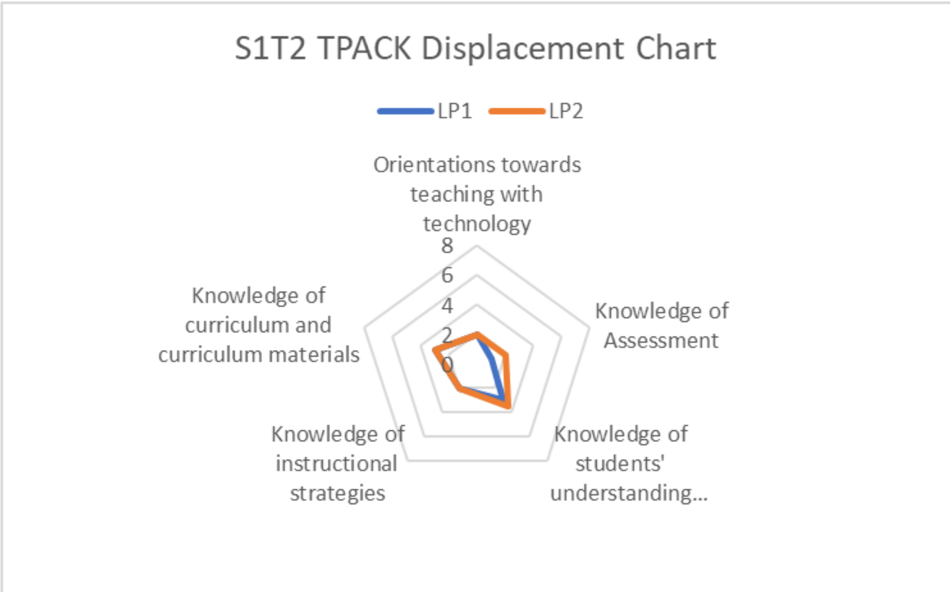


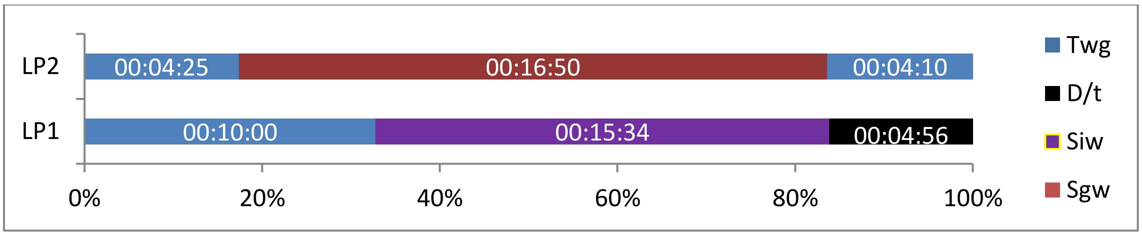
Figure 5.12 S1T2 TPACK Displacement Chart

5.6.4 S1T18 – Spanish

In their interaction chart it can be seen that S1T18 (Spanish) utilised individual interactions in one lesson and group-based interactions in another. However, it should be noted that in lesson one S1T18 (Spanish) did originally intend for the students to complete the task groups but due to the a few absences S1T18 (Spanish) was able to allow students' work individually. Significantly more time in lesson one was dedicated to teacher whole group interactions. This could be due to the S1T18 (Spanish) preparing the class for using technology and introducing them to how the lesson will unfold compared to their usual lessons. In total S1T18 (Spanish) spent 58 per cent of available class time engaged in student centred activities. Additionally, the chart shows that in lesson one nearly 20 per cent of the available class time was spent in discretionary time. The observation shows that this time was given to the collection and connecting of tablets in the charging cabinet. There is one major difference between S1T18 (Spanish) interaction chart and most other participating teachers in this study, S1T18 (Spanish) only had a maximum of three interactions per class. Additionally, the flows of these interactions are identical to all other teachers; teacher introduces lessons, students' work on task, teacher closes lesson. Interestingly, in the exit interview S1T18 (Spanish) scored this lesson a seven out of ten, while they rated the first as two or three due to network issues and this sentiment was echoed in their self-reflections.

"*Two of them were below a 3, I would give them a 2 because the network basically didn't work for those lessons and only a handful of students' benefitted. The middle lesson was fairly successful, I would give that probably a 7 in that most students were engaged, and I felt that they benefitted from it*."

Yet, during the observation no major issues were recorded. Some devices were removed from the students' due to poor connectivity or being unable to access the user account. Whether these issues were downplayed during the lesson or S1T18 (Spanish) is being too harsh remains unclear. It should also be noted that S1T18 (Spanish) did in fact record three lessons, however, the camera was not positioned as agreed in the ethical approval forms, instead it faced a closed window with the sound muffled and as such could not be used.



Repeat of figure 5.4. Classroom interaction for S1T18 Spanish two lesson plans

The TPACK displacement chart in figure 5.13 of S1T18 (Spanish) shows a clear strength in their knowledge of instructional strategies. However, every other domain was scored below 3. These average scores are mainly attributed to the lack of variety of the activities as well as the depth of learning these activities afforded the students'. Just as every teacher thus far has demonstrated, S1T18 (Spanish) achieved high scores for their proficiency with the content knowledge. The teacher was both fluent and capable of communicating with the students' through verbal and non-verbal interactions. S1T18 (Spanish) lessons are an example of a teacher who has discovered what works best for their students' and tends to replicate that success in subsequent lessons. While S1T18 (Spanish) was identified from the beginning as an early adopted and possible championing teacher amongst the staff, these observations show that S1T18 (Spanish) had relied too heavily on what had worked in the past. While it is not possible to transform every lesson with technology, it is somewhat disappointing that S1T18 (Spanish) did not use this opportunity to trial new methods or activities which they may not have had the time or support for in the past. However, it should be noted that S1T18 (Spanish) cited major connectivity issues in two of the three lesson they prepared, and this was even acknowledged by S1T18 (Spanish) in their exit interview when asked if they thought the integration of technology was of benefit to all teachers':

"*Yes, it has been. Those three lessons we recorded, maybe not so much, but right throughout the year it was extremely beneficial. Well in both science and Spanish, absolutely, I couldn't teach without it.*"

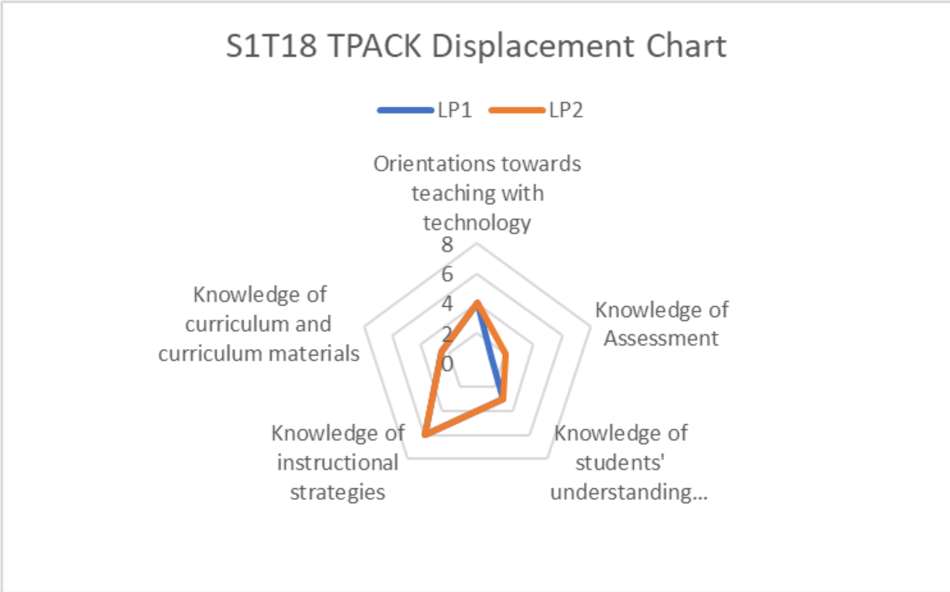
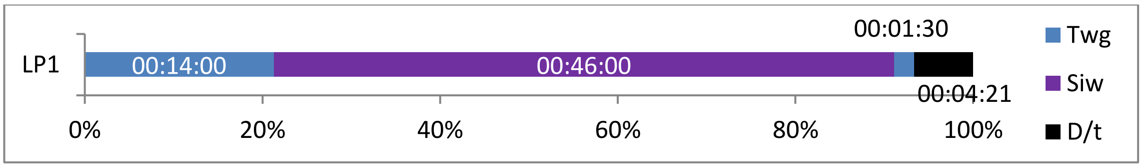


Figure 5.13 S1T18 TPACK Displacement Chart

5.6.5 S1T4 – Art

Not a lot can be extracted from one lessons interaction chart. Of some interest however is in their survey, S1T4 (Art) stated that they always make time for student individual learning, which is clearly evident in this lesson. Another interesting observation was that during the exit interview S1T4 (Art) felt that it took almost the full forty minutes to get the students on the laptops and starting work. However, it actually only took 14 minutes before the teacher set the students' the task, and after that very few instances of interruptions were observed.



Repeat of figure 5.5. Classroom interaction for S1T4 Art's one lesson plan

Again, with only one lesson, patterns cannot be determined. The TPACK displacement chart in figure 5.14 shows that, S1T4 (Art) strongest areas, as have been shown in other teachers thus far, is in orientations towards teaching with technology and knowledge of instructional strategies. S1T4 (Art) could have easily scored achieved the extreme score in their knowledge of instructional strategies, however, they themselves did not utilise multiple representations and activities. The majority of the lesson involved student – teacher interactions. In the lesson the students utilised an online tool which allowed them to create their own typeface, which was unique to them and involved some personal aspects of their life e.g. cars, makeup etc. While the students could have easily designed their own type face using hand drawings, what makes this activity transformative is in how students were introduced to and developed the skills necessary for working with adobe Photoshop and other industry standard software artist may use in their career.

S1T4 (Art) didn't use these lessons to further their use of technology, because they already have a lot of activities and resources which were used frequently. However, they teacher does still maintain a somewhat negative perception of technology and this showed in their exit interview. However, the students were engaged in the lesson and the use of technology was of a high standard.

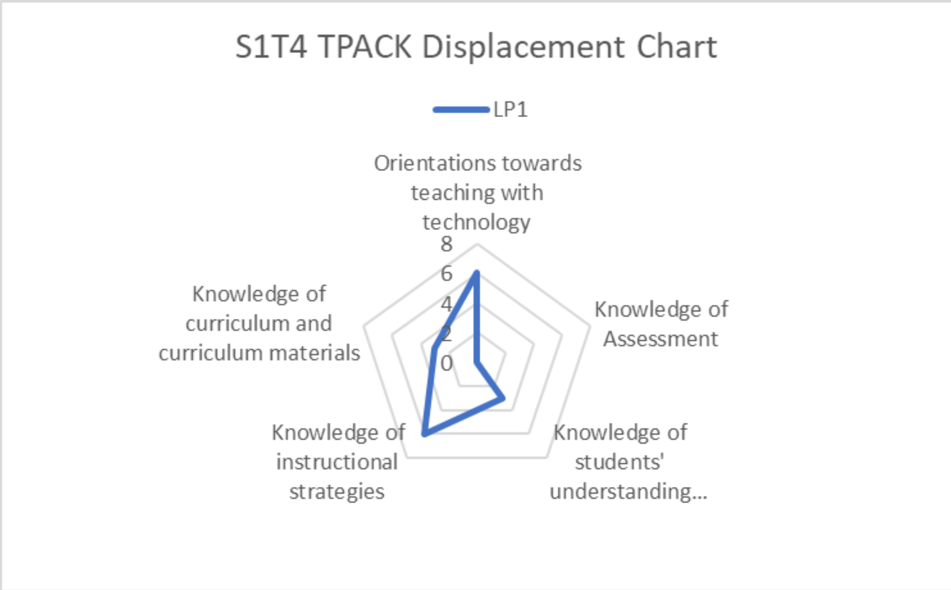
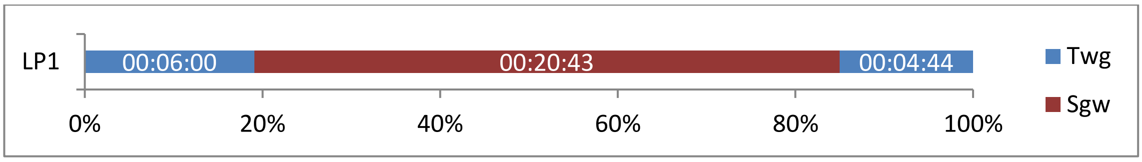


Figure 5.14 S1T4 TPACK Displacement Chart

5.6.6 S1T34 – Physical Education

S1T34 (PE) developed two lessons, however only the second of these lessons was recorded. In their exit interview, S1T34 (PE) spoke very highly of their first lesson. They asked students to perform a set of gymnastic skills and record themselves doing so. The students then had to review the videos and correct any mistakes or bad habits that were evident in their recording. Based on how successful the first lesson was, S1T34 (PE) decided to model the second lesson identical the first. Not surprisingly, the majority of this lesson was dedicated to student group work as evident in figure 5.6 What is interesting about this lesson is that it took place over a single class period. It is a testament to the teacher's time management that the students were able to get changed, briefed on the activity, complete the activity and close the lesson all within a 35-minute period. Alike S1T18 (Spanish), S1T34 (PE) only has three interactions throughout the whole lesson, two of which were teacher centred.



Repeat of figure 5.6. Classroom interaction for S1T34 PE's one lesson plan

Once again, the TPACK displacement chart in figure 5.15 highlights that S1T34 (PE) strongest domains were orientations towards teaching with technology and to a lesser extent knowledge of instructional strategies. While the lesson included a novel form of assessment for the students', it was evident that students were not engaging with it at the level the teacher hoped. In their exit interview S1T34 (PE) felt the second lesson was not as successful as the first but saw the merits of what they had tried to achieve and believes it is something they should continue to work on in future lessons.

"*The second group, not as a successful, and there have been issues since as well with what I was trying to do with the lesson. But again, it was the nature of what they were doing in the second lesson just made it a little bit harder to use the tablets within the lesson. But again, I would have been happy with it but certainly there would have been a lot of room for improvement and a lot more work that could be done with the lesson in the future*."

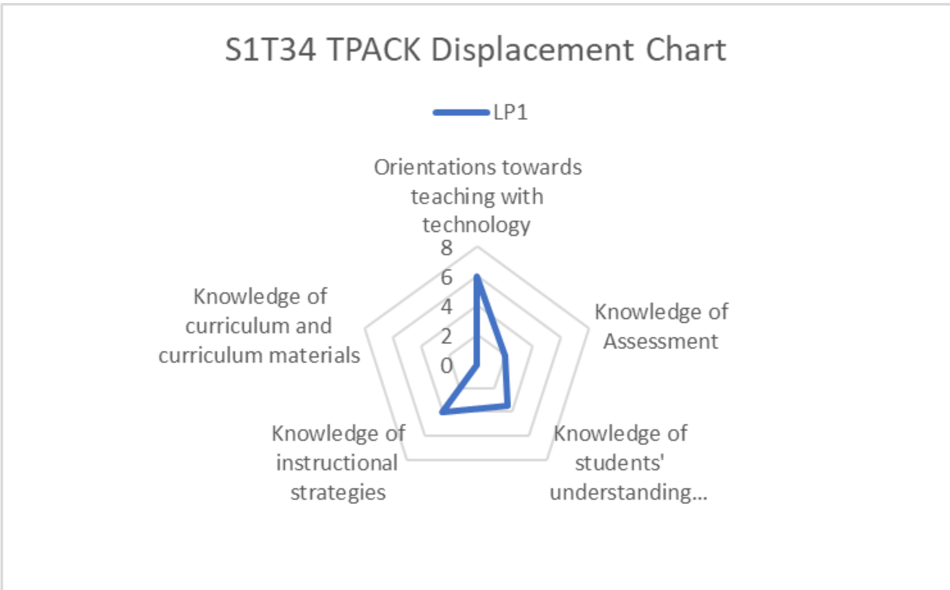


Figure 5.15 S1T34 TPACK Displacement Chart

5.6.7 S1T26 – French

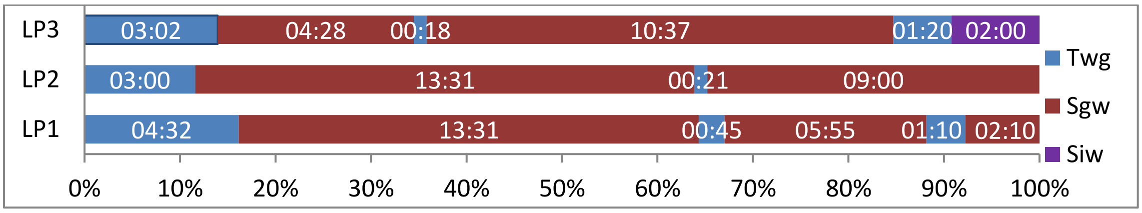
The interaction chart for S1T26 (French) shows that they tend to favour group work over any other methods, spending 80.8% of the available class time over the three observations in group work situations. Interestingly, S1T26 (French) explained in their exit interview why the students were put into pairs:

"*…in those three lessons putting them in pairs because I thought it would be easier instead of doling out one individually*"

A more telling example however, of how S1T26 (French) beliefs influenced their decision to implement group work can be found in a slightly later interview question. When asked how they viewed their role as a teacher S1T26 (French) replied:

"*Supporting and there to answer a question or if they weren't sure where to look up something…. so, you were more of an assistant rather than the dominating force in the room.*"

S1T26 (French) generally kept to the same structured format. The lesson was opened with the roll call and a brief introduction to the task, all while conversing in the target language. Then the students were given time to work on the task before the teacher called them to attention again either to give them a countdown or to clarify some issues. The class normally concluded with the teacher asking students to complete the task for homework. The only major difference between each of S1T26 (French) lessons is the inclusion of Siw in lesson three, which is attributed to students' collecting the poster onto their USBs and writing down their homework.



Repeat of figure 5.7. Classroom interaction for S1T26 French's three lesson plans

It can be seen from the TPACK displacement chart in figure 5.16 below, that at least during these lessons, assessment was not an important aspect of their teaching with only one of the three lessons incorporating any form of assessment. However, the assessment utilised in lesson two rates as the highest which was achieved by only two other teachers in this study. Another interesting observation was that S1T26 (French) did not use any student-based assessments, even though the majority of class time was dedicated to student centred approaches. During their interview S1T26 (French) felt that lesson two was their most successful, in fact they were somewhat apprehensive during the lesson as it was something they had never tried before and felt it could become very chaotic.

"*In my head I felt my second one was really good… the second one, they were moving around the room, I was kind of most scared of it because I thought they are up, they are moving, they are planting things and trying to speak in French about where the object was and just physically and health and safety and just noise, I thought this was going to be chaotic. But it actually wasn't, and it was the most full on as in they threw out.*"

Overall there is little variation amongst the lessons with second achieving higher ratings across more components that both lessons one and three.

From these lessons it can be shown that S1T26 (French) utilises group work because it is easy, but mainly because their belief is that teachers' role in the classroom is more of a facilitator than the dominating force which was corroborated in their exit interview. The level overall level of interaction observed in these three lessons corroborates this claim. It can also be shown that S1T26 (French) does not rely heavily on assessment in these lessons anyway. While most teachers utilised an end of lesson recall, S1T26 (French) did not, instead focusing all of the available class time to the task at hand, allowing for more time to achieve the aims set out in their lesson plan.

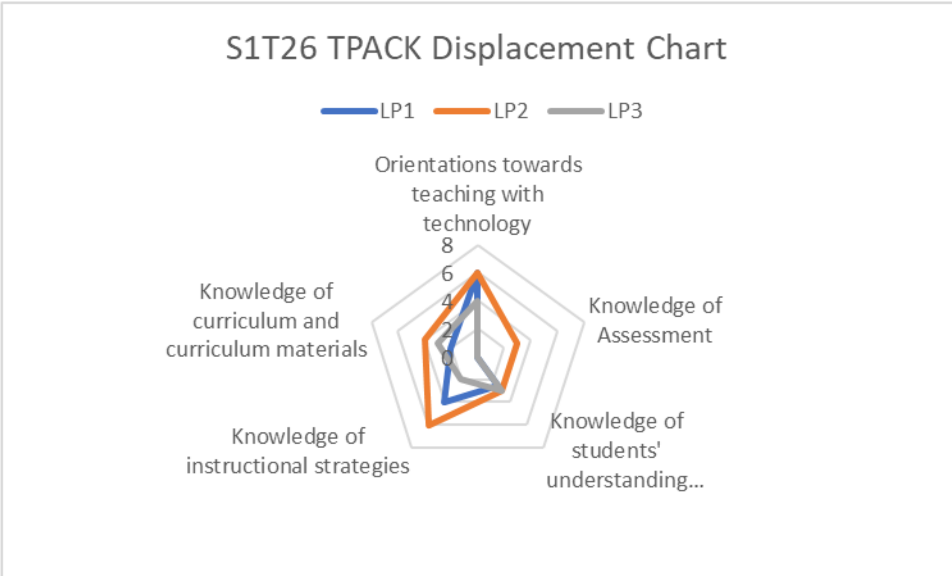
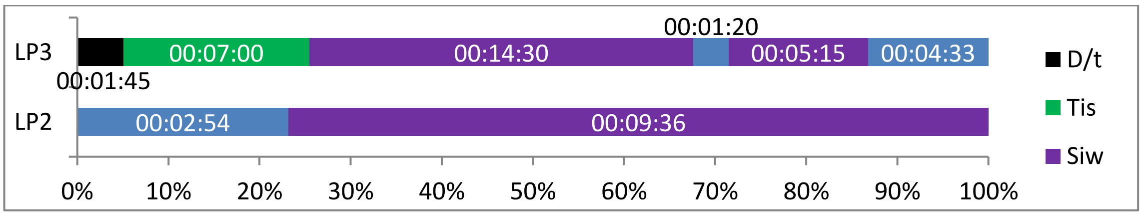


Figure 5.16 S1T26 TPACK Displacement Chart

5.6.8 S1T13 – Irish

S1T13 (Irish) first lesson did not go to plan for them at all. They had hoped to import all of the images from drop box and get the students to begin creating their timelines. However, an oversight on the teacher's part meant the students spent the majority of their time trying to locate a non-existent folder on the computer. By the second lesson the issue was rectified, and the students were able to create their video timelines.



Repeat of figure 5.8. Classroom interaction for S1T13 Irish's two lesson plans

S1T13 (Irish) TPACK displacement chart as seen below in figure 5.17, highlights a strong attainment of orientation towards teaching with technology as well as knowledge of instructional strategies. Interestingly, S1T13 (Irish) did not utilise assessment in either of their lessons and generally scored below average for all other domains ratings. The difficulties faced by S1T13 (Irish) during the first lesson may be a contributing factor to the generally moderate rankings. It should be noted that S1T13 (Irish) generally scored one to two marks higher in lesson two which did not have as many instances of disruption.

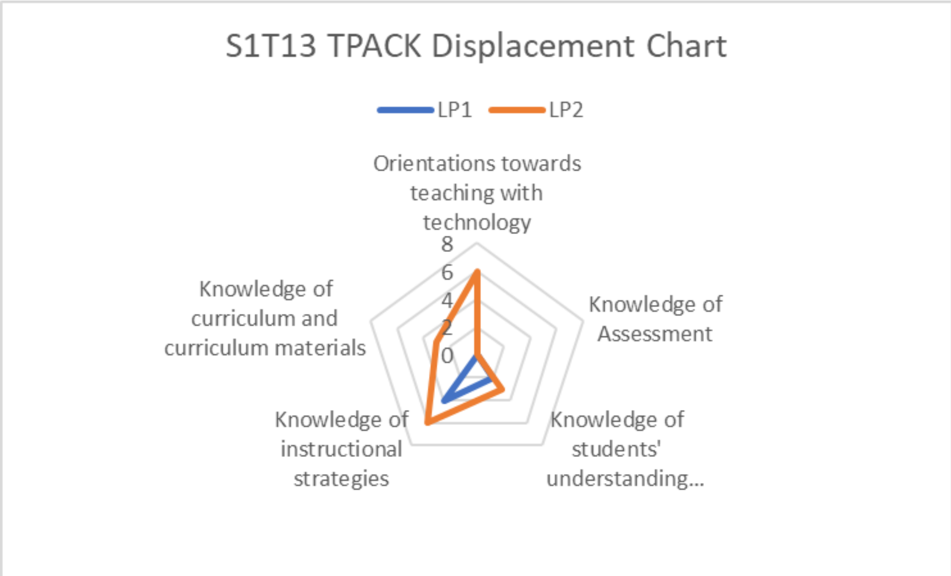


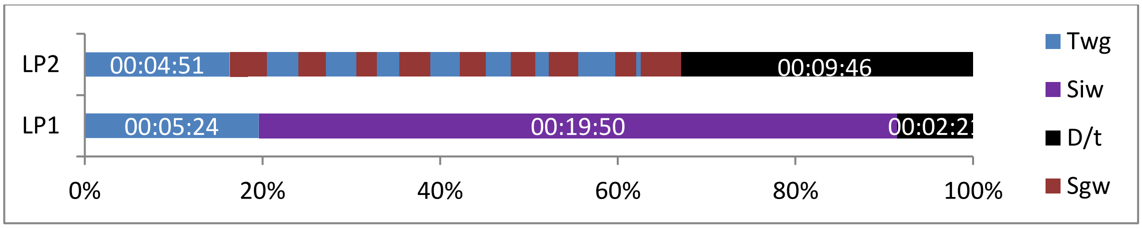
Figure 5.17 S1T13 TPACK Displacement Chart

5.6.9 S1T31 – English

S1T31 (English) is another example of a teacher who utilises two different student-centred methods over their lessons. The students' in these observations were more excitable than any others seen previously and as such S1T31 (English) spent a small amount of time disciplining the students'. Although only 30 per cent of the available class time in lesson two was actually spent in student centred learning, the majority of teacher directed interactions were feedback and counting down for the next group to record. The discretionary time in lesson two accounted for 33 per cent, however, some students' can be seen still working on reviewing their videos before deleting them from the device, and however, most students' have completed this by the five-minute mark. The majority (72%) of lesson one was dedicated to student centred work, even though the teacher spent quite a bit of time explaining to students' how to find and open Microsoft Word. During their exit interview, S1T31 (English) was asked to rate the two lessons. Surprisingly they gave both lessons four out of ten. In the first lesson they felt it was a "*complete disaster*" because students' did not know how to copy and paste and other simple tasks. However, during the observation, the teacher did not ask students' if they could perform these tasks, instead they took it upon themselves to describe in detail how to copy and paste text and images into word. In fact, two questions later S1T31 (English) was asked what technology they had previously used with this class group:

"*Well a lot of it would be on Word because obviously English warrants that. They might have to do Google images, so they might have to do an article or Facebook page, I have tried to make them do their own Twitter feed, things like this, just for characters in a film or a novel and writing diary entries, typing them up*"

From this quote we can deduct that S1T31 (English) has in fact used word with the students' before and may have possibly come across copying and pasting, but this cannot be verified.



Repeat of figure 5.9. Classroom interaction for S1T31 English's two lesson plans

The TPACK displacement chart in figure 5.18 shows that S1T31 (English) achieved mostly average scores and one instance of high achievement again, in the orientation towards teaching with technology. In lesson two, S1T31 (English) showed not only an understanding of the needs of the syllabus, but also provided the students with an opportunity to develop media skills and possibly, an interest in pursuing a career in journalism. Not unlike most other teachers, S1T31 (English) has shown a deep understanding of their subject content matter. S1T31 (English) had one of the most unique uses of technology seen by any of the teachers.

S1T31 (English) themselves used technology very sparingly, only using it in lesson one to show what the front covers a newspaper looked like. The students' however, in their first lesson used word to create a front page. In their exit interview, S1T31 (English) stated:

"*Whereas if I had just gotten them to draw it out in their copy and show them something on the screen they could have done it within 10 or 15 minutes whereas it took effectively 45 to 50 minutes to do one thing that would take 10 minutes if they drew it. So, I think it is great to have technology when it adds to a lesson but if it is something so minimal as that you would expect them to do it fairly quickly and they are just not, it is kind of taking away*"

S1T31 (English) is diluting the amount of learning opportunities doing the cover in word has afforded their students'. While the students could quickly draw out the front page and taken away the majority of the learning, they would have missed out on not only place setting in the document and the importance of fitting text and images around each other, but they would have also lost out on an opportunity to develop their photo research skills. If S1T31 (English) wanted to take this a step further, they could have introduced the concept of copyright and how some newspapers and magazine buy the rights to stock images. In the second lesson students not only developed on the skills S1T31 (English) set out, but they also learned in a way they never have before. Not only did the students develop their oral skills, but also had the opportunity to critically reflection on their work and change it as necessary. Overall there were two different interactions in the two lessons. In lesson one the students engaged in teacher-student interactions for the majority of the lesson, whereas in lesson two this shifted to peer to peer interactions.

S1T31 (English) provided their students' excellent opportunities due to their use of technology. However, the teachers' attitude and beliefs about not only teaching, but about their students led to some short comings. S1T31 (English) believed the students needed to be walked through basic functions, whereas students had already used word and quite possibly these basic functions. S1T31 (English) did not provide students with an opportunity to express how if or how their technical knowledge may be limited. This caused S1T31 (English) to reflect on the lesson in a negative manner, even though, from the observations and TPACK overview, the lessons achieved very higher standards.

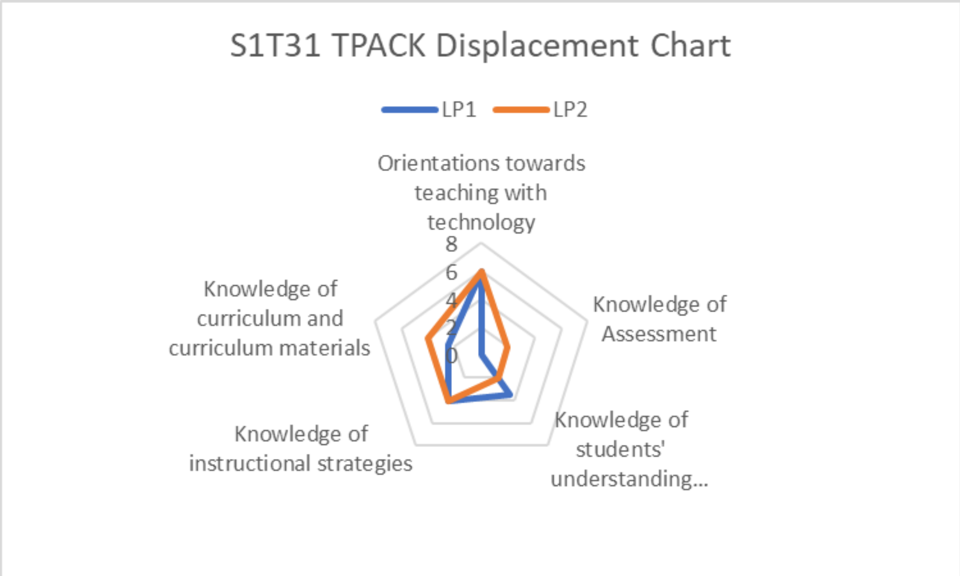


Figure 5.18 S1T31 TPACK Displacement Chart

5.7 Discussion

The purpose of case study one was to answer two of the research questions set out in chapter three, namely:

1. How do in-service teachers with minimal experience of technology integration, use technology in their classroom practice?
2. What support do in-service teachers need in order to improve their technology integration in classroom practice?

To assess these research questions, we examined the merits of using an observational framework for the purpose of determining teachers' TPACK. It was found that while there were many frameworks, none provided enough richness to the data that was collected. As such, a combination of Classroom interactions, Hughes (2005) technology supported pedagogy, Blooms taxonomy and Canbazoglu Bilici *et al.,* (2016) Technological Pedagogical Content Knowledge Observation Protocol were used. These tools were used to create three distinct areas of analysis namely 1) Interactions, 2) Integration and 3) TPACK. Using this framework teachers' level of TPACK was determined. Secondly, teachers were invited to participate in an exit interview in which their views of the challenges and opportunities of technology were discussed.

In this study, 9 in-service teachers from various subjects developed, implemented and reflected on a series of lessons which integrated technology. These lessons were then used to determine the teachers' level of TPACK.

5.7.1 Classroom Interactions - Teacher-student interactions

The importance of teacher student interactions cannot be over stated. In their study on conceptualising, measuring and improving student classroom interaction, Pianta *et al.,*. (2012) theorise that the nature and quality of the relationship and interactions between both teachers and students are not only fundamental to understanding student engagement but can also be assessed through observation methods. They also posit that providing teachers with the knowledge of relevant classroom interactions, teachers can increase their students' engagement. Typically, teacher student interactions can be identified as two distinct groups: teacher-student and student-teacher. A study carried out by the National Institute of Child Health and Human Development (NICHD) found that in 85% of classroom contact time, educational opportunities were categorised as teacher-student interactions. This included whole group interactions and individual work. The study goes on to report that in fewer than four times an hour the students interacted with the teacher and in these cases, it was usually to confirm task objectives or comply with a teacher directive. Furthermore, the study also found that the majority of instructional exchanges focused on either performing a certain skill or answering (in some form) a question which has a definite answer, rather than an ambiguous, thought provoking question. The NICHD study reminds the reader that teachers should capitalise on small group work which improves the student-teacher relationship.

The results in this study showed that there were two distant categories of lessons developed by the cohort of teachers these were: lessons which focused on content knowledge and lessons which focused on subject specific skill development. These lessons were identified by the learning objectives and tasks set out by the teacher either in their lesson plan or during their lesson. The lessons which focused on developing content knowledge generally tended to favour teacher directed interactions over student centred. Teachers S1T29(History), S1T12 (Business) and S2T2 (History) were coded as having teacher directed lessons due to the higher accumulation of teacher interactions. However, these teachers provided students with significant portions of class time for completing classroom activities, and in general these activities focused on individual student work over group work. The work of Pianta, Hamre and Allen (2012) showed that classroom interactions can be thought of as a continuum of interactions, at one end we have the classroom where teachers frequently look for students' thought and ideas, often dictating the direction of the lesson. In this case, students' play a formative role in the classroom (La Paro, Pianta and Stuhlman, 2004). While at the other end is the teacher structured interactions, these can be defined by the rigidity of the lesson, often following scripted plans, devoid of the interests and motivations of the students' by providing little to no opportunity for the students to engage or express their ideas or take ownership of an activity. Not surprisingly, research has shown students' thrive when given control over their learning (National Research Council, 2003) and recall having more positive school experiences, demonstrate increased motivation and are generally more engaged in the lesson (Valeski and Stipek, 2001). The teacher directed lessons developed by S1T29(History),12 and 2 contain huge variations between them. In S1T29(History), the students were given a specific set of questions to research and answer, allowing students' some form of control over their learning. In one of S1T12 (Business) lessons, students were asked to create a poster detailing the different types of insurance, again offering students' this choice of freedom. Then, however, two of S1T12 (Business) lessons and both of S1T2 (Home Ec.) lessons were much more rigid in their approach to students' freedom to independent learning, that is because these lessons provide students with fill in the blank style questions or very specific research on a particular website which all students' must use. From the video observations it is noticeable that the students' in S1T29(History) lessons were visibly more engaged than the students' in S1T12 (Business) and T2s lessons as suggested in the previously cited literature (Valeski and Stipek, 2001).

The second category of lessons were the development of subject specific skills. The remaining five teachers were identified as having conducted lessons which have a particular focus on developing subject specific skills. These teachers were: S1T4 (Art), S1T34 (PE), S1T26 (French), S1T13 (Irish) and S1T31 (English). What distinguishes these lessons from those conducted by the previous teachers were that these lessons were specifically developed to focus on developing a skill for example, in Irish the teacher wanted their students to practice the spoken language at home and create a "*movie*" using their own spoken dialogue and images they find online. When examining the interaction charts from S1T4 (Art) to S1T31 (English) it can be seen that the majority of these lessons focused on student centred interactions, be it as a group or individually. The key structural difference between these lessons and those observed by the previous teachers were that students were given a purpose in the lesson, a set of tasks which draw on their content knowledge, motivate them and in most of the lessons, provide some interaction with their peers. According to Biggs (2005) as cited in Mondéjar-Jiménez *et al*.,. (2011), these are the four aspects of which students require in order to better develop their skills. Each of the teachers in this second category contained all four aspects outlined by Biggs (2005), however, the problem then lies in assessing how skill development is affected as a result of the implementation of these lessons.

Examining the charts of the teachers' in category two again it can be seen that there is a predictable pattern emerging from the structure of the lesson. It is clear that the teachers introduce the lesson and cover some administration work i.e. roll-call before setting the task for the students', the teacher then allows the students' time to work on the task. More often than not, the teacher interjects roughly halfway through the lesson to check on students' progress before leaving them to work again. The teacher then wraps up the class either by giving homework or asking the students to pack away the devices. This pattern could also be seen in the first category of teachers, however, the times where the teacher interjected were significantly longer and often focused more on redirecting the task or delivering more content.

Perhaps the most striking observation noted between the two groups is in the change in teachers' role. In the lessons where the teacher focused on developing subject specific skills, the teacher was observed assuming the role of a facilitator of learning (Brookfield, 1986) rather than adopting the traditional teaching style associated with teaching. Teaching through facilitation is desirable because it pertains to the innate nature of humans desire to learn, but also learning is more meaningful to the student when it is self-initiated and the student can see the relevance of the learning in the context of the task (Rogers and Freiberg, 1994).

5.7.2 Level of Integration

To assess the level of integration achieved in the each teachers' lessons Hughes (2005) definitions of technology integration were used. These were:

1. Replacement: The acts of replacing a teaching tool or strategy with technology i.e. using PowerPoint instead of a whiteboard
2. Amplification: Where technology is used to accomplish a task more efficiently i.e. using online collaboration tools for group work
3. Transformation: Technology is used in innovative ways to encourage and engage students' cognitive development.

As discussed earlier, the concept of technology integration from these definitions was still quite abstract and as such, Blooms Taxonomy was used in conjunction with the definitions to provide some context to the integration utilised by the teacher. From the results, it could be seen that six lessons were coded as replacement, eight as amplification and four as transformation. For the six lesson which were coded as replacement the lessons tended to task the students' with applying knowledge, researching information or answering basic recall questions. These lessons were conducted by teachers S1T18 (Spanish), S1T2 (Home Ec.) and S1T12 (Business), all of whom were recorded as implementing lessons which focused on content knowledge. In the instances where teachers were observed as implementing amplification lessons, the middle levels of Blooms taxonomy i.e. apply was observed more, with four of the six teachers being labelled as apply lessons. Interestingly, this pattern of increasing levels of Blooms taxonomy the higher the level of integration continues where all of the lessons labelled as transformative were also rated in the higher levels of Blooms taxonomy i.e. create and evaluate. Using Blooms taxonomy as a labelling tool was done before in Valckle *et al.,*. (2009) where the students of their study were asked to label sections of a discussion using Blooms taxonomy. The results of these findings suggest that at lower levels of integration we tend to see lower cognitive tasks, which may be of little benefit to the students' overall learning (Mundy and Kupczynski, 2013).

5.7.3 Technology Pedagogical Content Knowledge Observation Protocol

To assess the level of TPACK achieved by the nine teachers during each of their lessons, Canbazoglu Bilici *et al.,*. (2016) TPACK observation protocol was used.

The TPACK-OP provided data on teachers' attainment of eight items contained within five domains. The scores in these domains was used to create a tabulated data on the cohorts' attainment of TPACK. It also provided a visualised description of teacher's attainment of TPACK on an individual level.

The results of the TPACK-OP showed that this cohort of teachers scored lowly in their attainment of TPACK domains. Assessment methods were a weak point for this cohort of teachers with a mean score of 1.80 and 1.42 in their ability to use assessment methods to evaluate important dimensions (item 2) as well as in the range of higher order assessments used for students'. However, teachers scored a mean of 3.63 in Knowledge of students' understanding subject specific knowledge which shows that these teachers were acutely aware of their students' prior knowledge, learning difficulties and common alternative conceptions and were knowledgeable enough to overcome these alternative conceptions and difficulties. While the results from the TPACK displacement chart show persistent weaknesses in these teachers' attainment of TPACK, it also provides an opportunity to engage objectively and discuss how improvement could be made to increase their levels of TPACK and therefore, technology integration.

5.7.4 Teachers' Perceptions of Barriers

To answer the second research question data were examined from the exit interviews which were held at the conclusion of the study. The exit interviews were analysed using Braun and Clarke (2008) thematic analysis methodology as described in chapter 3 section 3.3.2 and earlier in this chapter in section 5.1.3. Below in figure 5.19 is the mind map generated from the codes in NVivo 10 after the rounds of coding.

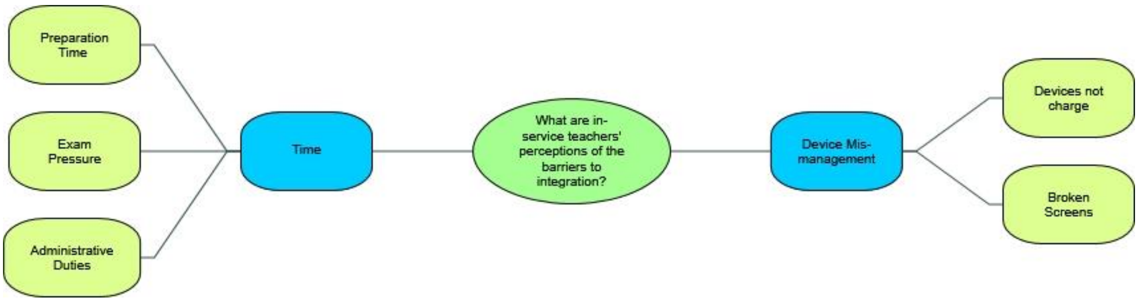


Figure 5.19 Mind map of the final codes and themes generated in NVivo from the exit interviews

During the exit interviews there were two major barriers identified by a number of teachers. These were: time and device management.

The first major barrier identified by the teachers was time. Time was coded in several different instances, for example, preparation time was one of the most highly coded instances of time. One example is from S1T12 (Business), the business studies teacher who had this to say:

"*Preparation, a lot of time, you need to be very organised and sometimes it is just not feasible when you have got nine classes a day and you are trying to teach, it is your main aim and you have got, like this year in particular, I have four exam classes at this stage of the year and trying to get ready for exams, so they are my focus. So, it is very hard then to try and shift your focus onto technology and all things in planning what time you are going to get them and who you are going to send to get them. How they are going to get there, what happens if something is not working? So that makes it very difficult.*"

Interestingly, in this quote, S1T12 (Business) also touches on two of the other time coded instances namely, exam pressure and administration time due to the introduction of technology. We can see in their quote that S1T12 (Business) believes technology demands a lot of time in terms of preparation and with an already full timetable it can be difficult to dedicate the extra time needed to plan a technology enabled lesson. As far back as Ertmer (1999) time has been identified as a major second order barrier to teachers and recent research still supports this discovery. In their study (Wang, 2017) found that 87 per cent of their teaching participants struggled with the limited amount of time and energy they had at the end of their normal teaching day to plan for a flipped lesson. The extra time used to plan these lessons becomes even more scarce when teachers have exam classes and they were in full exam preparation mode. Moving onto exam pressure, one teacher speaks of how their main use of computers is purely for research because when it comes to the exam it is a drawing-based exam. So, whatever they do with computers in class will not ultimately help them in the exam:

"*They use computers just for research really because everything to do with the exam then, it is all drawing based so the only thing they really use them for is research.*"

One study by Chen (2008) found that Taiwanese parents placed a huge amount of trust in use of school books as a means of achieving high results in terminal examinations, and this in return, reflected on teachers' practice. Teachers' would often refuse to use technology because the books were seen as the solution to performing well in these high stakes exams. In Ireland, students complete a high stakes examination their final year of post-primary education which determines their success in college and beyond. Therefore, we can see that some teachers were conforming to this ideology, that if technology does not support what is examinable then it is not worth integrating.

The third-time code was labelled as administration and encompassed issues such as collecting the devices and bringing them to the classroom, dispensing the devices to the students', gathering them, bringing them back etc. Quite a few teachers were coded as citing one or more of these issues, and the impact it had on their lessons. However, there was minimal disruption to these lessons as there was often a surplus of devices available for the teacher.

The next barrier cited by teachers was device management, namely, the mishandling of devices. In several observations, there were multiple cases of devices not switching on due to insufficient charge or in one particular case, the device's screen was broken. As one teacher put it:

"*if I am totally honest, and I would like to think I left the thing back the way I got it and that would be a concern for me, that it is a free for all and who is minding the baby? We are all in charge of it, but it is very hard to instil that into people to take responsibility for the equipment. I only know that from my own room and what I have seen go down and things we have had to replace and repair. And again, it is nobody's fault, but stuff happens.*"

While the literature often cites access to hardware as a key barrier to integration (Ertmer, 1999; Ottenbreit-Leftwich *et al.*, 2010; Ertmer and Ottenbreit-Leftwich, 2013; Wang, 2017) it is often in the context of actually having possession of the hardware. Nevertheless, one could extrude this to also mean access to working hardware when already available in the school.

5.7.5 Summary

The case study conducted in this chapter yield a variety of results which can be used in planning for future studies. The main findings in this study show that several teachers were able to plan and implement a replacement technology lesson. Most teachers were able to integrate technology at the amplification level while a small number were able to develop lessons which radically transformed the teaching and learning of their subject. The feedback received from teachers was quite positive with teachers' noting how much more students seemed to be engaged in these lessons and how the lessons tended to give students' control over their own learning. However, some teachers believed that using technology slowed down their progress with the curriculum.

Another finding from this study shows that there was a mixture of teachers' who led students' centred lessons and teachers' who developed teacher directed content lessons. The teachers who tended towards student centred lessons were recorded as showing a preference towards this methodology of teaching during their exit interviews. Those teachers' who implemented teacher directed lessons often expressed fears over covering the materials for examination purposes as well as citing time lost to planning and implantation of the lessons as a reason for not integrating technology in the future.

There were some interesting observations and patterns discovered in the analysis of the data. Firstly, it could be shown that teachers' who tended to use replacement lessons were consistently rated at the lower levels of Blooms Taxonomy while those at the amplification step were rated within the middle to lower levels of Blooms. The same held true for the few transformation lessons in which they were rated at the middle to highest levels of Blooms, this may be indicating that there is some intrinsic relationship between integration and Blooms rating for activities.

The use of TPACK-OP provided interesting insights into the level of teachers' attainment within the domains of TPACK. It showed that this particular group of teachers were weak at aligning their assessment to evaluate important dimensions while also not utilising higher order assessments to assess their students'. However, the teachers were very strong in their students' understanding of subject specific content knowledge, scoring on average 3.63. The use of TPACK also provided visual representations of teacher's individual levels of TPACK which can allow for direct comparison not only between that teacher's lessons, but also across other teachers' lessons.

Finally, teachers expressed the need for substantial and sustained professional development for technology integration to be successful. One key requisite of such professional development is the inclusion of example lessons showcasing best practice for technology integration.

Chapter 6 Case Study Two: School Two

6.1 Introduction

This chapter presents the background, case profiles and findings of a study conducted in School Two, an urban post-primary school in Ireland. Responding to the results obtained from School one, School two was selected to examine what the TPACK levels were of teachers with no previous experience using one-to-one devices in their teaching and what effect if any the introduction of these devices had on the overall level of technology integration.

This chapter will begin by introducing School two, the selection process and relevant background information on the school. Then the six participants will be introduced and discussed in terms of the subjects they taught, level of experience with both teaching and technology and the analysis of their technology integration.

6.2 School Two Background

School two is a catholic founded school which is owned and funded by the state. Enrolment figures at the time of this study indicated that there were 542 boys registered in the school and there were also 55 members in the teaching staff however, there were no official figures given by the school.

The school was built in 1967 and has three fully equipped science laboratories, several equipped woodwork and art rooms, one computer and one technology room and a dedicated sports hall. Recently, the school completed works on an Autism Spectrum Disorder Unit, making it one of a small number of schools in the country to contain such a unit. At Junior cycle level, the students were offered a total of 12 subjects of which 10 must be taken. Several subjects such as Irish, English, Mathematics and Science were core subjects, which gives students' the choice between History, Geography, Business Studies, French, Art, Woodwork, Technical Graphics and Music. Upon completing the Junior Cycle exam, students' have two routes to choose from. Up to 24 students' may apply to complete a fourth year, also known as Transition Year or continue with traditional education and start in fifth year. Once in fifth year, students' will once again complete Irish, English and Mathematics as they were core subjects but will also be offered to select up to 5 additional subjects from: History, Geography, Physics, Biology, Chemistry, Agricultural Science, Business Studies, Economics, Accounting, German, Art, Construction Studies, Design and Communication Graphics and Music.

School two has not been subject to a whole school inspection at the time of writing but in recent years, History, Irish and Woodwork have received subject inspections. In each of the inspection reports the teachers of each department were awarded a good to very good quality of teaching and learning. In all reports the teachers were asked to focus on cooperative learning strategies and integrating ore variety in their assessments. In Irish, it was recommended that teachers utilise technology and focus more on developing the spoken language. In a follow up report, the inspector only observed partial progress in both aspects.

Up until the beginning of this study, the school operated a no phone policy, however, acting on the recommendations made by the researcher, the management amended the policy to allow mobile phone usage during lessons where the teacher has given explicit consent to do so. The main form of communication between management and staff is in the form of a PowerPoint running through a television in the staff room. Management were not present in the staff room during the day but were present in the corridors throughout the day.

6.2.1 Purpose of study

First and foremost, the purpose of case study two was to further gather evidence to answer the two research questions set out in chapters one and three. However, following from the results of case study one in school one, it was decided that a similar study be conducted in a school where teachers expressed some interest in using technology in their teaching. These teachers would then be given a set of one-to-one devices to use in their lessons and were supported with workshops. It was hoped that by selecting teachers' who had previously expressed interest in using technology, some of the issues that were seen in school one could be removed and as such, a higher level of technology integration may be observed. To determine the level of technology integration, the designed observational framework was used with this new cohort of teachers' during the school year, as it was in case study one.

6.3 School Two participating teachers'

In this section, a brief overview of each participating teacher will be presented. This overview will introduce each teacher, the subjects they teach, and other relevant background information, before providing a brief outline of their observed lessons. The participants in this study consisted of six in-service teachers from a range of subjects. Two of the teachers' taught science, and the other four were teachers of geography, technical graphics, history and technology. They ranged in teaching experience from two years up to 15 years. A table summarising the teachers could not be developed as this cohort of teachers did not return lesson planning documentation.

6.3.1 S2T1 – Geography Teacher

S2T1 (Geography) is a geography and Irish teacher in school two. By their own admission S2T1 (Geography) wasn't very comfortable with using technology in their lessons. They could use PowerPoint and play videos but did not feel comfortable in allowing their students' independence with their own devices.

When asked during the workshop what they wanted students to take away from their subject, S2T1 (Geography) answered, enjoyment, content knowledge, awareness of natural disasters and understanding the social aspect of Geography. Next S2T1 (Geography) stated they believed that for a student to be categorised as good in their subject they must be able to "*complete an exam well*", "*show an interest… in their work*" and have an "*awareness of the world from a geographical aspect*". S2T1 (Geography) then identified regional geography, urban planning and exam questions as areas in which their students' struggle the most. They then identified that animations may make physical geography more visual for their students' and using local clips would help to emphasise the regional geography sections. S2T1 (Geography) developed two lessons for observation. During the first lesson, the teacher asked the students to develop a PowerPoint presentation which could be used as a revision tool for by students' in their first year of geography. The students were asked to choose from one of three topics, the PowerPoint had to contain at least 10 slides and the language must be appropriate to students of a lower age. After the introduction and briefing of the task, the teacher walked around the room for the remainder of the lesson while the students worked on developing their PowerPoints. Through the lesson the teacher reminded students to source images online and find local case studies to make the learning relevant to the reader. At the end of the lesson the teacher told students' they would be presenting their PowerPoints in the next lesson and as such should finish the work at home and email it to S2T1 (Geography) by the weekend. The second lesson begins with S2T1 (Geography) asking the first group of students' up to the front of the class where they present their presentation. The teacher then stops the recording before beginning again with the next group and then repeats for the third and final group.

6.3.2 S2T2 – History Teacher

S2T2 (History) is a history and Irish language teacher. S2T2 (History) is similar to S2T1 (Geography) with respect to their level of comfort with technology in their lessons, and it is evident in their response to question four, where they were unable to think of how technology could help in their teaching. When asked what they believed the essence of their subject was i.e. what did they want their students to take away from the subject, S2T2 (History) answered, an "*appreciation of content*", that students' are able to "*visualise events that took place*" and the students' are able to improve their grammar and literacy in the Irish language. S2T2 (History) believes that a student who "*is aiming to improve their progress on a continual basis*" is classified as a good student and when it comes to topics and areas which students' struggle with most often, grammar in Irish and documents and sources were identified. S2T2 (History) recorded two lessons for observation, both lessons were in History class and with the same group of students'. The objective over the of the two lessons was for students to develop a revision PowerPoint on either Christopher Columbus or Ferdinand Magellan. These two lessons unfolded very similarly to the first lesson of S2T1 (Geography), with S2T2 (History) introducing the lesson to the students', briefing them on their assignment and allowing the students' the remainder of the lesson to work on their PowerPoints. Throughout the lesson S2T2 (History) could be heard giving some guiding pointers to the students' as they were not focussing on the relevant information of the explorers. There were some issues with devices in this lesson and the teacher spent a significant portion of time troubleshooting device. However, due to the independent nature of the students' work, the lesson was not impacted upon by these issue, except for those students directly affected by the problem device(s).

6.3.3 S2T3 – Technical Graphics Teacher

S2T3 (TG) is a technical graphics and materials technology teacher. Unlike all other participants in this study, S2T3 (TG) is a recent graduate having worked previously in industry. S2T3 (TG) spoke about using technology quite extensively in their teaching, mainly through PowerPoint for visual aids but also SolidWorks for designing projects for upper second level students'. However, the context of how technology was used was later found to be in a teacher led method rather than one-to-one setting. During the workshop, S2T3 (TG) gave numerous answers to the questions posed to them and categorised them for each subject. What S2T3 (TG) wants their students to take away from technical graphics at the end of their three years include: problem solving, spatial awareness, creativity, logic understanding, numeracy and psychomotor skills. While in construction studies, which is an upper second level subject, S2T3 (TG) wants their students to build upon their psychomotor skills, can integrate into a working environment with colleagues and be able to follow instructions. When asked what it meant for their students' to be good at the subject, S2T3 (TG) felt the following applied: achieving good grades, being well organised, being able to apply one self, listen, learn and apply, work well in groups and contribute to the subject and their peers. S2T3 (TG) then identified an area at both upper and lower second level where the students' struggle. At lower second level, students tend to struggle with auxiliary views while at upper second level, students tend to experience difficultly with report writing for their experiments. Finally, S2T3 (TG) only identified technology as being able to help with students' report writing skills. S2T3 (TG) developed two lessons, both of which were used to introduce first year technical graphics students to the basics of Solid Works. In these two lessons, the schools own set of laptop devices were used aa the tablet devices would not be powerful enough to run Solid Works. The lesson begins with the teacher calling the roll and then showing students' how to open solid works and start a new project. Teacher then gives students' time to catch up and then begins to show the next step and walk students' through this before allowing them some time to catch up again. This is repeated once more through the first lesson. The second lesson begins and continues the same as the first lesson, except students' have slightly more independence during this lesson as they were rethreading the content from the previous lesson, which gives the teacher more freedom to roam the classroom and help individual students'.

6.3.4 S2T4 – Business Studies Teacher

S2T4 (Business) is a teacher of business studies and German in school 2. During the workshop S2T4 (Business) identified the essence of their subject as acquiring lifelong learning skills as well as developing knowledge from the curriculum material. For example, students' being able to create and maintain household accounts. Similarly, for a student to be seen as good in their subject area, S2T4 (Business) feels the students should be able to apply the content of the course to their life after school, e.g. knowing the differences between certain bank accounts and the fees involved. Surprisingly, the area in which students' struggle conceptually, is in accounting and S2T4 (Business) identifies that technology may be able to make accounts more visual for their students' and therefore easier to understand. In the first of their two observed lessons, S2T4 (Business) focusses on improving students' understanding of bank reconciliation statements, this is due to a particularly poor test the students recently undertook. The teacher begins by outlining the lesson which is to complete an Kahoot quiz and work through a word template for a bank reconciliation statement. It takes nearly 20 minutes before the teacher begins the quiz, due to some issues with devices, some discipline issues, roll call and other obstructions. While the quiz is running the teacher hands back homework from previous nights and when the quiz finishes students were asked to go to Edmodo to find the results of their previous in class test. Teacher then goes through the solution to the test on the smartboard and explains how the Kahoot quiz was a fun way to recap the content contained in the class test. The second lesson begins with the teacher noting there is some confusion amongst students' regarding how to use a household budget, as such the teacher has prepared an excel sheet which serves as a template for a household budget. The file is based on a previous homework question, so students were familiar with the question. S2T4 (Business) spends some time doing into detail about how to create the formulas in excel before moving through the rest of the file and showing students' how to complete other aspects of the budget.

6.3.5 S2T5 – Science Teacher (Chemistry Major)

S2T5 (Chemistry) is a science, chemistry and mathematics teacher. S2T5 (Chemistry) explained in their workshop answers that the essence of science revolves around exploration, explanation and curiosity. If a student wants to be successful in science they need to have a willingness to learn and explore, develop a fluency of science beyond rote learning and develop scientific processing skills and philosophical science literacy. S2T5 (Chemistry) identified several areas in the science curriculum which students' always struggle with, areas such as: bonding, ions, density, motion, formulas and calculations and biology terminology. S2T5 (Chemistry) goes on to say that technology can speed up the teaching process allowing them to cover a larger number of examples in a shorter space of time. This in turn will shift the focus from content and jargon to understanding the concept. S2T5 (Chemistry) recorded two lesson which focussed on developing students' understanding of pH. The first lesson began with S2T5 (Chemistry) directing students to the Phet simulation website and the simulation to download. Awhile after everyone had downloaded the simulation the teacher drew a table on the smartboard and then talks students' through how to use the simulation. Once the teacher has finished talking through how to use the simulation they walk around the students' making sure they were able to follow what was just said. The teacher then asks their students to try out different substances and record their observations in the table. In the second lesson, the teacher starts by asking students to reopen the Phet simulation from the last day and provide some of their observations. The teacher writes these observations down in their own table which is projected onto the smartboard. The teacher then returns to the simulation to discuss the concept of H and OH ions as red and blue dots in the simulation. After some explanation, the teacher asks students to copy down the teachers' results into a table. The teacher then runs through the simulation once more explaining the task for students', which is to count the red and blue dots in different solutions. Once students complete the task S2T5 (Chemistry) assigns them homework before the class ends.

6.3.6 S2T6 – Science Teacher (Physics Major)

S2T6 (Physics) is the second science teacher in school, unlike S2T5 (Chemistry), this teacher is responsible for the teaching of physics to upper second level students'. Although S2T6 (Physics) was present at the workshop, they did not return their answers to the four questions, as such no information regarding their beliefs and attitudes could be obtained. S2T6 (Physics) conducted two lessons, one in a first-year science class the other in a fifth-year mathematics lesson. The purpose of the first-year science lesson was to develop students' understanding of force and moments, to achieve this, the teacher used the "*Balancing Acts*" simulation from Phet. To start the lesson the teacher checks that all groups have the simulation downloaded and opened in front of them before asking if students would like a tutorial on how to use the simulation, or would they rather play around on their own. Students' were given time to get familiar with the simulation and after a few minutes S2T6 (Physics) provides students with a handout and asks them to answer the questions by drawing their setup from the simulation into the box provided. Students' use the simulations in pairs but were responsible for their own individual answers. After a few minutes of walking around and checking on individual students' the teacher asks the group if anyone is stuck and if so to follow them to the back of the class for individual instructions, one group follow the teacher to the back of the room. Later during the lesson, the teacher asks one group to describe what they have observed so far, and the group were able to describe the relationship between force and distance. The teacher the asks students to power down devices and place them back on their chargers on the trolley. The second lesson which was conducted with the upper second level students focused on introducing them to argand diagrams and the modulus. The lesson begins with the teacher handing out the devices for several minutes while also directing students to the required website. The students were then given a handout which contains the work for their lesson. At this stage students were given ten minutes to spend working on the handout before they were asked to shut down the devices and pack them away.

6.4 Classroom Interactions

One method of thematically coding the data obtained from the observations was through the classroom interactions. As discussed in chapter five section four, there were seven main classifications of classroom interaction, however, only five were applicable to the study and as is the case in this case study, the same five were applicable (Ohlberger and Wegner, 2013). These were: Teacher whole group (Twg), Teacher individual student (Tis), Student group work, Student individual work (Siw) and Discretionary time (Dt).

The next two sections will discuss the six teachers' lessons in terms of two themes which were identified during analysis and used to categorise the lessons. These are presented in figures 6.1-6.6 which represent the teachers' S2T1 (Geography), S2T2 (History), S2T3 (TG), S2T4 (Business), S2T% (Chemistry) and S2T6 (Physics). While in chapter five, the themes centred around the purpose of the lesson, a more obvious set of themes was apparent for the teachers' in this study. The first theme, teacher directed lessons, encompasses three of the six teachers', while the second theme, student centred lessons, includes the final three teachers'.

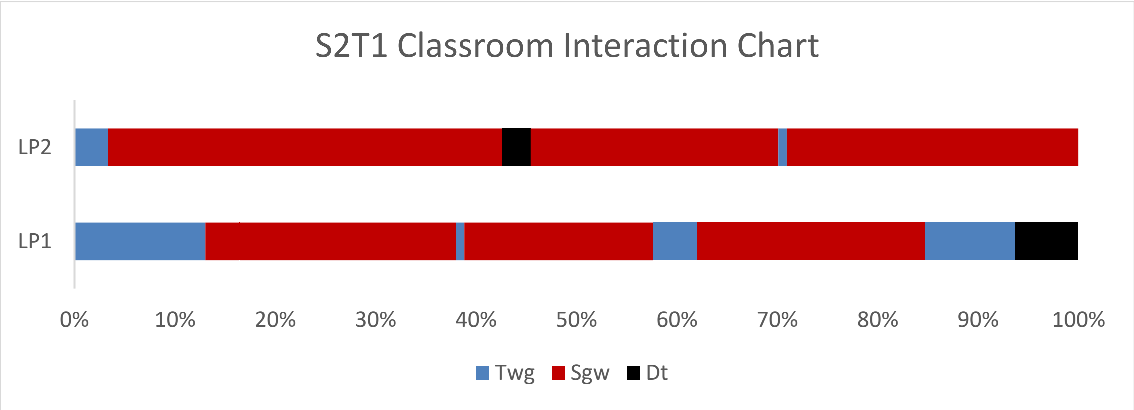


Figure 6.1. S2T1 Classroom interaction chart – Geography

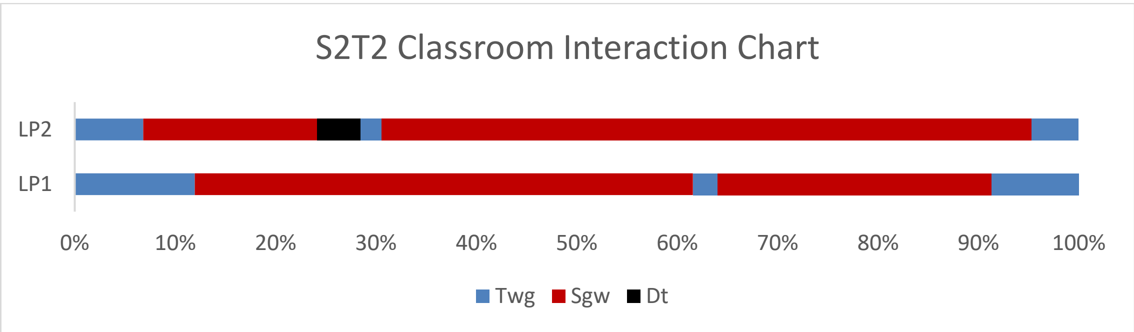


Figure 6.2. S2T2 Classroom interaction chart – History

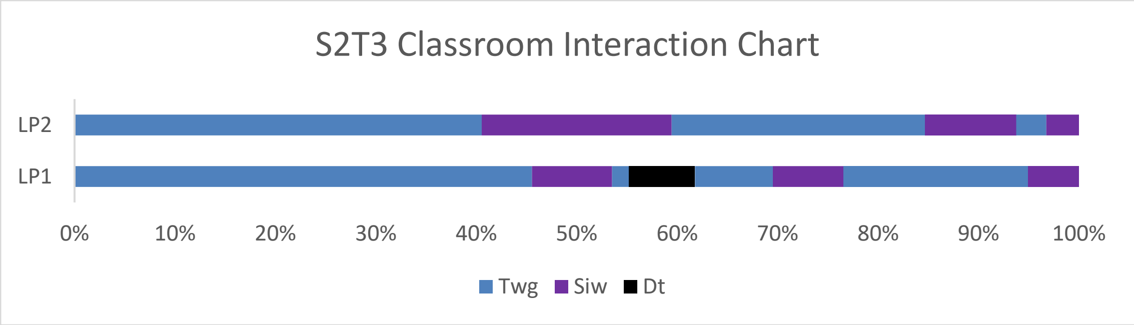


Figure 6.3. S2T3 Classroom interaction chart – Technical Graphics

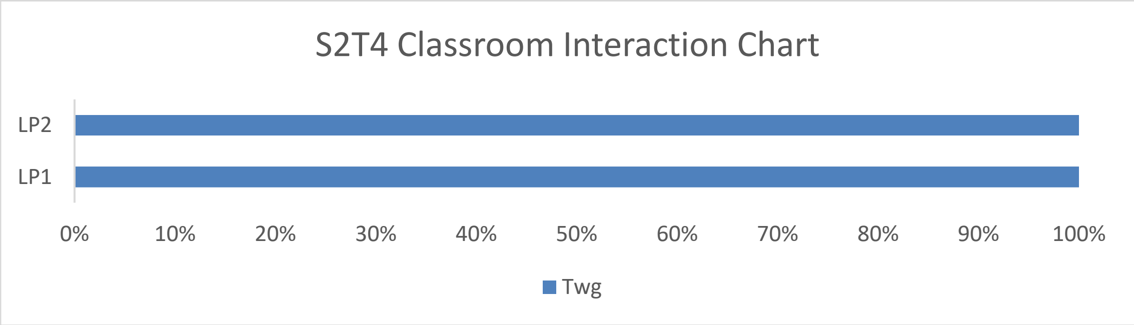


Figure 6.4. S2T4 Classroom interaction chart – Business Studies

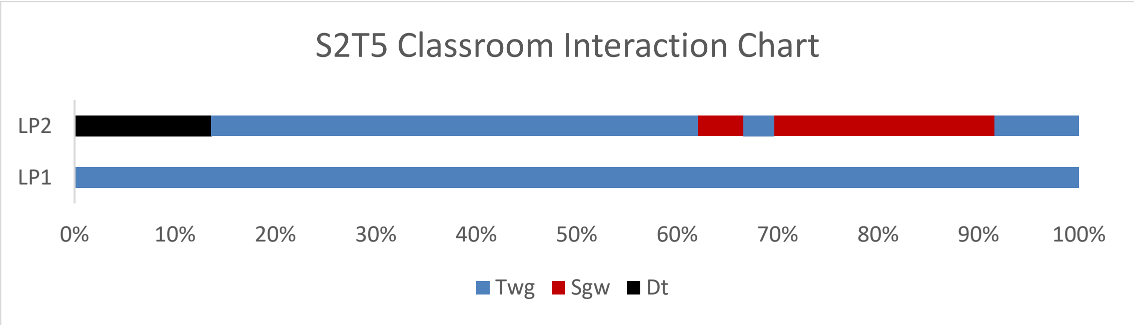


Figure 6.5. S2T5 Classroom interaction chart – Science (Chemistry major)

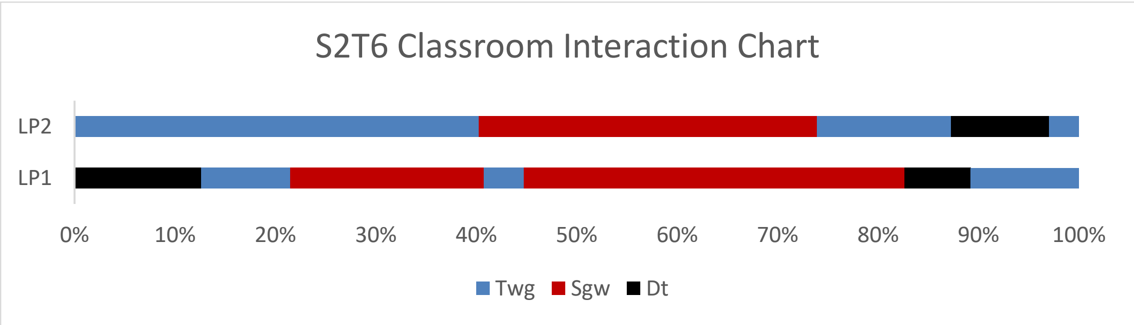


Figure 6.6. S2T6 Classroom interaction chart – Science (Physics major)

6.4.1 Teacher-Directed Lesson

Teacher-directed learning describes the methodological practice of a teacher whom directs the learner towards the desired knowledge. Ebrahimpour, Kabir and Yousefi (2008) defined teacher-directed learning as "*the teacher* [having] *a meta-knowledge over the problem solution and directs* *the leaner towards the desired output during the training process*" (pp. 198). To code for instances of teacher-directed learning, the teacher had to be addressing, directing, guiding or displaying some other example of managing the students' learning process. As described before, these teacher-directed codes were then subdivided into child codes, namely: Teacher whole group (Twg) and Teacher individual student (Tis).

Unlike the themes discussed in chapter five, the teachers' in this study mainly focused on revision and as such, their lessons accumulated a high amount of teacher-directed interactions. Teachers' S2T3 (TG), S2T4 (Business) and S2T5 (Chemistry) accumulated 72%, 100% and 77% of teacher-directed classroom interactions.

In S2T3 (TG) technical graphics lessons, the focus was on introducing students' to, and developing their understanding of, solid works software. This software plays a key role in upper second level students' planning and development process for their terminal project examination. Examining figure 6.3 it can be seen that in both lessons, S2T3 (TG) spends roughly 40% of class time introducing the lesson and directing the students', step by step, through the processes of using the software. The teacher then affords the students' some time to try what they have learned on their own before being guided again through the next steps. This lesson focusses heavily on imparting knowledge onto the students' and less on developing an understanding, as seen by the lack of student interaction time. This became a common observation in both S2T4 (Business) and S2T5 (Chemistry) lessons.

It is clear from looking at figure 6.4 that S2T4 (Business) used only teacher-directed instruction. The teacher wanted to have a fun class where the students were able to answer a Kahoot quiz which was actually revision for a test they had just previously performed poorly. However, between logging the students' in, directing them to Kahoot and registering onto the quiz, a sizeable amount of class time was used. Then once the students began working on the quiz, S2T4 (Business) read the questions and answers out loud for the group and would direct the students' through the quiz. Once the quiz was completed, S2T4 (Business) handed students' back their tests and explained the reason behind the quiz. In the next lesson, S2T4 (Business) decided to focus on developing their students' understanding of household budgets. To do this, the teacher developed an Excel template with formulas and functions which, when entered correctly, would derive the budget of the household. The teacher spent the majority of the lesson showing students' how to input the formulas and use the excel spreadsheet. Again, as was the case for S2T3 (TG), the two lessons developed by S2T4 (Business) focussed on imparting knowledge to the students', and in these two lessons, the teacher did not knowingly or unknowingly incorporate any student interactions.

S2T5 (Chemistry) wanted to use this opportunity to develop lessons where simulations were used as the main teaching tool. Using the topic of pH and acid and bases, S2T5 (Chemistry) developed two lessons in which the students used the pH Phet simulation. In the first lesson, the teacher spends the whole class preparing the students to use the simulation and to answer the questions which were asked of them, this includes drawing tables for comparison as well as walking the students' through how to use the simulation. Examining figure 6.5, it can be seen that S2T5 (Chemistry) accumulated over 50% of teacher-directed interactions, which occurred as a result of the teacher explaining in detail how to use the simulation, answer the questions they were asked and provided the students with two examples. After this, the students spent a short amount of time working on the task assigned to them which included counting the number of red and blue dots in a solution to determine whether it was acidic or basic.

Examining the charts of S2T3 (TG), T4 and T5 (figures 6.3-6.5) it became clear that these teachers' and their lessons focus heavily on teacher-directed instruction. In fact, none of these teachers' lessons achieved less than 70 per cent teacher-directed interactions, and in three of the six lessons 100 per cent of the lesson was dedicated to teacher led interactions. It should come as no surprise then that with such a high per cent of the lesson led by the teacher the main focus becomes about imparting knowledge. Even though students' were given the opportunity to engage in these lessons, it was in a very structured manner and often in short spaces of time that no real learning could have been achieved (Stallings, 1980). Another interesting observation comes from the management of discipline. In these lessons, the teachers were spending a notable amount of time correcting discipline issues. Whether this is in fact due to the teacher-directed nature of the lessons is unclear, however, Stallings (1980) found that in lessons where students were uninvolved or little to no gains were made, discipline issues became more prominent.

6.4.2 Student-Centred Lesson

The second theme derived from the observations was student-centred learning. In their paper "*Student-centred learning: the role and responsibility of the lecturer*", McCabe and O'Connor, (2014) identified the four fundamental features often associated with the student-centred approach, these were: independent knowledge construction, teachers' as facilitators, proactive management of learning experiences and active student responsibility for learning (pp. 351). As defined in chapter five, the codes used to categorise student-centred interactions were Student group work (Sgw) and Student individual work (Siw). These codes were used when students were given the opportunity to work independently, in groups or when the teacher assumed the role of a facilitator. Three of the teachers' in this study were identified as having student-centred lessons, these were: S2T1 (Geography), S2T2 (History) and S2T6 (Physics).

S2T1 (Geography) wanted to use this opportunity to develop their confidence in using technology in their lessons, as such they started with a task they would feel comfortable assigning to their students'. The task was to create a revision PowerPoint which could be used by students' in first year geography to help with their Christmas examinations. The first lesson had the teacher briefly introduce the task and then allow students' the time to create these PowerPoints, every so often the teacher would interrupt to remind students of the task as well as check on their progress. The second lesson wasn't a teaching lesson as such, instead it was dedicated to students' presenting their PowerPoints.

S2T2 (History) treated these lessons similarly to S2T1 (Geography), in so far as they had very little experience using technology in their teaching and desired to gain experience and confidence. Also, similarly, S2T2 (History) lessons focused on students' developing a revision PowerPoint. This time however, the students were given two topics to choose from and the purpose of the PowerPoint was for their revision rather than the revision of younger students'. S2T2 (History) dedicated both lessons to this task and both lessons followed a similar structure which can be seen in figure 6.2. The teacher briefly introduced the topic and the task before allowing students' the majority of the lesson to work in their groups. The teacher can be heard throughout the lesson giving pointers to each individual group and on occasion to the whole class but only once did this shift towards a teacher-directed interaction.

The final two lessons of this study, conducted by S2T6 focused on introducing students' to and developing their understanding of Moments in science and Argand diagrams and the Modulus in mathematics. Examining figure 6.6 we can see that in lesson one, which is the science lesson, that student interactions were the most prominent. The structure in this lesson had S2T6 (Physics) introduce the topic and ask students' whether they wanted to be shown how to use the simulation or play around themselves. Students' opted to figure it out themselves and this led to S2T6 (Physics) assuming the role of a facilitator and ensuring the students were able to attempt the task. There came a point where the teacher seemed concerned with the progress being made. As such, S2T6 (Physics) asked for those students' who were unable to grasp the task to come to the back of the room to receive more further instruction. The second lesson was conducted with a group of upper second level students' who had recently been introduced to imaginary numbers. In this lesson, S2T6 (Physics) wanted to use interactive tools make clear how their prior knowledge linked to the current topic. The teacher led the students' a lot more in this lesson but eventually could afford them the time to work independently. However, it should be noted that lesson two could be categorised as a teacher-directed lesson considering that nearly 60% of the lesson was spent in teacher-directed interactions.

A comparison of the classroom interactions can be found below in figure 6.7. When we examine the charts of S2T1 (Geography), S2T2 (History) and S2T6 (Physics) and compare them to those of S2T3 (TG),4 and 5 we can see major contrasting differences. In most cases the charts almost look flipped. With the exception of S2T6 (Physics) second lesson all lessons coded at student-centred accumulated more than 60 per cent of class time in student interactions. In contrast to those lessons conducted by S2T3 (TG),4 and 5 where the main focus was on imparting knowledge, four of these lessons, namely from S2T2 (History) and S2T3 (TG) focused on reapplying old knowledge to the creation of new materials. However, these charts could have looked very different if the teacher did not give the students' control over the creation of this content. S2T6 (Physics) lessons were similar to those of S2T5 (Chemistry) in that they both focused on developing students' understanding of new content, and while their goals and tools were nearly identical, the execution was drastically different. While in lesson one S2T6 (Physics) presented their students with the choice of tackling the simulation on their own or being shown step by step, S2T5 (Chemistry) did not provide them this choice and the outcome of these choices, or lack thereof were evident in the teachers' first lesson charts. Then, in lesson two, S2T6 (Physics) shifted into teacher-directed interactions and their chart clearly shows this.

These interaction charts have made evident that divide between teacher-directed and student-centred lessons. Observations have shown that in lessons which were more teacher-directed, discipline issues tend to be more frequent, compared to lessons of a student-centred nature. However, these charts provide no inclination as to whether the use of technology, and the activities involved were appropriate or of a high standard of teaching. For this, the teachers' levels of technology integration, and their integration of Blooms taxonomy were assessed.

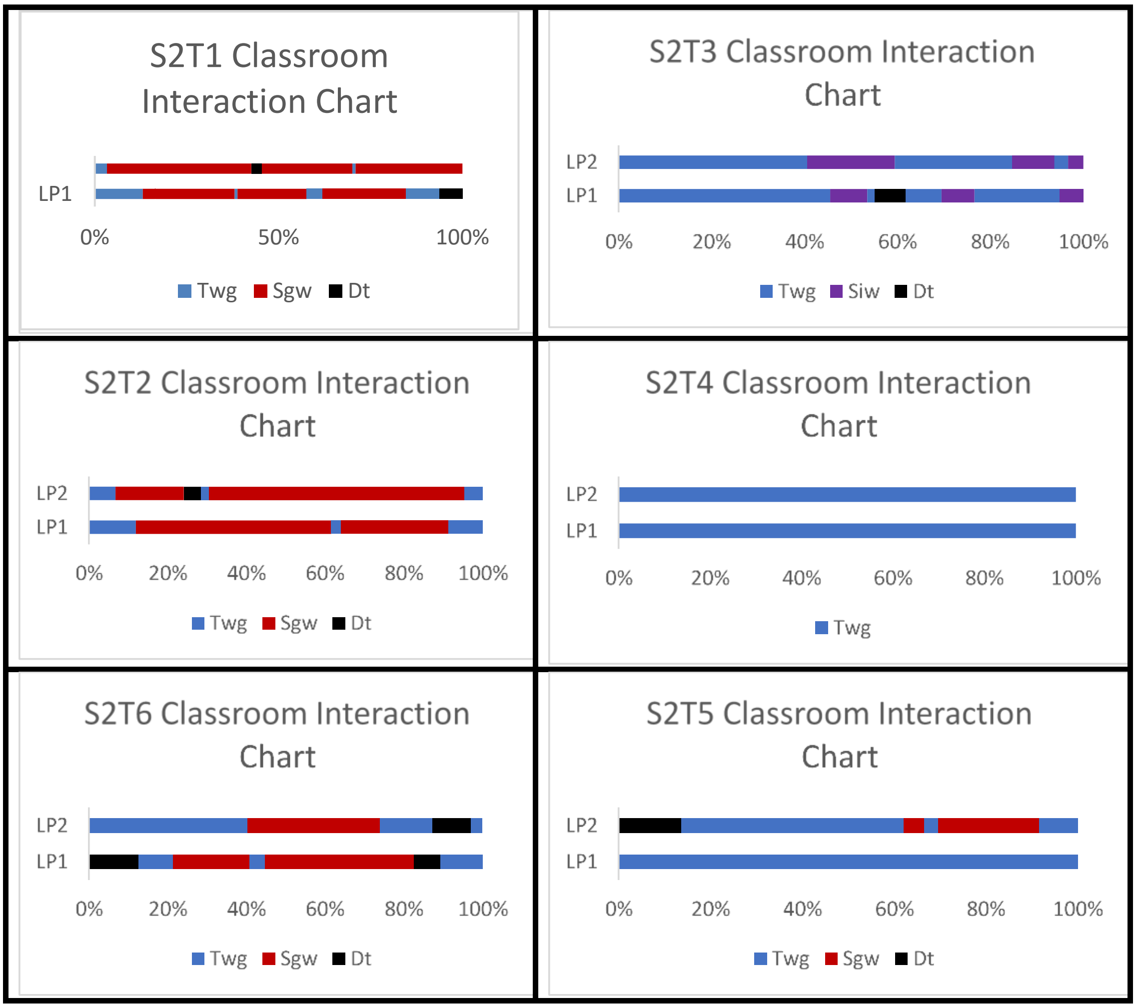


Figure 6.7 comparison table of each teacher's interaction chart

6.5 Technology Integration

In addition to coding the interactions present during teachers' classroom observations, their lessons were coded to determine the level of technology integration achieved as well as which tier of Blooms taxonomy is predominantly demonstrated in the activity, the results of which can be found in tables 6.1 – 6.3.

Table 6.1 presents the lowest level of technology integration achieved by teachers' during observations as well as the rating of Blooms Taxonomy demonstrated in their activities. The rating of "*replacement*" means the activities which contain technology could have easily been replaced with non-technological teaching tools or materials. Similar to the results found in chapter five, section 5.6.2, we can see that the teachers' whose lessons achieved replacement also demonstrated the lowest level of Blooms activities. Two of the four lessons presented in table 6.1 are clearly teacher directed technology activities, both of which were from S2T4 (Business). The activities in these lessons could have been replaced with paper-based versions or simple teacher instruction. For example, in the excel lesson, students never had the opportunity to engage with the excel sheet themselves, instead relying on the teacher's instructions. Therefore, the excel could have been replaced with a paper version where the teacher instructed the students' how to fill in the blanks. Both S2T6 (Physics) and S2T1 (Geography) had students' utilising the technology but in ways which were easily replicable with non-technological alternatives. For example, S2T1 (Geography) could have asked students to present a poster or S2T6 (Physics) could have drawn the graph for the students'. Therefore, we can identify that in these lessons, the use of technology did not promote higher learning and as such, can be easily replaceable.

Level of Integration	**Teacher and Lessons**	**Classroom Activity**	**Level of Bloom's**
replacement	S2T6 – Mathematics – LP2	Students' use an interactive tool to see the argand plot of imaginary numbers	Understand
replacement	S2T4 – Business studies – LP1	Teacher used Kahoot to assess students' knowledge	Remember
replacement	S2T4 – Business studies – LP2	Teacher used an excel template to develop students' understanding of household budgets	Remember
replacement	S2T1 – Geography - LP2	Students' presented their PowerPoints to the class	Remember

Table 6.1 Level of technology integration (replacement)

The second level of technology integration identified by Hughes (2005) is Amplification, which can be found in table 6.2 below. Unlike the lessons identified in table 6.1, those which were recorded as amplification cannot be easily replicated using non-technological teaching tools. Clearly, the majority of teachers' in this study achieved the rating of amplification and once again, there is a clear bias towards the middle to low levels of Blooms demonstrated by the teachers' in integration level. The lessons conducted by S2T3 (TG) were both coded as apply, while only one of S2T5 (Chemistry) lessons were also identified as apply. In S2T3 (TG) lessons, the students had the opportunity to utilise their knowledge of "*views*" in construction and transform these images into 3D drawings, something which isn't normally done with students' until their fifth year of post-primary education. S2T5 (Chemistry) also achieved a Blooms rating of apply due to the use of simulations allowing students to apply previous knowledge to the learning of new content. More specifically, students were asked to discover which items out of a range were acidic or basic and they had to rely on their previous knowledge of the pH scale to achieve this. It should be noted however, that the majority of this lesson was conducted by the teacher and not the students', but the rating achieved is for the small window of opportunity the students had to engage with the simulation. While discussing S2T5 (Chemistry), they also had another lesson of theirs coded in the amplification rating, lesson one. This lesson demonstrated an understanding level of Blooms namely due to the guided nature of the lessons. Students' were not presented with the opportunity to engage with the simulation and as such were asked simple recall and understand questions. The first lesson conducted by S2T1 (Geography) was coded as amplification, while both of S2T2 (History) lessons were also coded here. These three lessons can be discussed together as they were identical in nature. Both teachers tasked their students' with creating a revision PowerPoints which could be used either for themselves or for future first year students'. Both teachers placed a particular emphasis on researching the information online and finding reliable sources which were to be included in their PowerPoint. In these lessons students were summarising prior learning and provide a general understanding of the content, as such they were coded as understanding.

Level of Integration	Teacher and Lessons	Classroom Activity	Level of Bloom's
amplification	S2T3 – Technical Graphics – LP1	Students' learned how to use Solid Works to draw 3d diagrams and prepare design plans.	Apply
amplification	S2T3 – Technical Graphics – LP2	Students' learned how to use Solid Works to draw 3d diagrams and prepare design plans.	Apply
amplification	S2T5 – Science – LP2	Students' use simulation to determine if a solution is basic or acidic	Apply
amplification	S2T1 – Geography – LP1	Using PowerPoints to create revision documents	Understand
amplification	S2T2 – History – LP1	Students' used internet to develop a revision PowerPoint examining the life of two explorers.	Understand
amplification	S2T2 – History – LP2	Students' used internet to develop a revision PowerPoint examining the life of two explorers.	Understand
amplification	S2T5 – Science -LP1	Teacher shows students' how to use a simulation to view the pH of different acid and bases	Understand

Table 6.2 Level of technology integration (Amplification)

The third and final level of technology integration is Transformation, which can be found in table 6.3 below. Only one teacher in this particular study was coded as having attained a transformative lesson. For a lesson to be considered transformative, it should have some impact on students' learning routines including their cognitive processes (Pea, 1985). S2T6 (Physics) developed a lesson which not only introduced students to new content but challenged their way of thinking. The students were introduced to new ways of learning and it was observed that at least one group of students were able to verbalise the relationship between force and distance, which was the aim of the activity.

Level of Integration	Teacher and Lessons	Classroom Activity	Level of Bloom's
transformation	S2T6 – Science – LP1	Students' used simulation to determine the relationship between moments distance from fulcrum and the mass I.e. the moment of a force.	Evaluate

Table 6.3 Level of technology integration (Transformation)

Overall, similar results were observed from the group of teachers' in this study as were identified in the study conducted in chapter five. This provides further evidence that the majority of teachers achieved either amplification or replacement levels of technology integration, but also that the majority of their activities tend to focus on understand or remember domains of Blooms Taxonomy. The results also suggest that there might be some connection between the level of integration and the domain of Blooms taxonomy achieved.

6.6 TPACK Observations

The next phase of analysis consisted of completing the Technological Pedagogical Content Knowledge Observation Protocol (TPACK-OP) for each teacher. As previously discussed in chapter five section six (5.6), a modified version of Canbazoglu Bilici, Guzey and Yamak, (2016) TPACK-OP was implemented as the observation tool in this study. This observation tool contains five domains of TPACK which contain different key ratings on which teachers were scored. The domains can be found in a summary table at the end of this section (table 6.4) while the key ratings can be found in tables 6.4 – 6.8.

6.6.1 Orientation toward teaching with technology

The first domain of the TPACK-OP is teacher's orientation towards teaching with technology and it is one of two domains which contain only one item "*The teacher's goals and purposes of teaching the subject guide/frame the development and implementation of the lesson*". Table 6.4 shows that on average the teachers tended towards two with a mean score of 1.83. This indicates that the teachers did not provide the students' with engaging lessons, instead opting to focus more so on transmitting facts or developing students' process skills.

Item 1: The teacher's goals and purposes of teaching the subject guide/frame the development and implementation of the lesson.

	Criteria	TPACK-OP
0	Not Applicable	1
1	The lesson centres around transmitting the facts of the subject.	2
2	The lesson asks students to engage in activities to develop process skills.	7
3	The lesson provides opportunity for students to engage in "hands on" activities.	2
4	The lesson asks the students to define and investigate problems, do and/or design an "experiment", and present the data to others for debate, discussion, and/or evaluation.	0
	Mean ($\bar{x}$)	1.83

Table 6.4 Table of TPACK summary for Item one

6.6.2 Knowledge of Assessment

Table 6.5 contains the second domain in the TPACK-OP which focussed on assessment and incorporated items two and three. These examined the teachers' knowledge of assessment strategies and their implementation of assessment for students'. Examining item two, it is evident, at least during these observations, that teachers did not place an emphasis on assessment since six of the lessons were scored a not applicable. Two teachers' S2T4 (Business) and S2T6 (Physics) both scored a four in one of their lessons indicating that in these lessons all assessment methods were aligned with the learning objectives to evaluate the students' learning. On average the teachers scored a 1.5 highlighting that assessment wasn't a priority during the observations and when it was used, not all assessment methods were aligned with the learning objectives. Item three focusses more on the assessment items themselves, and in this area, teachers obtained an average of 1.08 indicating that teachers' either did not use assessment or focussed mainly on straightforward facts. In fact, five teachers' lessons did not include any student assessment while three lessons asked students to complete simple recall answers. Only one teacher achieved a score of a four which was S2T6 (Physics) in their first lesson. This was due to one group being able to verbalise their results and provide the teacher with the relationship between force and distance through experimentation.

Item 2: *Assessment methods aim to evaluate important dimensions.*

	Criteria	TPACK-OP
0	Not Applicable	6
1	All assessment methods aren't used to evaluate students' learning in a particular topic.	1
2	some assessment methods aren't aligned with learning objectives to evaluate students' learning in a particular topic.	0
3	all assessment methods are somewhat aligned with learning objectives to evaluate students' learning in a particular topic.	3
4	all assessment methods are aligned with learning objectives to evaluate students' learning in a particular topic.	2
	Mean ($\bar{x}$)	1.50

Item 3: Students' complete assessment that require them use critical, in-depth, higher order thinking, e.g., organize, interpret, evaluate, or synthesize complex information, and/or develop alternative solutions, strategies, perspectives or points of view.

	Criteria	TPACK-OP
0	Not Applicable	5
1	the assessment asked mostly for facts, straightforward answers.	3
2	the questions required application in a slightly different situation, one higher order thinking questions asked, mostly lower higher order thinking questions.	3
3	the questions involved synthesis and analysis and/or presented a new situation, two higher order thinking questions asked., mix of higher and lower order thinking questions (See lower half of Blooms)	0
4	the questions used evaluation and/or higher order thinking, three or more higher order thinking questions asked. (See higher half of blooms)	1
	Mean ($\bar{x}$)	1.08

Table 6.5 Table of TPACK summary for items two and three

6.6.3 Knowledge of students' understanding of subject specific knowledge

Table 6.6 contains the results obtained from the third domain of the TPACK-OP which is knowledge of students' understanding of subject specific knowledge. This domain also contains two items which focus on the teacher's awareness of their students' prior knowledge and their ability to utilise multiple modalities in their teaching. Teachers' tended to score much higher in item four indicating that these teachers were highly aware of their students' prior knowledge and are somewhat knowledge to overcome student's misconceptions. One reason teachers' may not be scoring a four in these lesson is due to their being no evidence of a teacher correcting a misconception. On average teachers scored a 3.25 with the majority of teachers' (n=7) scoring a three in item four. For item five however, the scores were noticeably lower, with teachers' scoring an average of 2.25. This indicates that teachers tend to use between two and three modalities per lesson, in fact, nine lessons were identified as having two or three modalities while three lessons were observed having four modalities. It is worth noting that no teacher was observed using more than four modalities just as no teacher was observed using only one modality.

Item 4: The teacher is aware of students' prior knowledge, learning difficulties and common alternative conceptions of the particular subject matter		
	Criteria	**TPACK-OP**
0	Not Applicable	1
1	the lesson is somewhat aligned with students' prior knowledge, alternative conceptions and learning difficulties but teacher isn't knowledgeable to overcome alternative conceptions and difficulties.	1
2	the lesson is somewhat aligned with students' prior knowledge, alternative conceptions and learning difficulties but teacher is somewhat knowledgeable to overcome alternative conceptions and difficulties.	3
3	the lesson is substantially aligned with students' prior knowledge, alternative conceptions and learning difficulties and teacher is somewhat knowledgeable to overcome alternative conceptions and difficulties.	7
4	the lesson is substantially aligned with students' prior knowledge, alternative conceptions and learning difficulties and teacher is knowledgeable to overcome alternative conceptions and difficulties	1
	Mean ($\bar{x}$)	3.25
Item 5: Using multiple modalities (e.g., kinesthetic/tactile, oral/verbal, written, numerical, graphic, pictorial, tabular) allows students to feel as though they and all of their peers (with different gender, ability, etc.) have had their needs met.		
	Criteria	**TPACK-OP**
0	Not Applicable	0
1	1 modality is used in the lesson presentation.	0
2	2 or 3 modalities are used in the lesson presentation.	9
3	the lesson is presented using 4 modalities.)	3
4	the lesson uses multiple modalities (more than 4) in an integrated way to achieve for students' understanding of the content	0
	Mean ($\bar{x}$)	2.25

Table 6.6 Table of TPACK summary for items four and five

6.6.4 Knowledge of instructional strategies

Item six, which is found in the fourth domain of the TPACK-OP disseminates the teachers' willingness to allow students' to be able to engage in various representations which can facilitate their learning, see figure 6.7 below. During these observations teachers tended to use a limited range of representations and activities which were somewhat appropriate to facilitating the students' learning ($\bar{x}$ = 2.17). Coupled with the knowledge that the teachers' generally use two or three modalities per lesson it can be determined that the teachers were repeating the same form of activities, for example using a whole lesson to talk students' through filling out an excel spreadsheet.

Item 6: The lesson allows students to engage in representations (e.g., illustrations, models, or analogies) and activities (e.g., problems, demonstrations, simulations) that can facilitate their learning in a specific topic.		
	Criteria	**TPACK-OP**
0	Not Applicable	1
1	The teacher uses a limited range of representations and activities that are not appropriate to the learning objectives of topic.	0
2	the teacher uses a limited range of representations and activities that are somewhat appropriate to facilitate students' learning in a specific topic	8
3	The teacher uses multiple representations OR activities that are appropriate to facilitate students' learning in a specific topic	2
4	The teacher uses multiple representations AND activities that are appropriate to facilitate students' learning in a specific topic	1
	Mean ($\bar{x}$)	2.17

Table 6.7 Table of TPACK summary for item six

6.6.5 Knowledge of curriculum and curriculum materials

The final TPACK-OP domain examines the teachers' knowledge of curriculum and curriculum materials which are contained in items seven and eight respectively, this can be found in table 6.8 below. Once again, the mean score in each of these items is quite low, ($\bar{x}$ = 2.33 and $\bar{x}$ = 1.67). For item seven this means that teachers did not give priority to linking the curriculum materials to broader curriculum goals or objectives which are relevant to their year group. However, S2T3 (TG) did teach the students' how to use Solid works which as they stated was not introduced to students until their fifth year of post-primary education. Item eight assesses the teachers' use of instructional materials for the general learning of the subject. Four of the teachers did not use any instructional materials in their lessons while only one teacher used instructional materials which were substantially aligned with the learning objectives of the topic. On average, teachers scored a 1.67 meaning the teachers tended to use materials which were either trivial or only somewhat aligned with the learning objectives of the topic.

Item 7: The teacher demonstrates an understanding of the goals and objectives for students' in a particular topic that they are teaching, and that is addressed in the national curriculum.		
	Criteria	**TPACK-OP**
0	Not Applicable	2
1	There might be some interesting facts, but they are trivial or inconsequential.	1
2	Main concepts are presented and somewhat aligned with the broader concepts of the curriculum goals and objectives at the grade level.	2
3	Main concepts are presented and substantially aligned with broader concepts of the curriculum goals and objectives at the grade level.	5
4	main concepts are presented and substantially aligned with broader concepts of the subject goals and objectives at higher grade levels	2
	Mean ($\bar{x}$)	2.33
Item 8: The instructional materials are relevant to teaching a particular domain of the subject matter and the general learning goals of the curriculum.		
	Criteria	**TPACK-OP**
0	Not Applicable	4
1	The teacher uses some materials, but they are trivial or inconsequential.	0
2	The teacher uses a limited range of materials and materials are somewhat aligned with learning objectives of topic.	5
3	The teacher uses a range of materials and materials are aligned with learning objectives of topic.	2
4	The teacher uses a range of materials which substantially aligned with learning objectives of topic.	1
	Mean ($\bar{x}$)	1.67

Table 6.8 Table of TPACK summary for items seven and eight

It is clear from the TPACK-OP that the majority of teachers' in this study displayed a very poor attainment of TPACK score below average in all of their means for each domain. A summative representation of this information can be found in table 6.9 below. In the next section, we will examine each teacher individually and present their own feedback which was obtained from the exit interviews.

	Components of TPACK	Orientation toward teaching with technology	Knowledge of Assessment		Knowledge of students' understanding of subject specific knowledge		Knowledge of instructional strategies	Knowledge of curriculum and curriculum materials	
		Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8
S2T1 (Geography)	LP1	2	0	0	2	3	2	0	0
	LP2	0	0	1	3	2	0	0	0
S2T2 (History)	LP1	2	0	0	4	2	2	3	0
	LP2	2	0	0	4	2	2	3	0
S2T3 (TG)	LP1	2	0	0	4	2	2	4	2
	LP2	2	0	0	4	2	2	4	2
S2T4 (Business)	LP1	1	4	1	3	3	2	1	3
	LP2	1	1	1	3	2	2	3	2
S2T5 (Chemistry)	LP1	2	3	2	4	2	3	2	2
	LP2	3	3	2	4	2	4	2	2
S2T6 (Physics)	LP1	3	4	4	0	2	2	3	4
	LP2	2	3	2	4	3	3	3	3

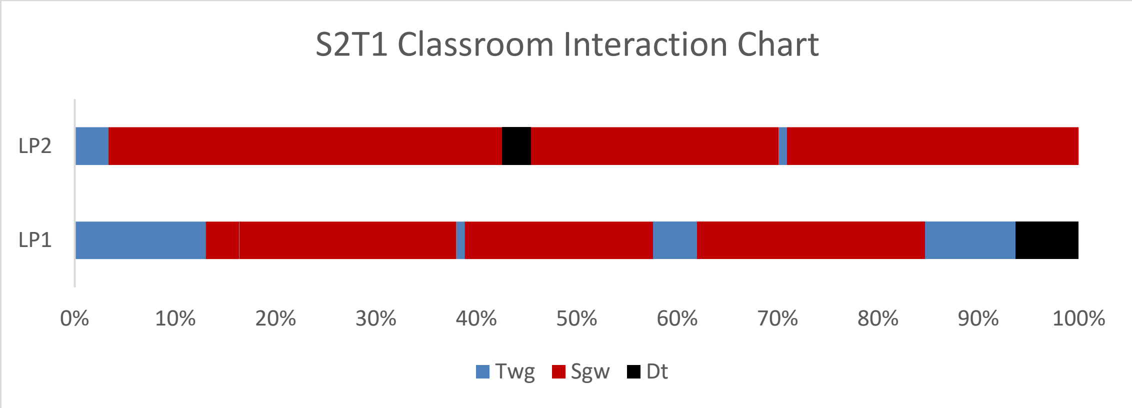
Table 6.9 Table of teachers' TPACK ratings from observations.

6.7 Teacher summaries

This section reports on the exit interviews from each of the six teachers'. In addition, a summary of each teacher will also be presented, and observations will be made with justification from the teachers' own words in the exit interviews. Each teacher was asked to provide a reflection at the end of each lesson, however, no teacher completed these reflections.

6.7.1 S2T1 – Geography

S2T1 (Geography) began this project, unsure of their ability to integrate technology into their teaching, beyond using PowerPoint to present to the class. For their two lessons, S2T1 (Geography) wanted the students to research and develop a PowerPoint, which could be used by younger students' as a revision tool. During the first lesson, students were given the devices and split into pairs to select a topic and research around it, populating their PowerPoint. In the second lesson, the teacher gave the students' the opportunity to present their work to their peers. We will now examine the individual data created from S2T1 (Geography). The below figure 6.1 shows S2T1 (Geography) classroom interaction chart for both lessons one and two. The first observation that can be made is the amount of student group work accumulated throughout the two lessons. In LP1, almost 70 per cent of the lesson was spent in students' centred interactions, while in LP2, over 90% of the lesson were coded as student interactions. In lesson one, the high proportion of student interactions can be attributed to the research assigned to the students by their teacher. While, in lesson two this is due to the students' presenting their PowerPoints to the class. Looking back at LP1 we can see a distinct pattern to S2T1 (Geography) lessons, firstly, they begin by introducing the task to the students', then allows the students' some time to work. The teacher then briefly interrupts the class to check on their progress before allowing them to work again. The teacher then checks up again a small while later, after which the students' resume their work, before finally, the teacher calls for attention to detail the homework and the plan for presenting these PowerPoints in next week's class. The second lesson focussed solely on students' presenting their work and as such no actual teaching took place from the teacher's perspective.



Repeat of figure 6.1. Classroom interaction for S2T1 (Geography) two lesson plans

The next piece of data to examine is the teachers' TPACK score from their observations, the data of which can be found above in table 6.9. It can be seen that S2T1 (Geography) scores quite poorly in TPACK, mostly due to the absence of a lot of the items. In fact, only items 1, 3, 4, 5 and 6 were scored, however, only items 4 and 5 have scores for both lessons. It may be easier to discuss lesson two first as the reasons for absence of TPACK items should be clearer. The majority of TPACK focusses on the teacher, their creation of the lesson, its environment etc. so because lesson two was dominated by student centred interactions, the majority of TPACK items had to be rated as N/a (0). However, in lesson two the teacher achieved their highest scores of both lessons in items four and five which were respecting students' prior knowledge and using multiple modalities. This shouldn't come as a surprise as the teacher has developed a lesson which afforded the students' an opportunity to demonstrate their prior knowledge. Back to lesson one, it is clear to see that the domains of assessment and curriculum and materials were both ranked as 0, meaning there was no evidence of these occurring during the observations. Otherwise, the teacher was ranked as average in items 1, 4 and 6, which were their orientations towards teaching, prior knowledge and engaging in multiple representations. This means that the lesson asked students to engage in activities to develop process skills i.e. research (item 1), where their prior knowledge was somewhat respected (item 4) and had the opportunity to engage in limited representations (item 6). From the TPACK scores, a TPACK displacement chart was created. This provides a visual representation of the teachers' attainment of TPACK during the two lessons.

Examining figure 6.8 we can see that S2T1 (Geography) has a very erratic displacement, due to the lack of attaining certain domains such as assessment and curriculum and materials. The chart would suggest that this teacher does not yet have the necessary ability to incorporate their usual teaching methodologies with technology, thereby ignoring important aspects such as assessment and development of curriculum materials. However, it should be noted that this takes place over two lessons and as such cannot be representative of the teacher as a whole. However, when asked how this lesson differed from their typical lessons the teacher responded with "*Not majorly*" other than the fact that the teacher had to take a step back and let the students' do all the work, so that was why "*I wasn't the focal point of those lessons*".

During their exit interview, it was clear S2T1 (Geography) did not benefit from this experience, however, they did notice a small change in their confidence in trying new technologies as well as their knowledge of teaching with technology, but identified a need to participate in a lot more professional development first:

"*I am still obviously very limited on my knowledge of technology, but I suppose what I did find, just from feedback from the boys… they were taking a little bit more of the driving seat themselves, being a little bit more autonomous with their learning… I would need a lot more in-services or something like that with regards to technology before I would be very confident in my approach to technology*"

Throughout the whole interview it became clear that the biggest obstacle to this teacher integrating technology more often was the practicality of bringing devices from classroom to classroom, because this teacher did not have their own assigned room.

"*My main problem with them is the fact that I am not based in a classroom so really it was taking up way too much time between getting the devices from... I would imagine if they had their own or if you were based in a classroom or if you could keep the devices then it would be a lot easier but for somebody like me who is moving around from class to class it is not practical in that sense at all. Because I was coming from one class, getting the devices at the beginning of class, getting them across the school. It is not a very big school, but still it was eating into about five minutes of the class*"

Interesting to note that time also features in the quote above, and how time is lost to the administration duties associated with technology. During the final few minutes of the interview, S2T1 (Geography) was asked a series of questions regarding their willingness to help their colleagues integrate technology into their lessons. S2T1 (Geography) felt they weren't the right person for this because they themselves lack the experience. The teacher has failed to realise that teachers would value the feedback of someone of a similar "*skill set*" as themselves. Realistic expectations would be set and eliminate the idea that only the best can integrate technology. After completing these lessons S2T1 (Geography) did learn that they could probably vary their own lessons a bit more, considering the students responded so positively to the change in routine.

"*So, I suppose that was the main thing, that maybe I should take more of a step back and let them do more work because it is them that should be doing the work rather than me doing everything for them a lot of the time. So, I suppose that was the main thing I have taken from it, that they need to do more and me less*"

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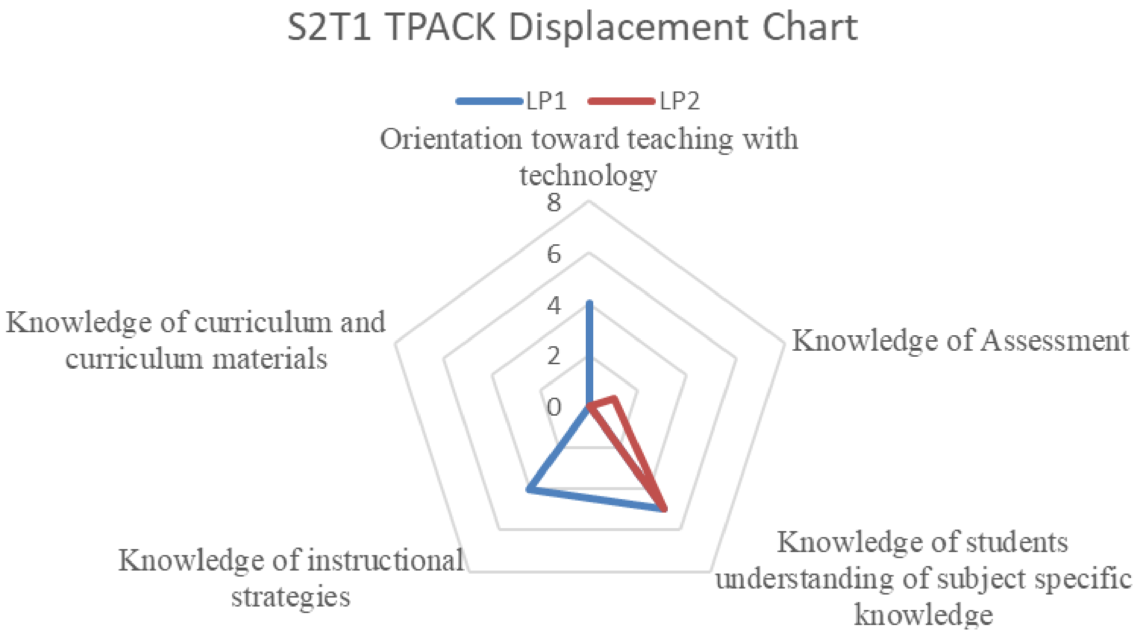


Figure 6.8 S2T1 TPACK displacement chart

The final section of the exit interview contained a list of Likert scale questions from the background survey used in School one. The responses to which can be found in table 6.10 below.

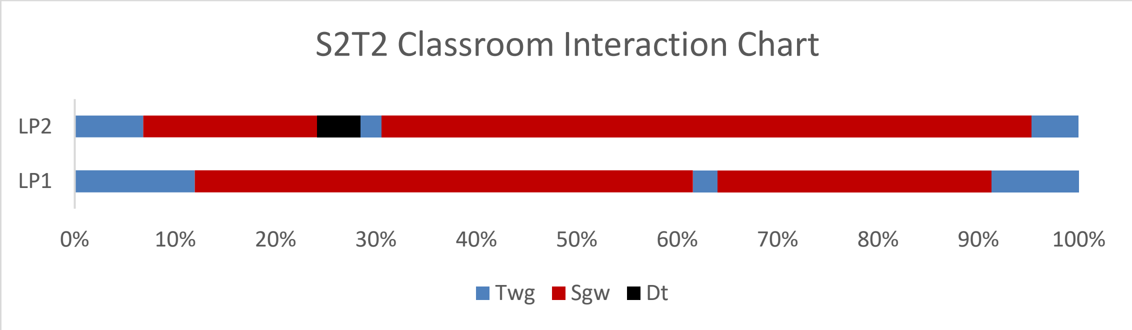
One of the few interesting answers here comes from questions seven through ten. Here we can see that S2T1 (Geography) is quite uncomfortable with appearing to lack content knowledge. They were uncomfortable with asking questions to which they do not know the answers themselves and when they cannot answer a question, it makes them feel inadequate as a teacher. This is somewhat evident in their teaching because in their exit interview, S2T1 (Geography) talks about giving up control of the lesson. They see themselves as the controller of information, information which will only be shared if they were confident and comfortable in being able to answer the question themselves. The teacher also stated that they did not feel comfortable manging a class where groups were doing different activities, which again, will impact on their willingness to integrate technology. But also, if the teacher lacks the confidence to accept not knowing an answer and is uncomfortable with students' working on different tasks, this may directly impact their technology integration.

Question	Teachers’ Response
Q1. I think the use of technology is appropriate to achieving the aims of the curriculum.	Agree
Q2. I think teaching with technology is only suitable for very capable students’?	Disagree
Q3. I think technology takes up too much time for me to implement.	Strongly Agree
Q4. I think technology and ICT skills are not needed in my teaching.	Disagree
Q5. If a student gives an unexpected answer I immediately tell the student, the right answer	Disagree
Q6. I am unsure how to ask students’ higher order questions that promote thinking.	Disagree
Q7. I find it difficult to manage a classroom where each student group is doing different activities.	Agree
Q8. If I don't know the answer to students’ questions I feel inadequate as a teacher.	Agree
Q9. I am uncomfortable with asking questions in my class where I am unsure of the answer myself.	Agree
Q10. I often show students’ the relevance of my subject in a broader context	Uncertain
Q11. I think a quiet classroom is generally needed for effective learning	Disagree

Table 6.10 Table of S2T1s responses to agree/disagree questions in exit interview

6.7.2 S2T2 – History

The next teacher to examine is S2T2 (History), the history teacher. S2T2 (History) had an identical integration plan to that of S2T1 (Geography). S2T2 (History) wanted the students to conduct research on a specific topic and develop a PowerPoint which they themselves could use for future revision. Unlike S2T1 (Geography), S2T2 (History) dedicated the two lessons to this research and did not record a lesson where students presented their work, during the observations, it was not hinted at that this would be a part of the task. Both of S2T2 (History) lesson unfolded nearly identically also, both accumulating roughly the same amount of student interactions. The lessons themselves started with the teacher introducing the class to the topic (LP1) before setting them the task and letting them begin. While the students were working away, the teacher became a facilitator and walked around the groups, checking their progress and offering tips and advice to those whom needed it. Then, once throughout the whole lesson, S2T2 (History) stops the class briefly to address the students’ and then allows them to continue their task again before finally calling the lesson to a close.



Repeat of figure 6.2. Classroom interaction for S2T2 (History) two lesson plans

Figure 6.9 displays S2T2 (History) displacement chart as detailed from their TPACK-OP results. It can be clearly seen that S2T2 (History) scored exactly the same in both of their lessons due to the replication of the lessons methods and pedagogy in both of the observations. It can be clearly seen that assessment is lacking in this teacher lessons as well as their use of curriculum materials, whether this is a reflection on S2T2 (History) attitude towards assessment is unknown. However, they did score well in the knowledge of students' understanding of subject specific knowledge, mostly due to the two fours obtained in item four.

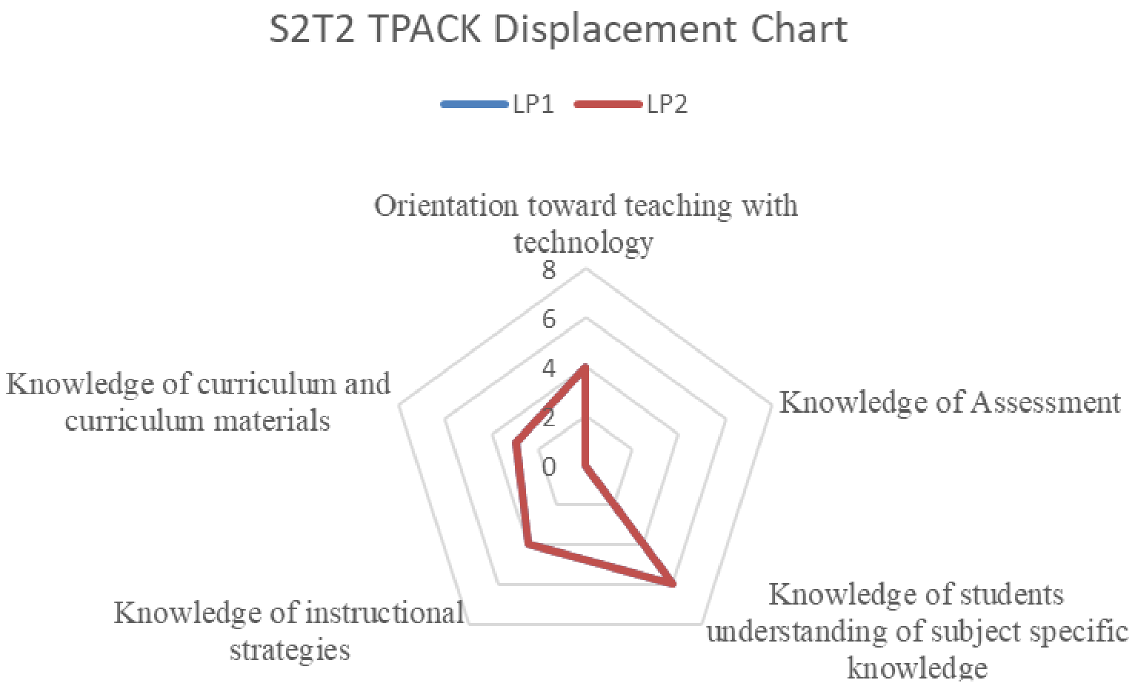


Figure 6.9 S2T2 TPACK displacement chart

Examining table 6.11 it can be seen that the teacher has a very negative attitude towards the use of technology in teaching as evident in their response to question one "*I think the use of technology is appropriate to achieving the aims of the curriculum*" where they responded with disagree. Further evidence of their attitude was found in the exit interview. When asked if they thought technology is a good thing for students of all levels S2T2 (History) answered:

"*It can be, but technology isn't the be all and end all. You can introduce a certain amount of technology but at the end of the day you still need to learn the information and no matter what* *amount of technology you use, unless they are going to sit down and learn the information they are not going to have it. I am very black and white on that. It is all well and good, you can have all them doing all this work with technology but at the end of the day they still have to sit down and do written exam at the end of it so if they are not willing to learn it*".

The above quote highlights that S2T2 (History) is clearly focused on the terminal examination and is reflecting on technologies ability to prepare students for this written examination. In their mind, technology is not need in their teaching and in fact, it takes "*Time and effort* (to integrate), *and too much of it*" (response to a question in exit interview).

Another point of interest comes from their response to being uncomfortable asking students' a question that they themselves do not know the answer to. In their response, S2T2 (History) indicated that they agree with the statement.

During the exit interview, it was observed that the teacher holds a utilitarian view of technology, i.e. technology is used for administration and task completion rather than for exploration. In a series of questions asking S2T2 (History) to talk about what technology demands of the teacher and the students', S2T2 (History) said that a lot of time and effort is need on behalf of the teacher. However, when asked about the student they responded with:

"*They don't have to set anything up*"

When probed further about what skills might be demanded from them S2T2 (History) stated:

"*They have all the skills anyway. You look at them using their phones… There is very little demand for students'. The students' can nearly tell you what to do*"

The first instance shows that the teacher thinks of demand not as cognitive, but rather physical, such as time and effort and when asked to think about the skills students' might require using technology, S2T2 (History) believes the students' already have the necessary skills.

S2T2 (History) did however believe that their use of technology did benefit some of the students' in their lessons, in particular, two students with Autism Spectrum Disorders. They noticed that "*there was not a lot of teaching involved*" once they briefed the students' on their task. However, they felt this made them "*vulnerable*" especially when their knowledge of troubleshooting is somewhat lacking. During this response, the teacher raised an interesting point:

"*So, I suppose you are a little bit vulnerable in that situation if you are not good at technology which me myself, I am not. So sometimes you have other students' saying, 'oh well if you do this, this and this.' And you are not going trying things that you are not sure will work because it could lead to more problems with the technology that you are using*".

The teacher was asked what they would do in a situation where they were asked to teach a subject or topic which they were not comfortable teaching. In their response, S2T2 (History) thinks the situations are somewhat different. They are open to different ways of teaching, but when it comes to using technology new issues are present such as what students' find on the internet. This might stem to a control or discipline issue, where the teacher wants to be able to dictate the direction of lesson and the knowledge and tasks students' can be engaged in.

Ending the exit interview S2T2 (History) indicated that they were no more motivated to use technology after participation in this study than before and felt that they did not learning anything more about teaching with technology. As a result of participating in this study, S2T2 (History) has become more sceptical of how they could use technology in their teaching, especially when they compare the amount of content they can cover without technology to how little was covered with technology.

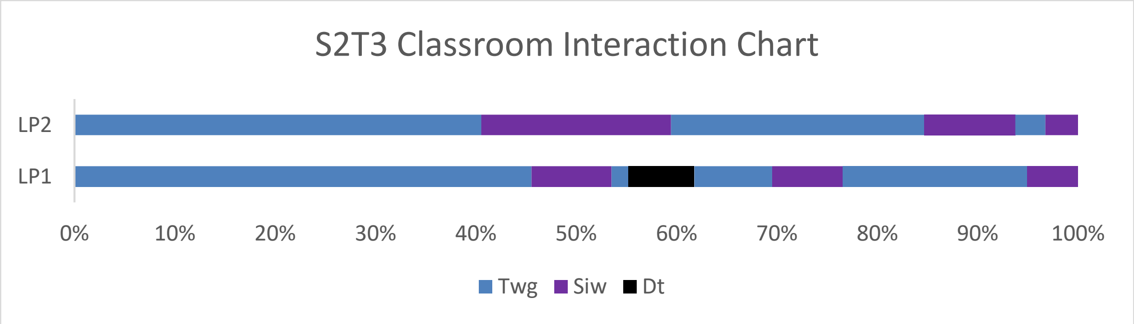
"*Yeah but I am still sceptical of how I can use technology in my lessons and at the same time get through the amount of work I need to get through, because not using technology I know exactly what I have to get through each term to get the whole course done. So, I am still a bit sceptical as to how to if I am using technology is that going to slow me down and then at the end I am left with a massive part of the course left to do and I won't get it done*".

Question	**Teachers' Response**
Q1. I think the use of technology is appropriate to achieving the aims of the curriculum.	Disagree
Q2. I think teaching with technology is only suitable for very capable students'?	Disagree
Q3. I think technology takes up too much time for me to implement.	Strongly Agree
Q4. I think technology and ICT skills are not needed in my teaching.	Agree
Q5. If a student gives an unexpected answer I immediately tell the student, the right answer	Disagree
Q6. I am unsure how to ask students' higher order questions that promote thinking.	Disagree
Q7. I find it difficult to manage a classroom where each student group is doing different activities.	Disagree
Q8. If I don't know the answer to students' questions I feel inadequate as a teacher.	Disagree
Q9. I am uncomfortable with asking questions in my class where I am unsure of the answer myself.	Agree
Q10. I often show students' the relevance of my subject in a broader context	Agree
Q11. I think a quiet classroom is generally needed for effective learning	Disagree

Table 6.11 Table of S2T2s responses to agree/disagree questions in exit interview

6.7.3 S2T3 – Technical Graphics

S2T3 (TG), the technical graphics teacher developed two lessons, conducted over three class periods, which were focused on introducing their students to Solid works, an advanced Computer Assisted Design (CAD) program which widely used in the construction industry. Examining their classroom interaction chart above we can see that the majority of the lesson was spent in teacher directed interactions with roughly 30 to 35 per cent of lessons one and two spent in student centred interactions. The high accumulation of teacher interactions can be attributed to the fact that S2T3 (TG) had to demonstrate to the students' how to use the software. The lessons consisted of the teacher talking students' through how to do certain tasks with the software before giving students' the chance to do copy what they had just been showed. During the student interactions, the teacher would help students' by telling them exactly what to do if they were stuck.



Repeat of figure 6.3. Classroom interaction for S2T3 (TG) two lesson plans

The TPACK displacement chart displayed in figure 6.10 shows that S2T3 (TG) shows good knowledge of the students' subject specific knowledge as well knowledge of curriculum and curriculum materials. They also scored average in the orientation towards teaching with technology and knowledge of instructional strategies domains. In S2T3 (TG) displacement chart we begin to see greater coverage of all the domains, however, assessment is still missing.

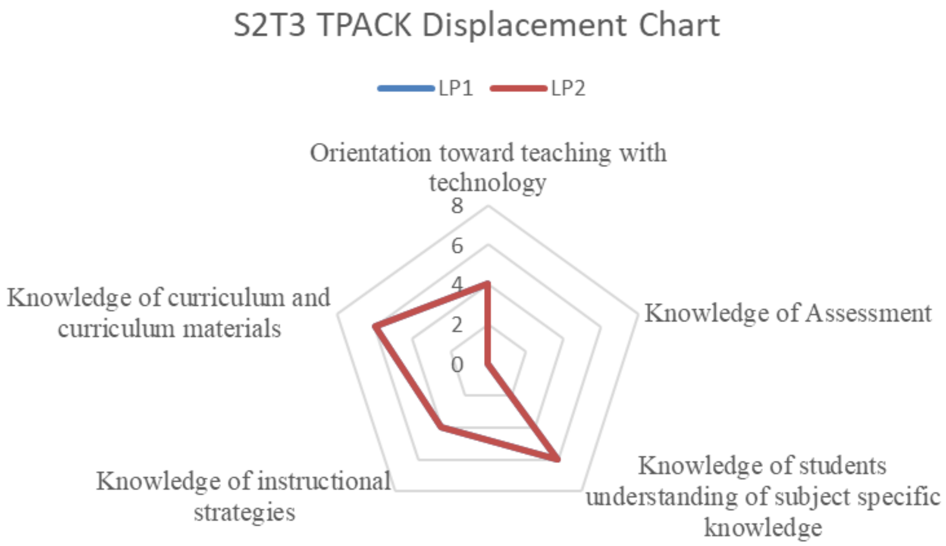


Figure 6.10 S2T3 TPACK displacement chart

During the exit interview, the results of which can be found in table 6.12 below, S2T3 (TG) was asked to rate how successful they believed the lessons to be. They rated them both at seven out of ten due to the exposure students gained to a piece of software which would make up to 40% of their final examination mark in their Leaving Certificate. Being a technology teacher, S2T3 (TG) was asked about their knowledge of professional development workshops in Ireland. S2T3 (TG) had recently attended one for their subject area. During the CPD the teachers were shown how to use a certain piece of software, enough so that they could teach themselves the rest of the software in their own time. The teacher continues by remarking at how the majority of CPD provided is basic, entry level tasks, such as using a certain software.

It was evident throughout the whole interview that S2T3 (TG) holds a very positive attitude towards technology and its role in teaching, for example, when asked if their knowledge of teaching with technology changed as a result of participating in this study they responded:

"*It has always been a part of my teaching and going forward I don't see that changing, I see it becoming a more prominent part of teaching and learning*"

More evidence can be found later in the interview when asked what they would like to do more or less of with respect to technology:

"*The obvious one is to try and get more machinery in, 3D printers, laser cutters. If you give them [students'] the skill set, going into third level some students' can already use the software in regard to 3D modelling and house builds and stuff like that. So, I would really like to direct the project stuff maybe towards that within construction studies.*"

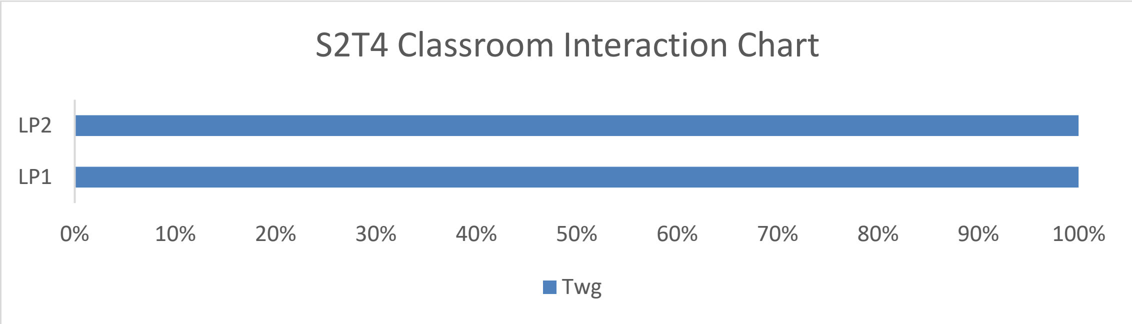
Question	Teachers' Response
Q1. I think the use of technology is appropriate to achieving the aims of the curriculum.	Agree
Q2. I think teaching with technology is only suitable for very capable students'?	Strongly Disagree
Q3. I think technology takes up too much time for me to implement.	Strongly Disagree
Q4. I think technology and ICT skills are not needed in my teaching.	Strongly Disagree
Q5. If a student gives an unexpected answer I immediately tell the student, the right answer	Disagree
Q6. I am unsure how to ask students' higher order questions that promote thinking.	Strongly Disagree
Q7. I find it difficult to manage a classroom where each student group is doing different activities.	Disagree
Q8. If I don't know the answer to students' questions I feel inadequate as a teacher.	Strongly Disagree
Q9. I am uncomfortable with asking questions in my class where I am unsure of the answer myself.	Strongly Disagree
Q10. I often show students' the relevance of my subject in a broader context	Strongly Agree
Q11. I think a quiet classroom is generally needed for effective learning	Uncertain *

Table 6.12 Table of S2T3s responses to agree/disagree questions in exit interview

S2T3 (TG) is the first teacher so far to state that they do not feel inadequate as a teacher if they don't know the answer to a question. An interest point here is that while both S2T1 (Geography) and S2T2 (History) were younger teachers' than S2T3 (TG), S2T3 (TG) is recently qualified and this may have some bearing on their "*appearance*" as a teacher to their students'. It can be seen that S2T3 (TG) strongly believes that technology skills are needed in their teaching and that using technology does not take up too much class time. The answers provided by S2T3 (TG) indicate that S2T3 (TG) holds more desirable beliefs and given that they have a more expanded TPACK displacement chart, this would seem to hold true.

6.7.4 S2T4 – Business Studies

S2T4 (Business), the business and technology teacher developed two business studies lessons to develop students' understanding of home budgets as well as recapping on the results of a difficult class test. It is immediately clear that S2T4 (Business) implemented two fully teacher directed lessons. During their first lesson the teacher wanted to introduce a fun way to recap on some important aspects of a previous class test in which the whole class performed poorly. To do this they developed a Kahoot quiz which is a student response clicker system using the tablets. There were serious teething issues while the teacher tried to get every student logged onto the Kahoot and eventually the teacher had to move forward with the quiz while some students still hadn't logged in. The teacher would read out each question and the possible answers so, the teacher was constantly speaking through the quiz. Then the teacher explained the reasoning behind the quiz which led to the closure of the lessons. The second lesson focussed on the household budgets and the teacher used an excel template to explain the budget to students'. For the whole lesson S2T4 (Business) walked the students' through what to do and how to do it within the excel.



Repeat of figure 6.4. Classroom interaction for S2T4 (Business) two lesson plans

Examining the TPACK displacement chart of S2T4 (Business), which can be found in figure 6.11, it can be seen that the teacher has a fuller coverage of the TPACK domains. However, the majority of their domains were below four which indicates less than average. Their best performing domains were knowledge of assessment and knowledge of students' understanding of subject specific knowledge. Their lowest performing domain was their orientations towards teaching with technology which examines their ability to utilise a variety of teaching methods when using technology. The chart indicates that S2T4 (Business) lessons focused around the transmission of facts rather than allowing students to engage in hands on activities which promote skill development or asking students to define and investigate problems. Not surprisingly, the TPACK-OP scores attained by S2T4 (Business) were quite low. However, S2T4 (Business) was the first teacher in this study to include assessment within their lesson. In lesson one, which was essentially one whole quiz, the students were assessed on their knowledge of a specific topic, however, the level of assessment which was implemented was quite low, in fact, the majority of the questions focused on recall knowledge. In lesson two, the assessment that was used by the teacher did not focus on assessing the learning objectives of the lesson or the topic. S2T4 (Business) did achieve higher scores in the items four, five, seven and eight. Items four and five were due to the teacher recapping on students' prior knowledge and using multiple modalities to present their lesson to the students'.

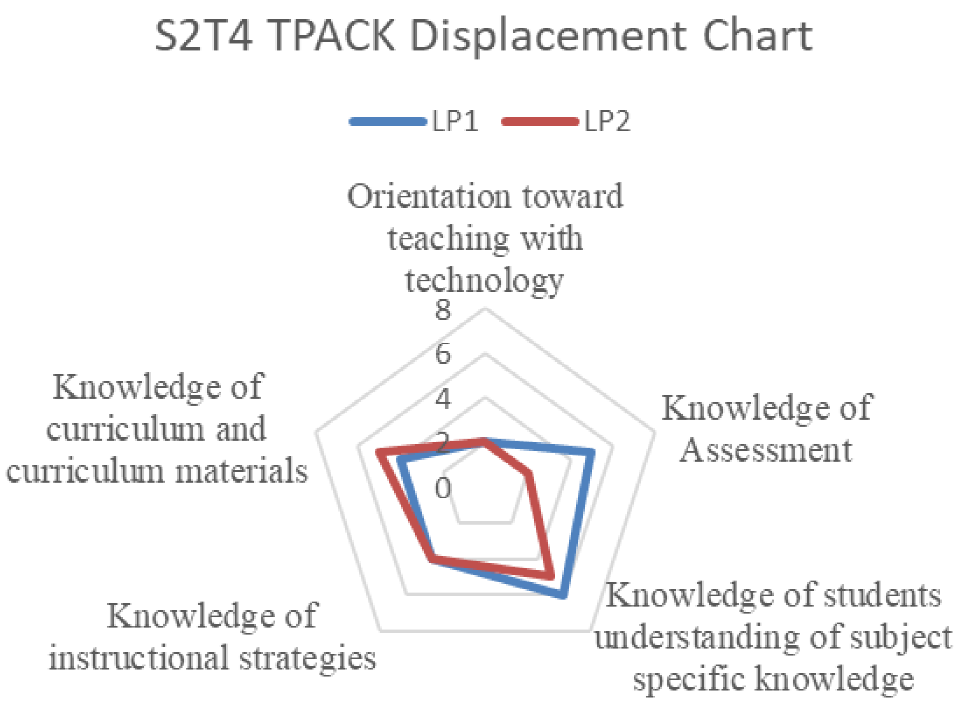


Figure 6.11 S2T4 TPACK displacement chart

Unfortunately, S2T4 (Business) was unavailable to participate in the exit interview and as such, it was not possible to justify the observations above with their own input.

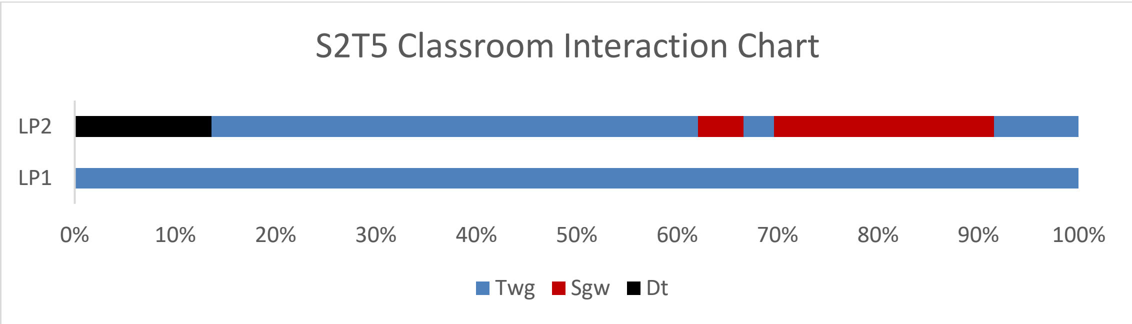
6.7.5 S2T5 – Science (Chemistry Major)

S2T5 (Chemistry) is one of two science teachers' in this project and was the coordinating teacher and point of contact with school two. In their two lessons, S2T5 (Chemistry) wanted to introduce students to the pH scale using simulations. Examining their classroom interaction chart, it can be seen that lesson one consisted of 100 per cent teacher directed instruction, while the second lesson had roughly 35 per cent of the lesson dedicated to student centred interactions. In lesson one, S2T5 (Chemistry) directed the students' through the process of opening the browser, finding the Phet simulations website, locating the simulation and running it. The teacher then began to walk students' through the task, answering their own questions and showing students' how to work the simulation to answer the questions. As a result, the students were passive for the duration of the lesson, listening and following the instructions provided to them by S2T5 (Chemistry). However, this was something S2T5 (Chemistry) had intentionally planned, by allowing the students to find the website themselves and going through the physical process of downloading the simulation the teacher was hoping the students would get curious and root around the website a little bit more. This did not happen, possibly due to the directed nature of the instructions, which could have placed blinkers on students', focussing them on finding that simulation and only that simulation.

"*I checked that I could go into the website, I could download the app because I wanted the students' do that for themselves. I felt it would be better for them that they download the app and it is not served up to them, that they get the idea of this is a specific website with simulations and* *stuff. And I was hoping that the odd one or two might get a bit curious and root around on the website and find other things. That didn't happen but if I tried this as an exercise again maybe then, go home, have a look at this.*"

In the second lesson students were given the opportunity to answer questions using the simulation. However, the majority of the lesson was still coded as teacher directed interactions. Yet, when asked what they felt their pedagogy in the two lessons were S2T5 (Chemistry) felt they conducted discovery learning, which is true for the student-centred interactions.

"*The first lesson was about them using the app, downloading and getting it set up and just seeing what was an acid or base and looking at the Ph levels. The sim did give you a Ph reading. The second time around I wanted them to look at the ions*"



Repeat of figure 6.5. Classroom interaction for S2T5 (Chemistry) two lesson plans

It can be seen from figure 6.12, S2T5 (Chemistry) was ranked as having all items observed during both of their lessons. All items were above a one with item four in both lessons achieving a score of four. This continues a trend so far that each teacher has displayed excellent awareness of their students' prior knowledge and demonstrates their ability to correct any misconceptions. The teacher also scored a four in lesson two for item six which is allowing students' the opportunity to engage in multiple representations, this was due to the teacher using simulations, documents, teacher talk and allowing the students to engage in an activity that appropriately facilities the students' learning of the content. While the TPACK-OP chart shows very little difference between the two lessons, it can be seen that in areas such as teaching orientation and representations there is a change, namely from two to three in item one and from three to four in item six.

S2T5 (Chemistry) displacement chart shows that their strongest domains were in their ability to utilise different teaching methods with technology and also their knowledge of instructional strategies. It can be seen that the same general shape is kept between both lessons, except for the change in domains one and four. S2T5 (Chemistry) was generally average in the domains with none of them marked as below average. However, it is clear that S2T5 (Chemistry) achieved higher scores in lesson two, partly due to the variation in their teaching methods and implementation of effective resources.

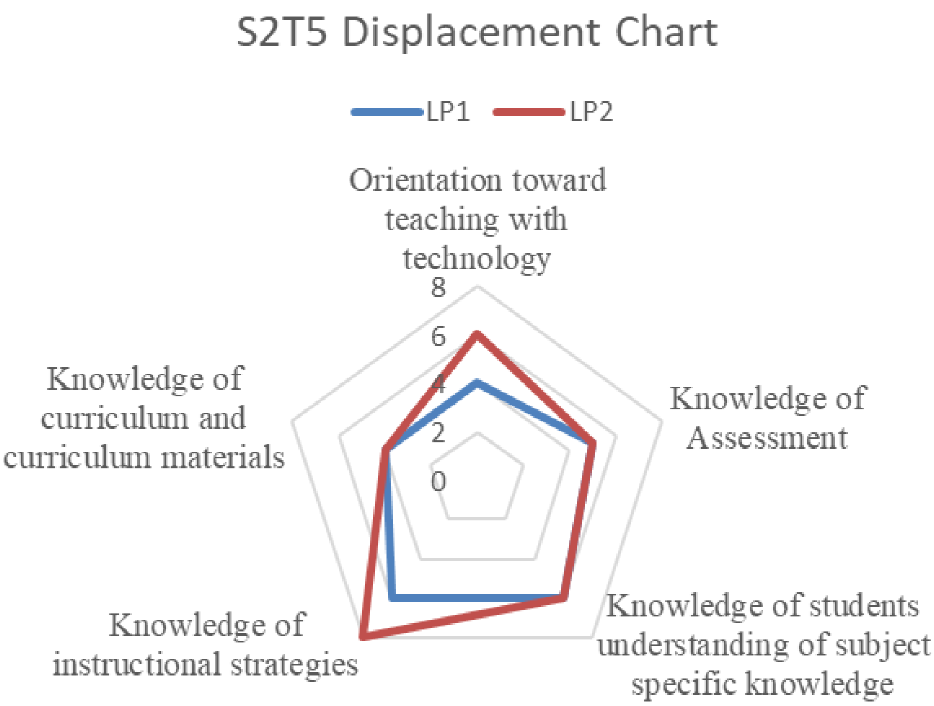


Figure 6.12 S2T5 TPACK displacement chart

Table 6.13 shows S2T5 (Chemistry) responses to the agree/disagree questions at the end of the exit interview. We can see here that S2T5 (Chemistry) is comfortable with not knowing the answer to a student's question while they were also confident in their ability to ask higher order questions and teach in a classroom where groups of students were performing different activities. One-point worth highlighting is their uncertain response to the question "*I think technology takes up too much time for me to implement*". Several times throughout the interview S2T5 (Chemistry) made reference to lacking time to adequately prepare for using technology in their teaching. They felt that with a full timetable, teaching multiple subjects and new administration hours, it was impossible to reflect and practice the class before the actual lesson.

"*...but I don't think I can emphasis strongly enough the length of time to reflect and practice for myself before class contact. I find that hugely debilitating when you are trying to introduce anything new or is technology based and not that reflective time, that time to talk to a colleague, oh I tried this last year. They tried something else and between the two of you come up with a third idea and you adapt it this way…I am not against the use of technology but more time and time that is controlled by me in terms of... We talk very often about independent learning and students' setting their own goals, well what I would like is specific time set aside that within that time period I can control what I need to do for me to be better in the classroom in terms of using IT or any other technique that might come along that I think is useful… So, to enable all of that, time, that would be the one resource almost more important than the hardware and the software, time. If you have time you can probably work around most issues*"

From the extract above it can be seen that S2T5 (Chemistry) places a particular emphasis on planning and reflection both before and after a lesson. They feel that the current structure of second level education does not allow a teacher the time to adequality reflect on their practice. Earlier in the interview this point was made more clearly, S2T5 (Chemistry) was asked if they thought the integration of technology into their lessons was beneficial and their response stated that they:

"*…didn't have enough time to think it through and you can say that about any innovation you introduce into a lesson, if you don't have enough time you are not fully sure if it has been useful or it takes a while or a little bit of reflection. But I would say it is beneficial once I am not introducing it for the technology's sake and once it is addressing an issue.*"

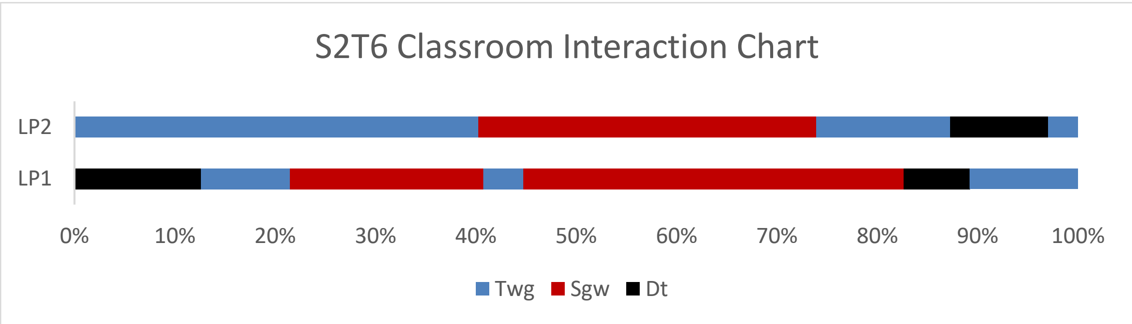
S2T5 (Chemistry) touches upon another important factor in their quote above, the appropriate use of technology. The extract shows that S2T5 (Chemistry) is aware that the introduction of technology "*for the technologies sake*" will not benefit the teacher or the student. Instead the integration should be meaningful and serve a purpose. In the case of S2T5 (Chemistry), the purpose of integration was to "*introduce[e] the basic idea of the hydronium scale*".

Question	**Teachers' Response**
Q1. I think the use of technology is appropriate to achieving the aims of the curriculum.	Agree
Q2. I think teaching with technology is only suitable for very capable students'?	Strongly Disagree
Q3. I think technology takes up too much time for me to implement.	Uncertain
Q4. I think technology and ICT skills are not needed in my teaching.	Strongly Disagree
Q5. If a student gives an unexpected answer I immediately tell the student, the right answer	Strongly Disagree
Q6. I am unsure how to ask students' higher order questions that promote thinking.	Disagree
Q7. I find it difficult to manage a classroom where each student group is doing different activities.	Disagree
Q8. If I don't know the answer to students' questions I feel inadequate as a teacher.	Strongly Disagree
Q9. I am uncomfortable with asking questions in my class where I am unsure of the answer myself.	Strongly Disagree
Q10. I often show students' the relevance of my subject in a broader context	Strongly Agree
Q11. I think a quiet classroom is generally needed for effective learning	Uncertain

Table 6.13 Table of S2T5s responses to agree/disagree questions in exit interview

6.7.6 S2T6 – Science (Physics Major)

The final teacher in this study was S2T6 (Physics), whom was the second of the science teachers'. S2T6 (Physics) conducted two different lessons with two completely different groups of students'. The first lesson, conducted with first year science students introduced students to the moment of a force and force balancing. While the second lesson was conducted with fifth year mathematics students' covering the topic of imaginary numbers and argand plots. Examining their classroom interaction chart above it can be seen that in lesson one nearly 60% of the lesson was spent in students' centred interactions while in lesson two this reduces to 35%. This reflects the nature of the lessons, recall from our detailed look at each lesson early in this chapter that lesson one was exploratory in nature, allowing the students' ample amount of time to work in groups on their devices. While in lesson two, the teacher was heavily mediating and guiding the learning. This may also reflect the teachers' attitude towards how they approach teaching mathematics versus science. However, as they explained in their exit interview, both sets of classes were required to complete similar activities, i.e. use the tablet devices to complete a worksheet, so perhaps this may not just reflect the differences between this teacher's attitude towards teaching science and mathematics, but the pedagogical differences between the subjects in general.



Repeat of figure 6.6. Classroom interaction for S2T6 (Physics) two lesson plans

In their displacement chart there were two distinct shapes, as though it were two different teachers' being observed. It can be observed from figure 6.13 that overall S2T6 (Physics) has achieve average to above average ratings in each of the domains with their lowest performing domains being orientation towards teaching with technology and knowledge of instructional strategies. Interestingly, during the exit interview it came to light that S2T6 (Physics) had previous experience teaching with technology in previous schools. During their time in these schools the technology was mostly used for research purposes and this was their first time to use simulations, especially in the format they presented their lesson.

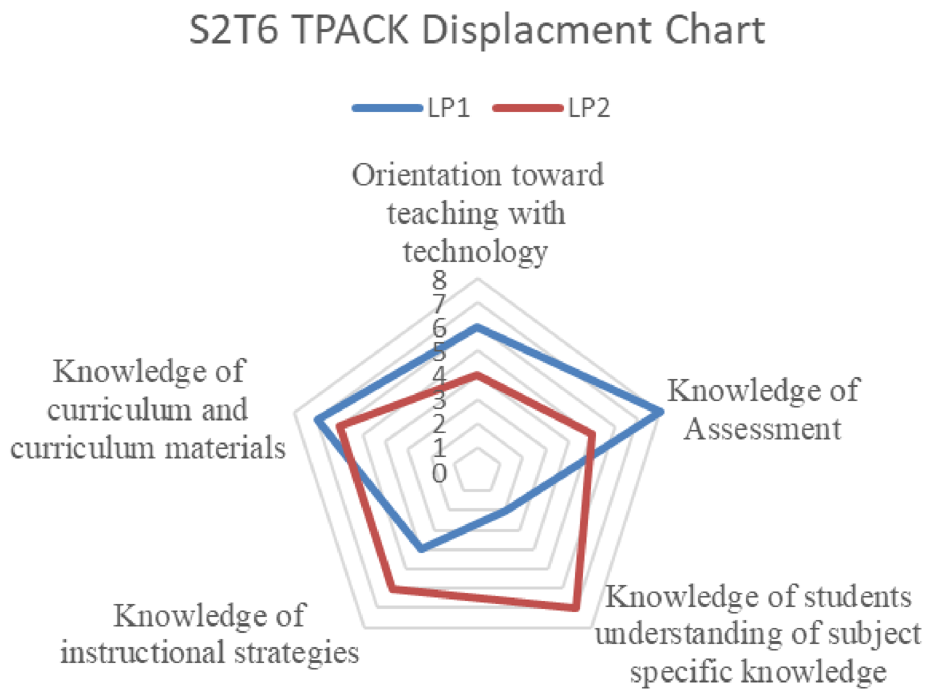


Figure 6.13 S2T6 TPACK displacement chart

An interesting response during the exit interview came when S2T6 (Physics) was asked about how they would typically use technology in their daily teaching.

"*I suppose my use of technology is the projector, that is terrible but that is my use of technology. There is a couple of data loggers up there that, again from 2003, but they are okay, they are manageable. And again, it is part of sitting down and trying to... Because the software is so clunky, and again I am giving out here, I would kind of use that, but I don't really use technology other than applets up on the screen*."

The teacher was then asked if all of these uses were teacher directed to which they responded:

"*it is all teacher directed, all of it*"

This is interesting not only because S2T6 (Physics) had one of the highest TPACK-OP scores, but also because later in the interview when asked the agree/disagree questions, S2T6 (Physics) stated they were in fact uncomfortable with not knowing the answer to a student's question in certain scenarios

Interestingly, when asked to rate their lessons on a scale of one to ten, S2T6 (Physics) rated lesson two higher than lesson one. Even though, from the observations, it looked as if students' in lesson one not only enjoyed the lesson more but appeared to be more engaged with the content.

"*I would say the 1st year one, that particular lesson was about a 7[out of 10], it had the potential to be a 9, definitely….The 7 was my, I suppose because it was the first time that I had done it there were some questions that I would change around and there was some material that I would have covered before I would have done the lesson that I didn't realise until I would doing the lesson* *actually they would have benefitted from having a class of doing the calculations separately and then, because they were trying to take on too much. So that was why it was a 7 and not a 9. The maths one, I would probably put that as an 8 because they were prepared. I kind of had that at the back of my mind from the first lesson so they were prepared, and it was stuff they were familiar with, so I felt they got a lot more out of it*"

We can see here though that S2T6 (Physics) is critical of the questions and material they designed for the students' and this is why they marked down the lesson. Learning from these mistakes, S2T6 (Physics) was able to better prepare for the second lesson and as a result felt the students got more out of the lesson.

In their responses to the agree/disagree section of the exit interview we can see that in questions five and eight there is an asterisk. These responses can be found in table 6.14 below. Firstly, looking at question five, S2T6 (Physics) offered this response

"*I would agree but I know that is completely wrong, but it is an instinct. I would strongly disagree with the sentiment but personally that is what I tend to do*"

The above response shows two things, firstly, S2T6 (Physics) is quite honest in their responses and secondly, even though S2T6 (Physics) believes the "*right*" answer is to disagree with the statement, they recognise that they themselves instinctively tell the student the right answer straight away. They even go so far as to say the strongly disagree with the sentiment, but unfortunately, it is something they do in their teaching.

When asked question eight initially S2T6 (Physics) responded with strongly agree, it was only after question nine was asked that they revisited question eight.

"*I would disagree. Actually, my previous answer I would just say disagree because it is something that as I have gone on in teaching and depends on what I am teaching. For instance, with physics now, because I have been teaching it for eleven years now, if the students ask me a question I am perfectly happy with being able to say, I don't know that. Whereas I was doing science last year and a student asked me a question I didn't know I was sweating because I didn't know whether that was something I should know or whether it was obscure enough that I am not going to look like an eejit if I say... Whereas I know in physics if I don't know if it is okay and with science and stuff like that*".

We can see in their response that the answer to question eight is conditional on the subject they were teaching. If a student asks the teacher a question in physics, the teacher is okay with not knowing the answer, whereas if it is in science, they immediately feel uncomfortable. Initially, this response was somewhat unclear, however, upon further reading it became clear that the teacher was basing this condition on their content knowledge. The teacher is clearly confident in their content knowledge when it comes to physics, so if a student asks a question they do not know the answer to, it is because it is something the teacher "*shouldn't need to*" know because it is probably "*obscure*", i.e. it is not on the exam. Whereas with science, it was a new topic to this teacher, so they have not had the years of experience developing their content knowledge, and as such, if they don't know the answer the teacher cannot figure out if it is something they "*should*" know or if it is just an irrelevant question with respect to the content and exam. We can also see S2T6 (Physics) discussing how this might make him "*look like an eejeit*", bringing in elements of their own ego or perhaps their image to the student, and how this might be important to the teacher. Perhaps this might go some way to explaining other teachers agreed with question eight.

Question	**Teachers' Response**
Q1. I think the use of technology is appropriate to achieving the aims of the curriculum.	Agree
Q2. I think teaching with technology is only suitable for very capable students'?	Strongly Disagree
Q3. I think technology takes up too much time for me to implement.	Uncertain
Q4. I think technology and ICT skills are not needed in my teaching.	Strongly Disagree
Q5. If a student gives an unexpected answer I immediately tell the student, the right answer	Agree *
Q6. I am unsure how to ask students' higher order questions that promote thinking.	Disagree
Q7. I find it difficult to manage a classroom where each student group is doing different activities.	Disagree
Q8. If I don't know the answer to students' questions I feel inadequate as a teacher.	Strongly Agree/disagree*
Q9. I am uncomfortable with asking questions in my class where I am unsure of the answer myself.	Disagree
Q10. I often show students' the relevance of my subject in a broader context	Strongly Agree
Q11. I think a quiet classroom is generally needed for effective learning	Disagree

Table 6.14 Table of S2T6s responses to agree/disagree questions in exit interview

6.8 Discussion

This section will discuss the results from this case study and present them thematically. Also, throughout this section, evidence collected from the exit interview with the principal of school two will be provided.

In this study, it was clear that the teachers were not at a highly integrated stage of technology, using mostly replacement and amplification techniques while incorporating mostly teacher directed lessons. Multiple factors played a role in the low level of integration observed within these lessons. Firstly, teachers required more professional development in order to develop appropriate technology integration strategies as well as develop their confidence in using technology. Secondly, while the majority of barriers to integration were removed, the teachers believed having a dedicated IT specialist within the school would increase their success of integration. Thirdly, time played a key role in limiting the integration of technology within these teachers' lessons. A full teaching timetable, with additional administration hours were identified as two main issues that teachers' face often distracting from any time teachers would normally use to plan future lessons.

In this discussion, I will refer to the research questions outlined in chapter three, these were:

1. How do in-service teachers with minimal experience of technology integration, use technology in their classroom practice?
2. What support do in-service teachers' need in order to improve their technology integration in classroom practice?

6.8.1 Technology Integration

Research question one asked how does a teacher, with little to no previous experience with technology integration, implement technology enabled lessons? To answer this question, we will need to examine the results from the interactions, integration and the TPACK-OP.

From the observations, it was evident that teachers' overall level of technology integration was low. Teachers' mainly developed lessons which were teacher-directed, involved replacement or amplification integration strategies and teachers often displayed low levels of pedagogical knowledge.

6.8.2 Classroom Interactions

Similarly, to how classroom interactions were measured in case study one, interactions in this case study were also measured superficially, in so far as no quantities or judgements were made on the quality of the interaction, only on the specific type of interaction. A graphic comparing all the school two teachers' can be found in figure 6.14.

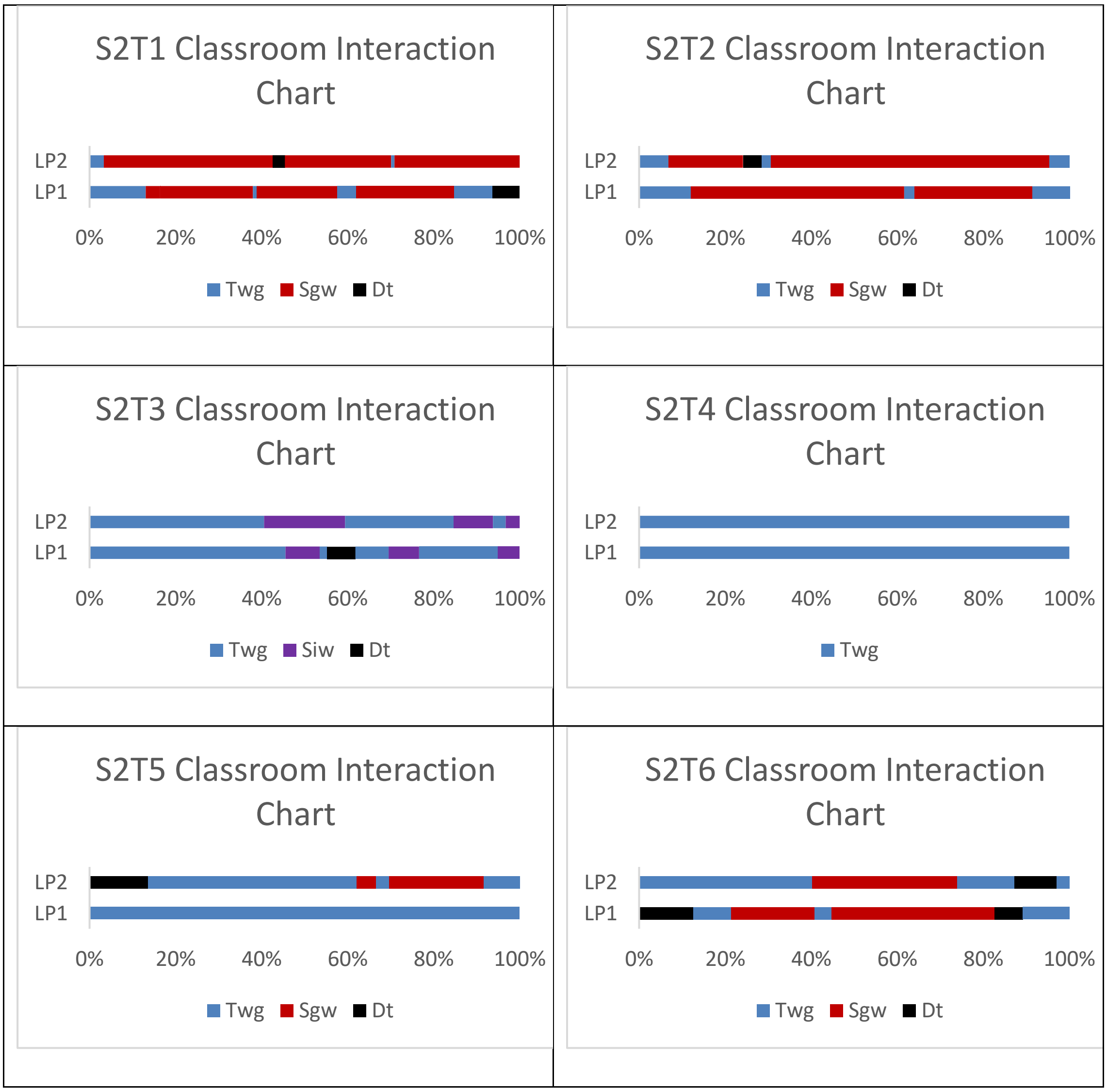


Figure 6.14 Graphic displaying the classroom interactions of all school two teachers'

From the comparison table, it can be seen that five out of the six teachers included some form of student centred interactions (SCIs). These interactions were important because a high quality of teacher and student interaction is fundamental to understanding student engagement (Puanta *et al.*, 2012). Lessons which focussed on the creation of an artefact or the curation of content accumulated the highest proportion of student centred interactions. These lessons were conducted by S2T1 (Geography) and S2T2 (History). Lessons which asked students to complete a set of predefined tasks had the second highest accumulation of SCIs, as seen in both lessons conducted by S2T3 (TG) and S2T6 (Physics) as well as lesson two by S2T5 (Chemistry). Conversely, the lessons in which the teacher dictated the pace, content and general running of the lesson saw the lowest accumulation of SCIs as can be seen in both of S2T4 (Business) lessons. This divide showcases the type main types of learning, active learning and traditional learning (Prince, 2004). Research has robustly shown that students' whom participate in active learning strategies tend to perform better than their colleagues in traditional lecture style classrooms (Freeman *et al.*, 2014).

In their meta-analysis on undergraduate STEM students', Freeman *et al.*, (2012) found that students' were one and a half time more likely to fail in traditional lectures than those in active learning classrooms, this can be attributed to the superficial learning which takes place during lecture style teaching methods which fail to stimulate students' enthusiasm, motivation or confidence (Augustine, 2005). It is encouraging to see that the majority of teachers' in this study do employ some form of student centred interactions and active learning techniques, however, teachers' three, five and six, still accumulated high proportions of teacher directed interactions. These interactions tended to focus on providing the students with direct instructions on how to use the device or tool or complete the task. This would indicate that these teachers were still somewhat uncomfortable with relinquishing complete control of the learning to their students'.

6.8.3 Level of technology integration

While the classroom interaction provides some details into the generally structure of the lesson and interactions contained within it does not show the quality of the teaching materials and teaching methods employed. For this, the technology integration chart was used which incorporated Blooms Taxonomy to differentiate, as best as possible, between all the teaching materials and teaching strategies employed. The results in this study showed that the majority of lessons observed were in the amplification phase of technology integration, with one lesson was observed as transformative and four were coded as replacement. These strategies are often not beneficially to the students' learning, especially in the case of replacement and amplification as these tasks often just replace typical teaching tools or allow the teacher to accomplish tasks more efficiently without altering the task itself (Hew and Brush, 2007). During the analysis of the results it was observed that lessons which had a tendency to focus on replacement or amplification strategies, tended to utilise the lower levels of Blooms taxonomy. While this is a novel method of technology integration assessment, some research has been conducted on using Blooms as a labelling tool (Valckle *et al.*, 2009). The research also supports the idea that the lower levels of technology integration do not benefit the student (Mundy and Kupczynski, 2013).

6.8.4 Technological Pedagogical Content Knowledge

Two domains of pedagogical knowledge were measured in this study, Technological Pedagogical Knowledge (TPK) and Pedagogical Knowledge (PK), these were measured via observations using the TPACK-OP. In the TPACK-OP several of the key ratings of indicators can be used to make observations on the specific teachers' PK namely, items one, five and six. To determine technology pedagogical knowledge, the same items were used however, when technology is observed the item now also covers TPK as well as PK. Table 6.15 below highlights the results obtained in these pedagogical domain indicators.

	Components of TPACK	Orientation toward teaching with technology	Knowledge of students' understanding of subject specific knowledge	Knowledge of instructional strategies
		Item 1	Item 5	Item 6
S2T1 (Geography)	LP1	2	3	2
	LP2	0	2	0
S2T2 (History)	LP1	2	2	2
	LP2	2	2	2
S2T3 (TG)	LP1	2	2	2
	LP2	2	2	2
S2T4 (Business)	LP1	1	3	2
	LP2	1	2	2
S2T5 (Chemistry)	LP1	2	2	3
	LP2	3	2	4
S2T6 (Physics)	LP1	3	2	2
	LP2	2	3	3
X(bar)		2	2.25	2.36

Table 6.15 Table containing the summary TPACK scores of all school two teachers' in each lesson

In general, the teachers' displayed average PK and TPK which indicates that the teachers' were developing lessons which focused on developing processing skills, utilised a narrow variation of stimulus and employed a limited range of instructional strategies (Canbazoglu Bilici, Guzey and Yamak, 2016). A potential reason for the average scores obtained by the teachers could lie in the professional development services provided to teachers at second level education. The teachers' in this study often highlighted the need for more professional development with respect to using technology in their area of expertise. Some of the teachers communicated that the current professional development programmes available to in-service teachers' is either at a very low standard or not applicable to their subject area. Han, Eom and Shin (2013) argued that the lack of professional development associated with technology, integration strategies and content specific training is the most cited barrier to integration, a finding which this study supports.

6.8.5 Barriers to technology integration

The second research question asks what support teachers' need in order to improve their technology integration. To answer this, we need to examine the barriers to their integration for clues. Several barriers were identified by teachers throughout the interview questions namely: 1) professional development, 2) access to and management of hardware, 3) time and 4) in school support structures. These categories were derived from the exit interviews and were emergent themes in the data. A summary of teachers' responses can be found in figure 6.15 below.

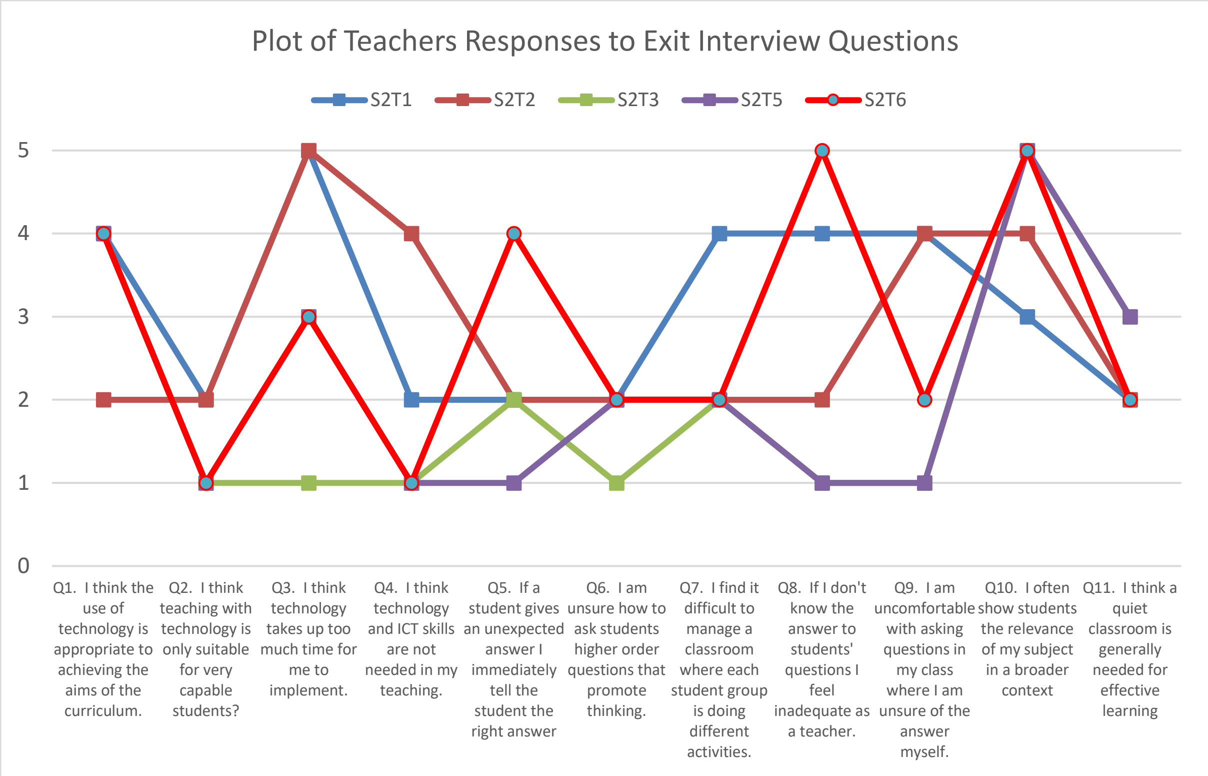


Figure 6.15 Summary of teachers' responses to the exit interview Likert questions

Figure 6.16 below shows the mind map generated from NVivo showing the connections created from the data presented below and the coding and themes created.

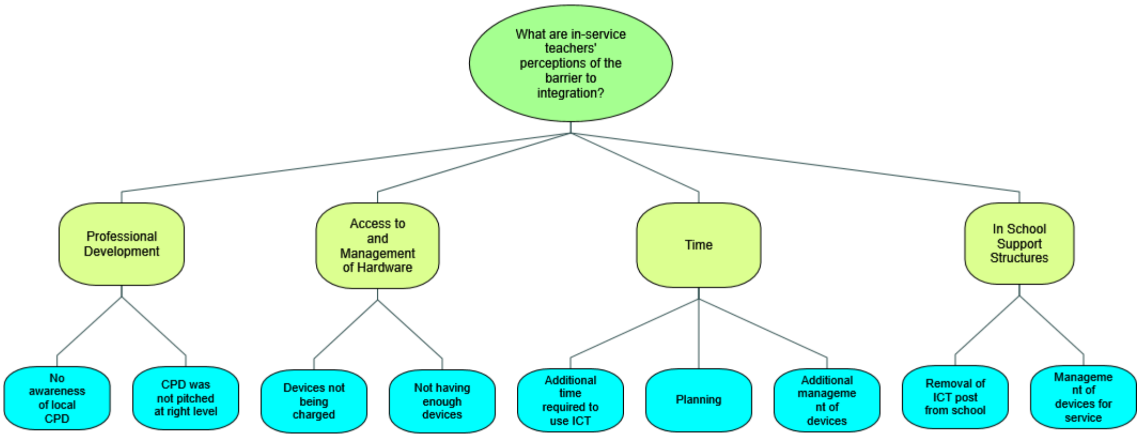


Figure 6.16 NVivo Mind Map showing the connections from data to codes to themes.

1) Professional Development

The first and major barrier identified by every single teacher was professional development. Firstly, when asked what professional development is available to each teacher there were two main responses: either, the teacher provided a response alluding to their lack of knowledge surrounding what is actually available to them in their local and national education centres or they formed very negative opinions on the professional development that is currently available. For example, S2T1 (Geography) and S2T2 (History) were unaware of the professional development on offer to them:

"*It would be very vague any knowledge that I would have to be honest with you, it is something that I probably should look into a bit more but haven't really delved very far into it*." S2T1 (Geography)

"*I wouldn't have a clue*" S2T2 (History)

While S2T3 (TG),5 and 6 all expressed negative views on the professional development offered to them:

"*they expect you to go and learn this stuff outside in your own time. It takes probably four times the amount of time it should take if you were getting some quality tuition on it. PDST does have other stuff up there on their website in regards to IT. Not being disrespectful, some of it is entry model stuff, how to open up a Word document, and I understand there is older people in the school systems, but at the same time if they want us to use technology to its full potential they really need to give us some quality professional development…*" S2T3 (TG)

"*now the problem with a variety of apps is every different in-service you go to will give you their favourite app. I would love the PDST or whoever to agree that there are maybe half a dozen apps and those half a dozen apps show how each one can work with different subject areas. It was a problem before when we got the last big investment in IT, each different in-service was showing teachers' different video software. So, then it took ages for us in the school to actually go, just use this one. Well I have done this. No, just use this one. So that is a practical problem in schools the in-service people aren't thinking of…*" S2T5 (Chemistry)

"*My only knowledge is the in-services and to be honest my faith in in-services is pretty poor because they are pitched at entry level as opposed to people who actually have a bit of knowledge about computers. Now again I am making a very broad judgement on that from my own experience of in-services before, but any in-services where they have mentioned ICT it is like, wow look here is a computer and here is a screen and look at these pictures on the wall. It is really basic stuff. So that is all I am aware of.*" S2T6 (Physics)

It is clear to see that there are two views being held within these teachers' and neither of them were positive. As stated in the previous section, Han, Eom, & Shin, (2013) argued that professional development is now the single biggest perceived barrier teachers' face when integrating technology into their teaching. In addition, it can be seen from S2T3 (TG), S2T5 (Chemistry) and S2T6 (Physics) that when the professional development lacks the connection to actual classroom practice or tends to focus on developing basic technical skills it becomes negatively associated as a barrier (K. Bradshaw, 2002; Hinson, LaPrairie and Heroman, 2006; Mouza, 2009)

2) Access to and Management of Hardware

The second most commonly identified perceived barrier to integration was access and availability of hardware. For this case study, the teachers were provided with 15 tablet devices, the school itself has a classroom set of laptops but it appears to be rarely used. Three of the teachers', S2T3 (TG), T5 and T6 all cited access to hardware and management of the hardware as one of their major barriers to integration. Each of the three teachers' described how firstly, not having enough devices was hindering their ability to effectively integrate the technology but secondly, how over the course of the year issues such as devices not being charged, backup of the devices and other management issues come into effect and how these issues might negatively impact their ability to integrate technology (Ertmer, 1999; Clark, 2006).

3) Time

The next perceived barrier identified by this cohort of teachers was time. Teachers' cited time as a likely barrier to their future integration attempts. Time in this respect was classified as additional time required as a result of using technology. This could be in the form of additional time planning, correcting misbehaviours, troubleshooting or implementing the devices in the lessons (Bauer and Kenton, 2005; Clark, 2006). Two teachers' cited time as the main barrier to their future integration attempts. Time lost to the delivery of the devices to students' or opening of documents etc were cited as time losses which would negatively impact the progress of the lessons. When asked about their thoughts on teachers' citing time spent planning materials for technology enabled lessons being a barrier, the principal of school two had this to say:

"*The maximum hours that teachers' would have would be 22 hours. We wouldn't have many teachers on that full timetable, 33 periods, that being said the week is... There is time out of class, they have inherently time out of class anyway, which is supposed to be there for preparation. So, I wouldn't fully listen to that argument because there is a tendency here [unclear 00:28:20] that people haven't got the time, that they leave the building. I did give middle management people, year heads, time off 18 hours and they found they weren't here in the building, that it was the culture in voluntary secondary schools when you finished teaching your classes you go home. So, I am not sure I could listen to that argument. One the one hand looking for more time but when they have the time they leave the building. It depends on the individual, you find that some people stay well above the time as well, to 5:00 or 6:00 but that is inherently their personality. You will find the time with the 22 hours if you are interested in it, if not you won't.*" - Principal of school two.

It is clear that the principal believes the argument of time is not a valid argument, at least from their perspective. However, research has shown that teachers' still perceive time as a barrier (Clark, 2006; Ertmer *et al.*, 2012). While other research has also highlighted the influence management has on teachers' effective integration of technology (Palak and Walls, 2009; Ottenbreit-Leftwich *et al.*, 2010).

4) In School Support Structures

The final barrier identified by two teachers' and the principal revolved around the removal of the ICT coordinator post in schools. Other teachers also allude to the lack of in school support as potentially hindering their integration but only minorly. From the teacher perspective issues surrounding having the appropriate devices and cables, maintaining them and servicing them were all cited as issues which the teachers' themselves felt they would not be able to solve and require the assistance of an ICT coordinator. Meanwhile, the principal believes that for integration to be successful an ICT coordinator is required. The school is contracts an external contractor to resolve any ICT issues the school may have, issues which the principal believes could be resolved if an ICT coordinator were available within their school.

6.8.6 Summary

The purpose of this study was to build upon the findings uncovered in case study one and examine whether the same opportunities and challenges were found in school two and to further test the research questions. The findings indicate that teachers were not equipped both pedagogically or physically (in terms of hardware) to deal with the challenges integrating technology presents. In their observations, they often rely on basic teaching strategies when integrating technology, often utilising very teacher directed methods in student centred variations.

The findings also indicate that the teachers required significant professional development to enhance their pedagogical knowledge, technological knowledge and technological pedagogical knowledge. While teachers were willing to participate in the development of technology enabled lessons, their perception surrounding their own personal barrier to integration discourage them from future attempts at integration. It is clear from this cohort of teachers' that in order to improve their levels of technology integration, focused and sustained professional development should be provided (Choudhary and Bhardwaj, 2011; Comiskey, McLoughlin and Finlayson, 2015; Blackwell, Lauricella and Wartella, 2016). This professional development should focus on developing subject specific pedagogical strategies for integrating technology into teaching (Galligan *et al.*, 2010) and not focus solely on developing technical skills either with a specific device or piece of software (Kopcha, 2012).

Chapter 7 Case Study Three: Pre-service Teachers'

7.1 Introduction

The studies conducted in chapters five and six of this thesis examined and discussed the practices adopted by in-service teachers' in two post-primary schools who were integrating technology into their teaching particularly, in ways which they had not before. One outcome from these studies suggested that in order to increase in-service teachers' TPACK, more should be done in initial teacher training, a finding which has also been suggested in the literature for example Tran *et al.*, (2014). This chapter details the development and implementation of a second-year undergraduate teaching with technology module with pre-service teachers' over 10 weeks. Firstly, this chapter begins with a short examination of the relevant literature and sets out the context in Ireland for the development of this module. Secondly, the methodology for the study is described and the rationale and teaching themes were discussed in detail while presenting the learning objectives from the module. Finally, the assessment of student artefacts as well as data collection methods utilised in this study will be presented.

7.2 Study rational and methods

7.2.1 Theoretical basis and research questions

The results from case studies one and two showed that teachers' felt the required more professional development – at an appropriate level, in order to develop their technology integration. Findings which have been mirrored in historical and recent literature (Ertmer, 1999; Kopcha, 2012; Wang, 2017). However, as discussed in both case studies one and two, teachers' face significant time pressures and therefore developing professional development would prove difficult. Instead, recent literature has identified initial teacher training as a key career development point whereby researchers may influence their technology integration (Chai *et al.*, 2010).

It was already argued in Chapter two of this thesis as to why teachers should integrate technology into their teaching. Pre-service teachers' (PSTs) are no different, and in this regard and have the benefit of undertaking specific ICT Courses designed to teach them effective implementation strategies for the integration of technology (Tondeur, Van Braak, *et al.*, 2012). However, there is a clear disparity between what pre-service teachers are taught and what they exhibit in real life classroom (Ottenbreit-Leftwich *et al.*, 2010). This raised two questions which were examined in this literature review: what challenges are faced by researchers when attempting to develop a course deigned to improve pre-service teachers' technology integration. Secondly, what should a technology integration module for pre-service teachers comprise of to reduce this disparity.

Due to advances in technology and recent investment of ICT in second level schools (Department of Education and Skills, 2017), familiarisation and engagement with technology has become a vital component of pre-service teachers' education (Goktas *et al*., 2008).

Reviews of ICT use in science education has found that, ICT has been beneficial in making science more relevant, authentic and interesting (Dawson, 2008). Dawson (2008) also indicated that the use of ICT in science teaching can increase communication and collaboration, while allowing more time for observations, discussions and analyses. An earlier review of the literature conducted by Osborne & Hennessy (2007) found that there are several benefits for the students of a science classroom due to the integration of ICT. These include, increased exposure to visualisation, ease of which data can be obtained and manipulated, enhanced motivation and increased development of students' critical thinking skills. How is it then, that even with evidence highlighting the potential benefits to both students' and teachers, newly qualified teachers are often cited as not integrating technology more appropriately into their lessons? (Tondeur, van Braak, *et al.*, 2012). Perhaps, as Tondeur, van Braak *et al.*, (2012) stated it was because newly qualified teachers' do not feel prepared upon completion of their degree to integrate technology. Research has also strongly linked pre-service teachers' perceptions of how their education programme promoted the integration of technology to their usage of technology later in their careers (Tondeur, van Braak, *et al.*, 2012; Franklin, 2005; Sandholtz & Reilly, 2004)

In several studies, newly qualified and in-service teachers' have cited issues which inhibit their ability to integrate technology appropriately, namely: access to hardware, lack of time for planning and implementation and lack of sufficient technological knowledge and skills (Comiskey *et al.*, 2015; Teo *et al.*, 2009; Dawson, 2008; Wepner *et al.*, 2003). While access to hardware is still an issue in Ireland, internationally it is also a somewhat prominent barrier. In her study, Dawson (2008) surveyed 33 early career teachers', those with less than three years' experience. Asking what factors influenced the teachers' decision to use ICT in their lesson, it was found that just over a quarter of teachers' (27%) surveyed felt that access to hardware was a negatively influencing factor. While over half (52%) of the teachers' responded that their workload was also a negative influence on their decision to integrate ICT. One of the major findings of this study found that while teachers rated their beliefs and values about ICT as a major positive influence (79%), the actual use of ICT was generally of low quality and favoured word, email, internet and PowerPoint usage, which were the main tools taught in their teacher education degrees. Interestingly however, Kirschner & Selinger (2003) found that even if all of these barriers are removed, it is still not enough to adequately prepare pre-service teachers for technology integration in their careers.

One of the first steps made to improving pre-service teachers' integration of technology was by Schrum (1999). In their paper, three critical components were identified. These were: 1) exposure to various technologies, tools and applications in a skill-based setting whereby specific skill were taught to the pre-service teachers' 2) pre-service teachers should experience how specific technologies can be integrated into their chosen subject area with tailored methodologies 3) pre-service teachers should be in a technology rich environment where appropriate pedagogical support so they may receive guidance on their technology enabled lesson planning. Since then, the literature has consistently shown that in order for teachers' to effectively integrate technology into their teaching they must possess a good understanding of how technology, pedagogy and content knowledge are interrelated (Hughes, 2005; Canbazoglu Bilici *et al.,* 2016). However, initial teacher training institutes typically approach ICT modules in a one-off course, showcasing strategies which can be used with ICT in the classroom (Kleiner *et al.*, 2006). Unfortunately, these pre-service teachers often complete their degrees feeling under prepared to integrate technology (Sang *et al.,* 2010). Traditionally, assessment of these courses typically followed a self-reflective practice, recalling on the pre-service teachers' perceptions of the course and its content. Some of these failings can be attributed to a lack of a distinct framework through which technology integration could be modelled. Recently however, the development of the TPACK framework by Mishra and Koehler (2006) has provided the most comprehensive explanation of ICT integration. With this framework, initial teacher training institutes may now be able to better prepare their pre-service teachers for ICT integration than they have in the past.

One such study utilised the TPACK framework as a means of determining pre-service teachers' technology integration. The study conducted by Buss *et al.*, (2018) examined the effectiveness of a technology infused curricula on the development of pre-service teachers' technology integration. In their study, the researchers co-developed two technology infused curricula. These curricula placed an emphasis on the use of multiple forms of technology to develop the pre-service teachers' technology integration. Data collected from the 91 4^{th} year (mean age 21.63 years) pre-service teachers included a 53-item survey on the various TPACK knowledge domains and focus group transcripts. Analysis of the qualitative data was done through the constant comparative method (Glaser *et al.*, 1965). The results of their study showed that the use of a technology-infused approach to pre-service teachers' courses was effective in developing their TPACK and technology integration.

The literature above shows there has been success in developing pre-service teachers' technology integration during their initial teacher training. Furthermore, recent work has shown that modules that infuse technology throughout have been effective in developing pre-service teachers' TPACK and technology integration. Therefore, the development of a technology infused module for pre-service teachers was appropriate to addressing the concerns of the in-service teachers' in case studies one and two. Therefore, the purpose of this study; case study three, was two-fold:

1. How do pre-service teachers with no technology integration experience, use technology in their classroom practice?

2. What support do pre-service teachers' need in order to improve their technology integration in classroom practice?

7.2.2 Methods: NorthStar, Interactions, TPACK

To answer the research questions set above in section 7.2.1 several data collection tools were deployed. While the majority of the data collection methods were identical to those in case studies one and two, there were some minor changes.

The first change was the inclusion of the NorthStar digital literacy assessment. The NorthStar project started as a direct result of the world-wide recession in 2008 (Northstar Digital Literacy Project, 2017). Founded by a group of librarians and other stakeholders from the St. Paul Community Literacy Consortium, they developed a community-based process in order to determine how to quantify and assess digital literacy. After several meetings and revisions, a standard was developed, which was used to apply for funding to bring their standard to an online assessment platform. Since 2011 the NorthStar Digital literacy assessment tool has been used by over 2 million users (Northstar Digital Literacy Project, 2018). The NorthStar digital literacy assessment is an online tool for evaluating eight aspects of technology literacy. These were:

1. Basic Computer Skills
2. Internet Basics
3. Windows
4. Email
5. Word
6. Social Media
7. Excel
8. PowerPoint

Each assessment consisted of a varying number of questions, however, each user experienced the same amount of questions in the same order. At the end of each test, the students were presented with the results which were downloaded and placed into a word document. This document was then sent on to the researcher in charge of the module. The scores were inputted into excel and means were calculated for each.

As discussed in chapters three, five and six, classroom interactions were captured by generating timestamps during each observation based on changes to teacher-student interactions. Similarly, the observations were conducted in a similar fashion as those carried out in case studies one and two with a few differences. Firstly, the participants in this study were pre-service teachers with no classroom experience. Secondly, since observations were conducted during class time, the length of the observations were capped to ensure all students could be observed during the one lesson. Finally, the pre-service teachers conducted their lessons in a team teaching scenario, this further alleviated the time constraints placed on the observations.

The final data collection method was an exit interview which asked questions similar to those in case studies one and two but were adapted to suit the context in which they were asked. These interviews were also transcribed verbatim and coded using thematic analysis as described by (Braun and Clarke, 2008)

7.3 Participants

The study discussed in this chapter involves the development, implementation and analysis of an undergraduate module focussing on the development of pre-service teachers' 'technological pedagogical knowledge (TPK), technological knowledge (TK) and technological content knowledge (TCK) through the technology infusion method (Wepner, Ziomek and Tao, 2003; Buss *et al.*, 2018). The module in which this study took place was undertaken by a second-year cohort of students' in the undergraduate Science Education Programme, a Bachelor of Science Degree with concurrent teacher training elements. Eleven pre-service teachers were enrolled in the Teaching with Technology module and ten of these students volunteered to participate in this study. Before the beginning of this module, the pre-service teachers had no formal ICT training and tended to have had limited experiences with Word, PowerPoint, Simulations and Video editing software. At this stage the pre-service teachers had no classroom teaching experience as their first school placement took place the following semester. The module was designed to introduce students to the TPACK Framework and focus on developing their TPK and TK and TCK. The participants were asked to pair up and choose a topic from the new junior cycle curriculum as upon graduation, these pre-service teachers were expected to teach to the new specifications. An overview of the participants can be found below in table 7.1 which contains information on which group they were in, subject chosen, and technology used during the observations.

Pre-service teacher	Group	Subject taught during observation	Technology Used
PST 1	A	Heat transfer	Deekit, physical demonstration, PowerPoint, videos.
PST 2			
PST 3			
PST 4	B	Phases of the sun and moon	Animations and simulations
PST 5			
PST 6	C	Series and parallel circuits	Phet simulations
PST 7			
PST 8	D	Atomic structure	Kahoot, PowerPoint
PST 9			
PST 10	E	Energy transfer	Phet Simulation

Table 7.1 Summary of participants in case study three

7.4 Module design

In this section, I will outline and justify with evident from the literature, the reasoning behind why each of the skills and competencies were chosen to be developed in this module.

7.4.1 Structure of the module:

The module examined in this study is a semester long introduction to teaching with technology designed for second year pre-service teachers'. The 10 weeks of the module were separated into two sections. The first seven weeks focussed on the development of the pre-service teachers', PCK, TCK and TK, which was achieved through the use of classroom activities and post-lesson critical evaluations of the tools and technology. The final three weeks provided the pre-service teachers with the opportunity to develop practical experience teaching with technology, critiquing technologies, tools, resources, teaching methodologies and engaging in critical self and peer evaluations. The pre-service teachers were asked to pair up as they would team teaching during the microteaching session. The only condition set for the microteaching was that each member of the group had to have equal teaching time, how they worked that between them was left for them to decide. At the beginning of the module, when the groups were finalised, the pre-service teachers then decided on a topic they would use in their microteaching and each week developed resources on this topic.

In her paper Ertmer (1999) describes how teachers' attitudes and beliefs towards teaching and technology may influence their decision and engagement with technology integration. On top of this, Mishra & Koehler (2006) combined Shulman's (1986) PCK with technology, highlighting the importance of understanding not only the subject content, but also the teaching and technological content to ensure adequate integration. Therefore, to remove these possible barriers to the pre-service teachers' integration, it was important to ensure the content was broad enough to develop their subject understanding while also being focused to target their skills and knowledge of technologies and its affordances with respect to skill and content development.

The participants of this study were second year pre-service teachers', therefore the content focused on the development of the pre-service teachers' technological and pedagogical knowledge domains. As these pre-service teachers had no prior classroom-based teaching experience, it was therefore appropriate to focus the content towards preparing them for their first placement which took place six weeks after the completion of the module. To achieve this, the content of the module was divided into thematic principles, interwoven throughout the module. The skills A) collaboration and communication, B) visualisation, multiple representations and probe ware, C) computational and critical thinking and D) collaboration were present throughout the entire module. However, each lesson presented the students with a range of different tools chosen to showcase a specific purpose i.e. simulations as an example of multiple representations. Each lesson centred around a different thematic principle and pre-service teachers were tasked with designing appropriate teaching materials for the tools utilised during the class. During these tasks, the pre-service teachers worked individually to create a simple resource to familiarise themselves with the tool and its affordances before regrouping with their partner to develop a classroom ready, technology infused resource, which could be used in their microteaching later in the module.

7.4.2 Aims of the module

The aims of this module were threefold.

(I) Firstly, to develop pre-service teachers' TPK, TCK and TK.

(II) Secondly, to provide opportunities for pre-service teachers to engage with a variety of technologies, software and applications.

(III) Finally, provide an opportunity for pre-service teachers to plan, implement and reflect on a microteaching lesson where technology was appropriately integrated.

To achieve these aims, the module needed to explore a range of technologies, both familiar and unfamiliar to the pre-service teachers' and include discussions around appropriate methodologies. A framework was developed to facilitate the development and implementation of this module. Examining the data from the two previous studies and the relevant literature, six key skills and competencies were highlighted, and these were aligned with the National Council for Curriculum and Assessment (NCCA) key skills framework. The framework which shows the overview of the module and the explicit links between the skills and competencies and the national document for key skills can be found below in table 7.2.

SKILLS AND COMPETENCIES	NCCA KEY SKILL
COMMUNICATION AND ORGANIZATION	Managing myself, communicating with others,
COLLABORATION	Working with others
COMPUTATIONAL THINKING AND USING SIMULATIONS	Managing information and independent thinking, being creative.
VISUALIZATION	Managing information and independent thinking, being creative.
INDEPENDENT THINKING	Managing information and independent thinking,

Table 7.2 Overview of module framework and NCCA key skill alignment

The overall purpose of this module was to provide pre-service teachers with an opportunity to engage with technology as both a learner and a teacher. Guskey (2010) argued that in order for technology to be effectively integrated into teaching practices we must witness success of technology before we experience behavioural and attitudinal changes to support long term integration. By providing this cohort of pre-service teachers with experience in the use of technology from the learning and teaching paradigms, they should begin to examine their own internal attitudes and realign them with their new experiences, leading to positive increases in technology integration.

To facilitate these experiences a set of learning objectives were created for the module. These included, teachers' being able to:

1) Integrate technology into their classroom practice
2) Teach in both synchronous and asynchronous learning environments
3) Design and coordinate assessment using technology
4) Identify underserved learning needs of students' and develop rudimentary applications to target these needs
5) Use sensors and data loggers for data acquisition and analysis

A series of lessons were developed to achieve these learning objectives for the module over a 10-week period. Each of these lessons focused on a particular skill as outlined above in table 7.2. Table 7.3 below, provides an overview of the main skill focus of each week in this module as well as where there were overlaps in skills.

Week number	Communication and organisation	Visualisation, multiple representations and probe ware	Computational and critical thinking	Collaboration.
Week 1	●			
Week 2	●	●		●
Week 3	●	●		
Week 4	●		●	●
Week 5	●	●		
Week 6	●	●		
Week 7	●			●
Week 8	●			●
Week 9				●
Week 10				●

Table 7.3 Summary table of the skill focus for each week of the module

A) Communication and organisation

Some of a teacher's greatest support structures include, their colleagues, subject group meetings, professional development and other similarly designed "*meet ups*" which serve as a way for teachers' to learn from each other and is seen as critical to their professional development (Clarke, Triggs and Nielsen, 2014; Kelly and Antonio, 2016). Recent developments of social networking sites (SNS) and professional learning networks (PLN), has provided teachers' with more ways than ever to communicate with one another both during and after school hours (Ivanova, 2009; Trust, 2012, 2013). These online, digital spaces provide the opportunity for teachers' to share, interact, facilitate and provide feedback to their students' in an asynchronous environment (IVANOVA, 2009) and it is this support which has been reported to lead to an increase in not only job satisfaction but also the retention of teachers' in the profession (DeAngelis, Wall and Che, 2013). House (1981) (as cited in Kelly & Antonio 2016) distinguished social support into four categories: 1) instrumental support, namely in money, time and labour. 2) Emotional support taking the form of listening, concern, trust and affection. 3) Appraisal support via feedback and affirmation and 4) Informational support which can take the form of advice, directives and suggestions.

Kelly & Antonio (2016) conducted a study to examine teachers' access to support in large Social Network Sites (SNS) and what kinds of support the teachers were accessing in these SNS. To conduct their study, the authors implemented two phases of data collection. The first, examined the interactions between teachers' in a large open group on Facebook over a 12-week period. The second phases consisted of confirming their analysis by conducting further analysis on an additional five groups over one additional week. The results of their study showed that while teachers utilised the experience of others in the group, the main questions were generally of advocates of practice. The authors found that less than six percent of responses could be coded for modelling teacher practice, providing feedback or supporting reflection (Kelly and Antonio, 2016).

Another important aspect of teaching, which can now be imparted through SNS is teacher organisations. Teacher organisation can take the form of self-organisation and academic organisation. For example, the teacher may keep folders of their work online or on a storage device for easy retrieval (self-organisation). More importantly, the teacher can organise the content in such a way as to assist with the development of their students' understanding of the content. A study conducted by Subramaniam (2016) found that when using technology science teachers' used teaching actions such as scaffolding and social arrangement to construct the scientific content knowledge in a meaningful manner. These studies show that SNS can not only be a powerful structuring tool for teachers' content, but also a platform to empower teachers' through interactions with their peers.

One such SNS which has risen to prominence in Ireland in recent years is Edmodo (2008). The Professional Development Service for Teachers' (PDST, 2018) provide whole school training on this SNS and as a result, the pre-service teachers enrolled in this module were introduced to Edmodo, shown how to create and post assignments, create small working clusters within the main teaching group and how to upload and create documents on Edmodo. Edmodo also features community's which teachers were free to enrol in. These communities feature a specific point of interest, often the chosen curriculum subject. This is why it the use of Edmodo was included in this module.

B) Visualisation, multiple representations and probe ware.

One of the challenges of teaching, particularly in science education, is ensuring that there is a connecting between students' pre-existing conceptions to scientifically based understandings. In 2003 technology use in science education was categorised into five domains by Linn. These include: Science visualisations, science modelling and simulations, data collection and representation, discussion and collaboration, and literature (Linn, 2003). Studies have shown that students' can develop misconceptions of scientific phenomena due to the complexity or delivery of the content (Nakhleh, 1992; Garnett, Garnett and Hackling, 1995; Mikkilä-Erdmann, 2001). Çalik *et al.,* (2015) found that the introduction of technology and scientific inquiry into an undergraduate module, increased students' self-perceptions of fluency with innovative technologies. This was due to technologies ability to extend students' thinking and create multiple representations of their understanding by providing them with authentic learning experiences combing the theory and practice (Çalik *et al.*, 2015).

In their paper Anderson & Wall (2016) state one way to overcome the challenges faced in addressing pre-misconceptions is through visualisation and simulations. For decades, studies were conducted to assist with students' conceptual understanding of micro and macroscopic chemistry through the use of visualisation (Kozma and Russell, 1997; Wu, Krajcik and Soloway, 2001; Rice, Finlayson and Nolan, 2016). One such study by Baki *et al.,* (2011) found when developing students' spatial visualisation skills both physical or virtual manipulatives are more effective than traditional teaching methods while, more recently, Geelan (2014) stated that the use of images and visualisations may have a positive impact on the development of students' understanding of the content. Research has suggested students' in their early years of second level education can benefit greatly from the introduction of simulations, visualisations and probe ware (Anderson and Wall, 2016). With advances in technology students' can now immerse themselves in worlds designed to represent specific scientific phenomenon based on the natural laws of physics (Mohanty and Cantu, 2011).

Research has shown that students' who engage only in hands on experimentation may have difficulty in developing an understanding of more sophisticated concepts (Hofstein and Lunetta, 2004). One such example is the behaviour of molecules in gases when the volume or pressure is increased or decreased. Students' may learn the relationship via rote learning but will often struggle to draw a visualisation of the processes. However, it is currently accepted that meaningful design and data collection as opposed to repetitive data collection provides the students' with a deeper comprehension of the content (Milner-Bolotin, 2012). Not only do probe ware tools such as the Vernier LabQuest allow for quick and easy resetting of parameters, graphing and instantaneous results, but also develop the necessary skills needed for working in the current science industry (Milner-Bolotin, 2012). In their article, Brunsell & Horejsi (2010) present data collected by a high school physics teacher in Idaho using sensor probes in his teaching. Mr. Sullivan found that being able to see the experiment and data collection happen synchronously in real time makes the science come alive for his students' and due to the instantaneous nature of data acquisition made possible by the probe ware, students' have more of the "*ah-ha*!" moments (p.1)

Therefore, to have the greatest chance of developing PTS TPK, TCK and TPACK, the PTS should be introduced to simulations and probe ware as an alternative or complimentary form of experimentation utilising the inquiry-based methodology as well given the resources and pedagogy necessary to utilise online visualisation tools to improve their students' understanding of the content.

C) Computational & critical thinking

Computational thinking was first coined in an multidisciplinary role by Papert (1996) who saw the benefits of utilising computational representations for demonstrating powerful concepts (Weintrop *et al.,* 2016). Since 1996, many attempts have been made to provide an accepted definition for computational thinking as an integrated model of teaching were only two have prevailed, but all have included the key aspects of problem solving, designing systems, understanding human behaviour and drawing on the concepts which are fundamental to computer sciences (Wing, 2006). Computational thinking asks you to the breakdown the problem and solve it to determine their relationships, these are strategies which should regularly be implemented by teachers', especially in the STEM subjects. The question is, how do teachers teach computational thinking? Recently there has been a push towards programming, this is despite the failed programming courses introduced in the 1980s to teach science students' logo and pascal. The difference this time around is in the development of a new type of programming language, block coding - a coding language which uses blocks of codes built upon each other to create a string. An example of this block language is MITs Scratch. In recent years' scratch has risen to prominence in the Irish primary education sector, but so far has failed to be adopted in second level schools. However, another block programming language developed by MIT, AppInventor, builds upon scratch's success and transforms it into a powerful web tool with the ability to create simple, fully-functioning applications for the Android mobile operating system.

A critical review of the literature conducted by Fu (2013) stated the use of ICT had been found to:

- Support student centred and self-directed learning
- Produce a creative learning environment
- Promote collaborative learning in distance education environments and
- Offer more opportunities to develop critical thinking skills. (Fu 2013, p.113)

One of the elements mentioned in Fu's analysis was critical thinking skills. The development of undergraduate critical thinking skills is an important issue for higher education institutes (Guiller, Durndell and Ross, 2008). In her book, The Skill of Argument, Kuhn (1991) believes critical thinking is the ability to develop a reasoned argument with a social element. To explain this Kuhn claims that the student needs to possess a number of skills, firstly, the student should be able to delineate between their point of view and the one being proposed. Secondly, the student should be able to draw on non-spurious evidence to strength their point of view. Thirdly, conjugate possible alternative theories to their own in order to support their point of view. Next, the student should provide evidence which supports their theory while refuting the alternatives and lastly, the student should be able to adopt the theory which is valid upon evaluation of the evidence. This is known as the reasoned justification of arguments. Recently, ICT has been identified as a possible pathway to strengthen the development of students' critical thinking skills. One of the first studies to examine the benefits of ICT on critical thinking was by McMahon (2009). McMahon (2009) conducted a study to investigate whether there were significant correlations between students' computer skills and the development of critical thinking skills (p.270). Using the Ennis' Weir Critical Thinking Essay Test and Australian Schools Computer Skills Competition (McMahon, 2009), the author was able to determine that there were significant differences between the critical thinking skills of those students' whom were immersed in technology for more than five years compared to those with less than five years' immersion. An earlier study by Guiller *et al.,* (2008) wanted to determine if those whom participated in online discussion as opposed to face to face discussions exhibited higher levels of critical thinking. The asynchronous nature of online discussion courses may prove beneficial to developing critical thinking skills as it allows the users time to reflect before committing to a response. To determine what benefit, if any, online discussions have over face to face, the students were divided into groups and asked to discuss a journal article each week using the mode assigned to them, i.e. face to face or online discussion. The discussions were transcribed and analysed using indicators of critical thinking and examining the nature of the discourse. Their results showed that more evidence of critical thinking was found in the online discussion compared to the face to face discussions. This supports the argument that asynchronous discussion groups facilitate critical thinking skills, and this is why reflections were included as a key component of this module. These reflections were based on the set of tasks given each week to the pre-service teachers'.

The importance of embedding ICT alongside the development of critical thinking at pre-service level may present an opportunity to not only influence the pre-service teachers' existing skills, but also their pedagogical knowledge which in turn may be utilised in their careers to develop future students' critical thinking skills.

D) Collaboration

The final component in this module focusses on collaboration and what benefits ICT may have on the development of students' collaboration. Collaboration is an important aspect of the teaching and learning process, as Tudge (1992) stated: "*development is most likely to occur when two participants differ in terms of their initial level of competence about some skill or task, work collaboratively on it, and arrive at shared understanding*" (p.1365). Not only does collaboration develop generic communication team building skills, but for teachers' it can be used as a form of classroom management strategy (Szewkis *et al.*, 2011). Technology has been used in many meaningful ways to support and develop collaboration, for instance Wikipedia is run by the consorted efforts of individuals collaborating online. Also, in the video game market, Massive Multiplayer Online games require constant collaboration to achieve the goals set to the team. However, to achieve collaboration in the classroom requires the meeting of certain conditions which Szewkis (2011) summarized in their report. These are, the existence of a common goal, effective communication and coordination as well positive interdependence between the peers, each student to hold themselves accountable for their work and equal rewards for all involved (Szewkis *et al.*, 2011). Regarded as a key skill to develop, collaboration was integrated throughout the entirety of the module via face to face and online group work between the pre-service teachers' as well as co-developing a ICT enabled microteaching lesson to be taught together during the module.

7.5 Assessment methods used in the module

The coursework in this module set out to capture the development of several artefacts which were created by the pre-service teachers'. These included: individual and group curated resources, individual critiques of the tools used and possible teaching methods which can be utilised, group lesson plan and video recorded microteaching session, individual self-reflections of microteaching and peer evaluations of microteaching.

Table 7.3 shows an overview of the assessment used with pre-service teachers' taking this module. The majority of the marks went to pre-service teachers' development of the weekly resources with nearly half of the modules marks been awarded. Coupled with the weekly critiques of each of these resources, 60 per cent of the module was awarded for the development and evaluation of these technological resources. The remainder of the marks were awarded for the implementation and evaluation of a microteaching session. These forms of assessment are discussed in the following sections.

Assessment Method	Percentage of module marks
WEEKLY RESOURCES	48 %
WEEKLY CRITIQUES	12 %
ASSESSMENT OF MICROTEACHING AND SELF- REFLECTION	25 %
PEER MICROTEACHING CRITIQUE	15 %

Table 7.4 Breakdown of assessment methods and their respective weight

7.5.1 Weekly Group Resources

As discussed previously, each week focused on a developing a range of different skills and competencies. Each week the pre-service teachers were required to create a resource using the application(s) or tool(s) presented to them in that week's lesson. The purpose of creating these resources were two-fold. Firstly, it provided the pre-service teachers with increased exposure to the tool, whilst focussing on appropriate curation of a classroom ready resource. Secondly, it presented the pre-service teachers with an opportunity to develop a wealth of resources within the cohort which may be shared amongst each other for their future teaching placements. Pre-service teachers had free reign to design any resource they felt were applicable to their learning objectives using the tools available from that week. The resource had to be tailored to the topic previously chosen at the beginning of the module for their microteaching session. To assess these resources a rubric (See table 7.5) was devised consisting of four main aspects: alignment with curriculum, content, use of ICT/ease of use and pedagogical considerations. The marks were distributed evenly amongst the four criteria and broken into four categories of requirements not met, needs improving, achieving within expectations and achieved beyond expectation

Criteria	Requirements not met	Needs improving	Achieving within expectations	Achieved beyond expectations
Alignment with curriculum	The resource does not align with any aspect of the topics learning outcomes	The resource aligns with one learning outcome	The resource aligns with most applicable learning outcomes	The resource has aligned with all applicable learning outcomes
Content	The content of the resource is of low quality and bears no resemblance to the curriculum	The content of the resource addresses all of the relevant content at a low level of questioning	The content of the resource covers all the applicable content at a higher level of questioning	The content of the resource challenges the students' understanding of the content.
Use of ICT/Ease of use.	The use of ICT is merely substitution replacing common teaching practice/method. The resource is extremely difficult to use and requires a lot of teacher dissemination	The use of ICT amplifies the teaching and learning by providing somewhat unique experiences. The resource is somewhat student centred requiring some input from the teacher to start/complete	The use of ICT is either unique or applicable to the students', their abilities or the content at hand. The resource is completely student centred but does not follow an inquiry-based approach	The use of ICT is unique and applicable to the students', their abilities and the content at hand. The resource is completely student centred and follows the inquiry-based approach
Pedagogical considerations	No consideration was given to pedagogical practices in this resource.	The resource makes use of one appropriate pedagogy	The resource includes more than one pedagogical practice	The resource has targeted the development of all students' understanding by utilising appropriate pedagogy.

Table 7.5 Rubric used to assess pre-service teachers' weekly resource

7.5.2 Weekly Critiques

In addition to submitting a weekly resource, the pre-service teachers also completed a critique of the tool(s) used in the lesson. The purpose of the critique was to prompt the pre-service teachers to think critically about the affordances and challenges of the tool(s) while proposing a strategy for integration of the tool in future lessons. To achieve this, the critique was designed with four guiding questions:

- What are the opportunities & challenges in using this tool?
- How appropriate is the tool/application for your learning objectives?
- What are the benefits to the teacher and student in using this tool?
- How would you integrate this tool into a lesson? Include points about teaching methods, class setup etc.

Each weekly critique was designed to challenge the pre-service teachers' to not only think as educators, but also as students to identify the affordances associated with each tool. This was an important dichotomy, while a teacher may see the affordances of a tool mainly due to a decrease in workload or administration tasks, the students' may find it challenging and ultimately detrimental to their learning. To assess these critiques, a simple rubric was used awarding either full or partial marks. In the case of question one, "*What are the opportunities & challenges in using this tool*" full marks were awarded if the student could outline at least three unique and non-trivial opportunities and challenges for both teacher and student. For example, if pre-service teachers were to use a Phet simulation a trivial opportunity would be "*reduces time taken in set up of equipment*". While time is an important factor, teachers' must consider that reducing time is not an affordance which should influence their decision to use the tool. Full marks were awarded for questions two and three if evidence was provided or if a unique benefit was identified from one of the tools utilised that week. Finally, the pre-service teachers were asked to outline how they would integrate the tool into their teaching. Full marks were awarded if the pre-service teacher outlined an appropriate strategy for the integration of the tool or provided sufficient evidence as to why the tool is unfit for integration.

7.5.3 Microteaching and self-reflection

The microteaching lesson was broken up into two components: lesson planning documentation and the observations. As this cohort of pre-service teachers' do not yet have classroom teaching experience and have minimal lesson planning practice, the first component provided the pre-service teachers with an opportunity plan their lesson in the presence of the researcher to guide them and answer any questions with respect to lesson planning. The lesson plans were assessed using a modified version of the TPACK Lesson Plan Assessment Instrument (TPACK-LPAI) developed by Canbazoglu Bilici *et al.*, (2016). The TPACK-LPAI comprises of five sections: name of pre-service teacher, description of the lesson being planned, identification of aims and objectives, safety and technological tools, ratings of key indicators and additional comments. The key ratings of indictors section were of particular interest, it provided eight key criteria for assessment. These key indicators were assessed on a four-point Likert scale where each point was clearly defined for the set of criteria. The key indicators listed in the TPACK-LPAI were:

1. The teacher's goals and purposes of teaching science guide/frame the development and implementation of the lesson.
2. Assessment methods aim to evaluate important dimensions of science learning
3. Students' complete assessment that require them use critical, in-depth, higher order thinking, e.g., organize, interpret, evaluate, or synthesize complex information, and/or develop alternative solutions, strategies, perspectives or points of view.
4. The teacher is aware of students' prior knowledge, learning difficulties and common alternative conceptions of the particular science concepts
5. Using multiple modalities (e.g., kinaesthetic/tactile, oral/verbal, written, numerical, graphic, pictorial, tabular) allows students to feel as though they and all of their peers (with different gender, ability, etc.) have had their needs met.
6. The lesson allows students to engage in representations (e.g., illustrations, models, or analogies) and activities (e.g., problems, demonstrations, simulations) that can facilitate their learning in a specific-science topic
7. The teacher demonstrates an understanding of the goals and objectives for students' in a particular science topic that she is teaching is and that is addressed in the national and state level frameworks.
8. The instructional materials are relevant to teaching a particular domain of science and the general learning goals of the national and state level frameworks.

The second component involved in the microteaching element of the module was a twenty-minute microteaching session. Each group was asked to teach their planned lesson to the cohort, whilst being video recorded. As stated previously at the beginning of the module, all pre-service teachers formed into groups and had selected a topic to be taught during this session. As was the case in the previous studies carried out in this thesis, the TPACK Observation Protocol (TPACK-OP) was used to assess the pre-service teachers' microteaching.

7.6 Results

7.6.1 Technological Literacy Results

The results of the tests show that students performed quite well, achieving scores of over 87 percent in the majority of the domains, with one exception, Microsoft PowerPoint. All but one teacher completed the six tests. This teacher did not complete the Microsoft PowerPoint test. As such, their score was removed from the calculation of the average for that test. Unlike other studies which examined teachers' TPACK, this study utilised an objective measurement of technology literacy rather than self-reported survey data (Archambault and Crippen, 2009; Chai, Koh, *et al.*, 2011).

Pre-Service Teacher	Basic computer unit (40)	World Wide Web (33)	Windows (29)	Microsoft Word (29)	ME (39)	MP (25)	Percent (%)
PST 1	31	32	28	25	34	16	85
PST 2	38	29	28	29	35	19	91
PST 3	34	31	28	29	32	18	88
PST 4	39	33	29	28	36	20	95
PST 5	38	31	29	25	29	16	86
PST 6	37	33	29	28	36	23	95
PST 7	39	33	29	28	37	20	95
PST 8	36	31	27	25	35	16	87
PST 9	34	30	28	23	29	19	84
PST 10	37	33	29	27	35	-	83
Class Average (marks)	36.3	31.6	28.4	26.7	33.8	18.6	89
Class Average (%)	91	96	98	92	87	74	
Standard Dev (%)	2	1	1	2	3	2	

Table 7.6 Results from pre-service teachers' technology literacy tests

7.6.2 Microteaching Observations

The microteaching observations were conducted in groups of one two or three. However, each PST was rated individually using the TPACK Observational Protocol developed by Canbazoglu Bilici, Guzey and Yamak (2016). The pre-service teachers developed and implemented a 20-minute lesson which was observed in real life by two observers, the researcher and the supervisor of this thesis. In total ten teachers were observed, three groups of two, a group of three and one teacher on their own. In the sections below each group will be discussed in the context of the whole lesson while each teacher will be discussed in terms of their TPACK scores.

7.6.3 Group A: PST 1,2 and 3

PST 1,2 and 3 developed and conducted a lesson on the three methods of heat transfer. PST1 began the lesson by introducing the topic to the students' and then showing them the ball and ring experiment before asking them to identify what might be happening. Teacher asks students to provide answers on the website "*Deekit*" which works as online sticky notes. After nearly four minutes the teacher goes through the answers provided by the students' and then introduces the concept of conductors and insulators. Students' next task is to identify real life examples of conductors and insulators which lasts for one minute when the teacher looks for one answer and then there is a teacher change from PST1 to PST2. PST2 begins their segment of the lesson with a demonstration of convection. Before beginning the demo, the teacher asks the students to predict what will happen. Demo was conducted in silence and the teacher asked the students to return to their seats and fill in a Deekit with their prediction, their observation and an explanation of any observations they made. Teacher then introduces convection and how a radiator is an example of heat transfer through convection. However, the teacher then asks the students to explain how air flows in a radiator to expel heat to its surroundings. Teacher gives students' 20 seconds to discuss this and then expands on the first answer given to them. Next the teacher asks the students to list some other examples of convection and to post them onto the Deekit. Some examples were given then PST3 takes over the lessons. PST3 starts the lesson by recapping on what they have learned so far and then introduces the third method of heat transfer, radiation. Teacher asks a student to stand by the nearest window and comment on any change in temperature/heat compared to where they were sitting. Student notices that they can feel more heat. Teacher explains that it is the heat from the sun which travels through the vacuum of space through radiation. Teacher then puts on a four-minute video which talks about radiation. After video ends teacher poses the class a question to be answered on Deekit. After 40 seconds the lesson is ends.

7.6.4 Group B: PST 4 and 5

Group B developed a lesson on the phases of the sun and moon. The lesson began with PST4 looking for a volunteer. The teacher asked the student to walk over to the window and give an approximation of the suns position. When the students gave their approximation the teacher then asked the class a series of closed recall questions regarding the sun such as where does the sun rise, when is it at its highest etc. For the next four minutes the teacher asks students to locate an animation loaded onto Edmodo along with some questions to consider whilst using the animation. The teacher stops the lesson briefly to ask students' a question "*can you see the moon during the day*" and asked them to answer the question with evidence from their animation. The teacher then shows the class a video for 45 seconds before the teacher change over occurs. PST5 begins their half of the lesson by directing the students to another simulation about astronomical events and dates. The teacher asks students to use the simulation to work out key astronomical dates i.e. the change in seasons. After some time, the teacher asks students to answer but none were forthcoming. The teacher quietly returns to walking around the classroom helping individual students'. After three minutes the teacher asks a student what they have learned today and then ignores the student's response by detailing the next task which is interrupted by the end of the lessons.

7.6.5 Group C: PST 6 and 7.

PST6 began this observation by introducing the topic of the lesson and asking the students to find a post on Edmodo containing the link to the simulation being used during the lesson. While students were navigating Edmodo, the teacher walked around the classroom handing out a worksheet for students to complete using the simulation. For the next seven minutes the students' pair up and work together on the worksheet. Teacher calls for the students' attention and looks for answers from the students' which were all basic recall questions. The teachers' change over and PST7 begins their portion of the lesson which examines how different materials effect the condition of a circuit. The teacher asks students to work on the next section of their worksheet while the teacher(s) walk around the classroom helping students as needed. This activity continues for eight minutes begore the teacher directs the students' to Padlet to engage in a discussion, this however is cut short due to the lesson ending.

7.6.6 Group D: PST 8 and 9

Lesson begins with PST8 introducing the lesson on atomic structure while PST9 walks around the classroom providing the students with handouts. PST8 then moves onto a short recap on previous knowledge before examining definitions on their PowerPoint. The teacher then asks students to examine their handout while watching a video on the alkali earth metals. This whole episode lasts four minutes when a teacher change over occurs. PST9 begins with a recap of electronic configuration and directs students' to Kahoot. The next four minutes were spent completing the Kahoot quiz. PST9 then shows students' how to draw an atom and then four one-minute PST8 takes over and continues showing students' how to draw an atom. PST9 takes over once again continuing with the drawing and then sets students' the task of drawing a carbon atom in the handout. This lasts three and a half minutes and is interrupted by the end of the lesson.

7.6.7 Group E: PST 10

The final group consisted of one pre-service teacher, PST10. PST10s lesson focused on the conservation of energy. To begin their lesson, the teacher holds the whiteboard duster high in the air and drops it. The teacher asks students to describe the energy changes. Next the teacher asks students to make a copy of a document saved to Edmodo. Within this document is a worksheet with questions and a link to a Phet simulation which they used during the lesson. When all students' have caught up, the teacher gives them one and a half minutes to play with the app to become familiar with how it works. The teacher then provides the students with instructions on the task and allows them in excess of five minutes to work on the tasks. Teacher then checks students' progress and adds an additional layer of difficulty for those students' who have finished early. Teacher then allowed students' an additional four minutes to complete the task before gaining their attention at the whiteboard to get students to explain the relationship between kinetic and potential energy. The lesson ends four minutes later.

The above sections have provided the necessary context to the lessons of each group of pre-service teachers'. The section below will now look at the results and analysis of these lessons in terms of the level of classroom interactions, TPACK scores and TPACK displacement charts and finally examine students' perceptions of the module and their own assessment of their TPACK.

7.7 Analysis of observations

7.7.1 Classroom interactions

The first analysis conducted on these microteaching observations was to code the interactions present in each teacher's portion of the lessons. To do this, the same methods were applied as in case studies one and two of this thesis. That is, the lessons were watched and coded for examples of teacher directed or students' centred interactions. These were in the forms of Teacher whole group (Twg), Teacher individual students' (Tis), Student group work (Sgw), Student individual work (Siw) and Discretionary time (Dt).

A series of graphs contained in figures 7.1 to 7.10 show that every teacher had a mixture of teacher directed and student-centred interactions throughout their lessons, the extent to which varies widely over the course of observations. For example, PST3 accumulated just 39 seconds of student group work while PST10 accumulated 10 minutes and 22 seconds of student individual work. Teachers' 1, 2, 3, 5, 8 and 9 spent the majority of their lessons in teacher directed interactions while 4, 6, 7 and 10 were recorded as spending more time in student centred interactions. One interesting observation that can be found in the figures above is the teachers' conformity to what has been seen so far as atypical teacher classroom structure, i.e. teacher introduces lesson, assigns task, checks progress and then checks content or wraps up. What makes this interesting is that these teachers taught one lesson together and still followed this rigid structure. The one slight exception was group three, their figures show a very minimal time between teacher swaps in terms of teacher directed instruction. Another interesting observation is the uniqueness of each teachers' lesson even though the lessons were planned together in their group rather than individually. Examining PST4s interaction chart it can be seen that there was an accumulation of three and half minutes of discretionary time. Recall that in their microteaching session PST4 asked students' a question and received no response. This was the time between the question being asked and the next time the teacher address the class. Even though clearly in the video the students were working away, the reason this section was coded as Dt was due to the question being left unanswered and the teacher not clearly directing or informing the students' what to do next.

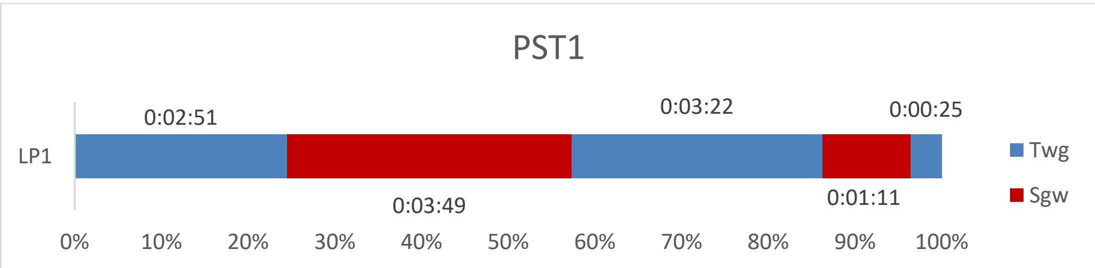


Figure 7.1 Classroom interaction chart for PST 1 (Group 1)

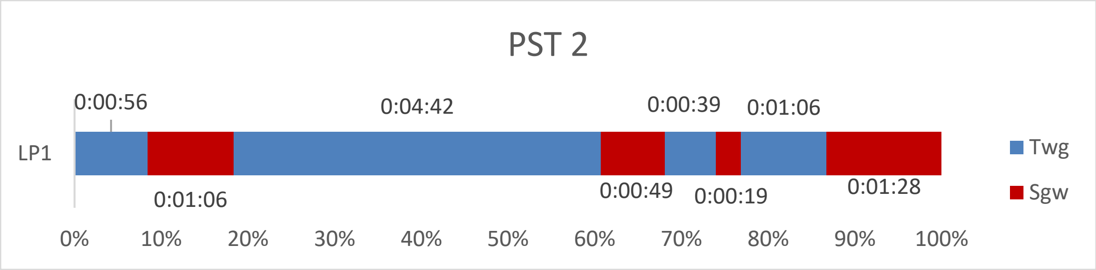


Figure 7.2 Classroom interaction chart for PST 2 (Group 1)

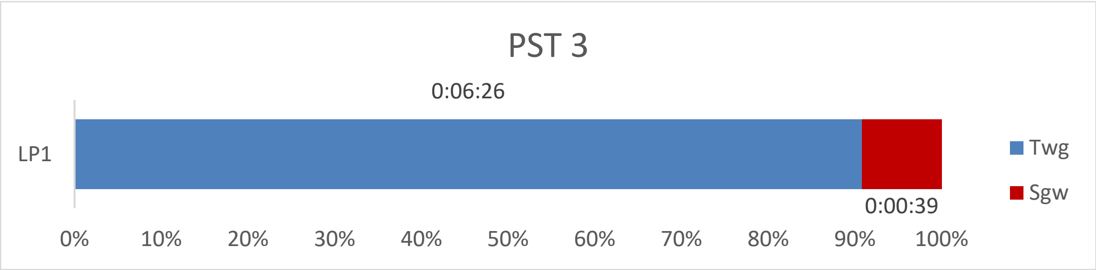


Figure 7.3 Classroom interaction chart for PST 3 (Group 1)

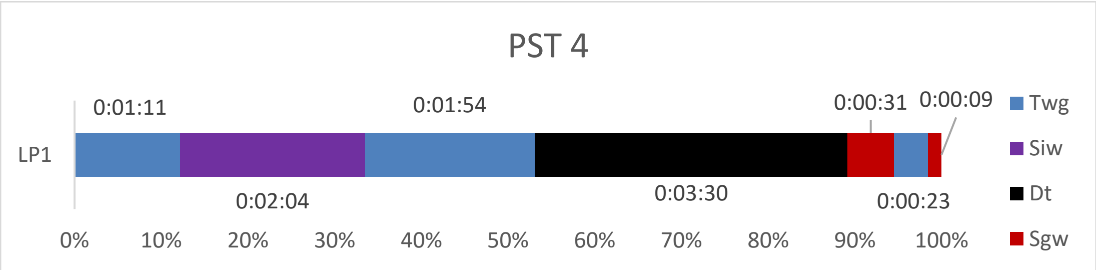


Figure 7.4 Classroom interaction chart for PST 4 (Group 2)

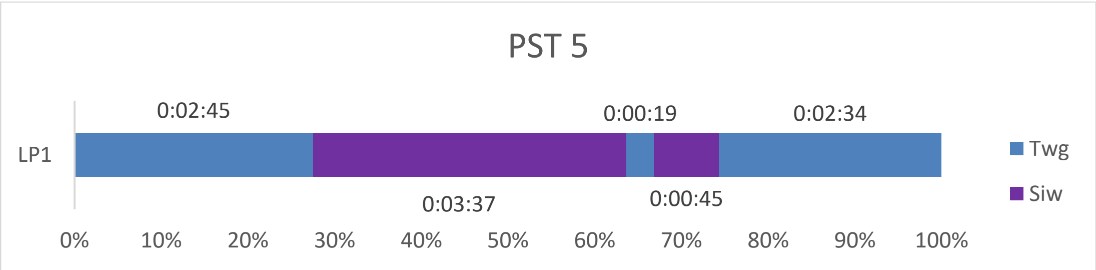


Figure 7.5 Classroom interaction chart for PST 5 (Group 2)

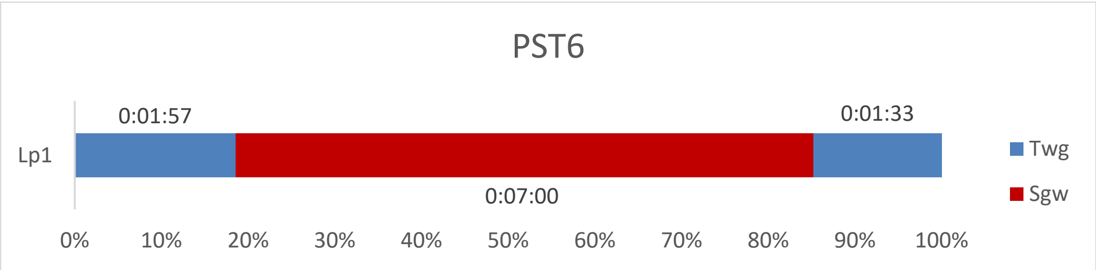


Figure 7.6 Classroom interaction chart for PST 6 (Group 3)

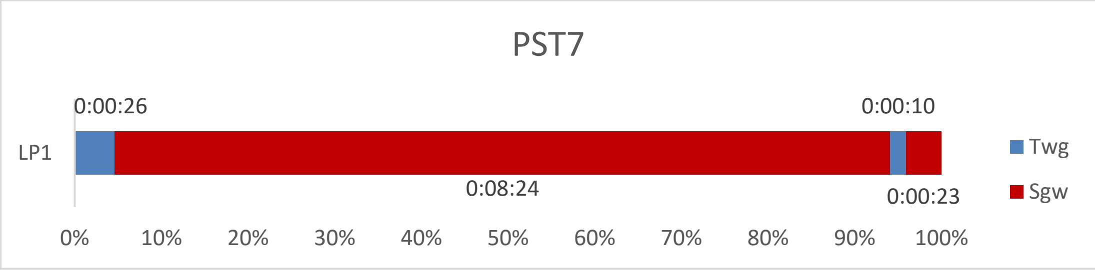


Figure 7.7 Classroom interaction chart for PST 7 (Group 3)

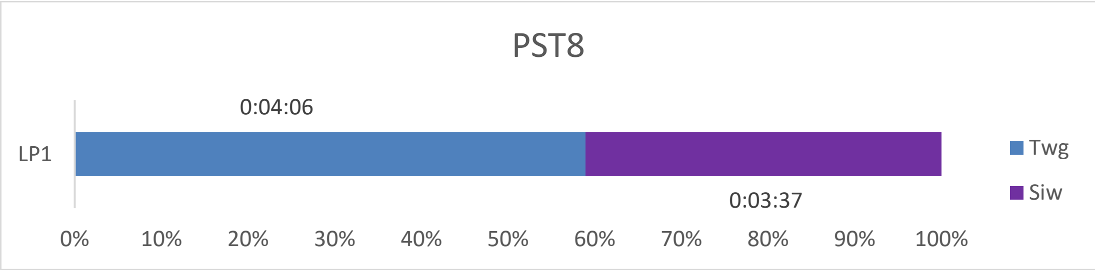


Figure 7.8 Classroom interaction chart for PST 8 (Group 4)

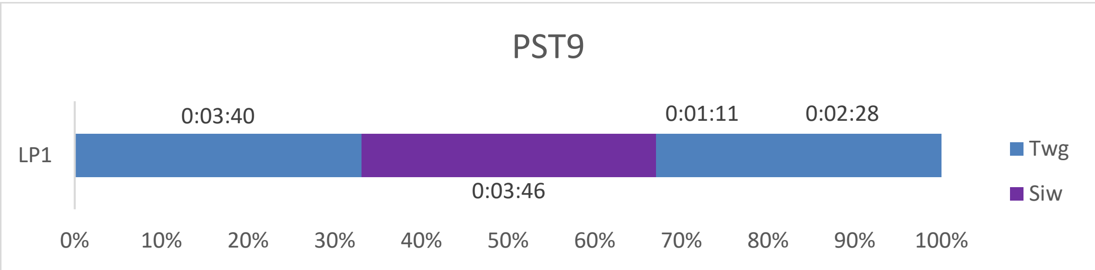


Figure 7.9 Classroom interaction chart for PST 9 (Group 4)

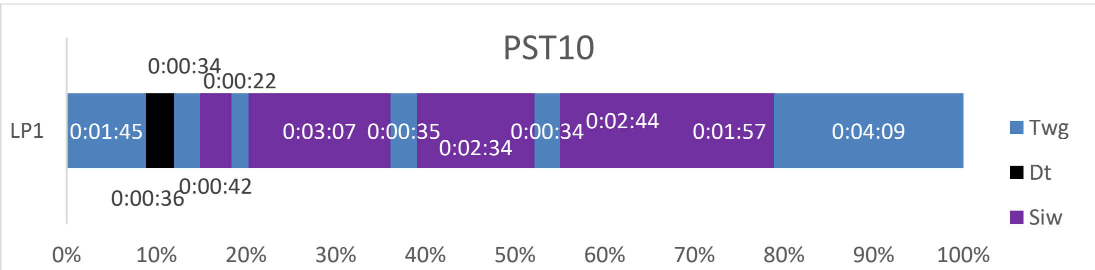


Figure 7.10 Classroom interaction chart for PST 10 (Group 5)

7.7.2 TPACK Observations

This section will examine the data retrieved from the TPACK-OP portion of the observations. Since this was the first time the TPACK-OP was used with pre-service teachers', reliability had to be reassessed. The researcher and his supervisor recorded the observations and independently reviewed two of these. They then reviewed their scores and made any adjustments necessary. The only concern both reviewers had was with the protocol was item four, which evaluated prior knowledge. The reviewers felt this was impossible to assess with this cohort of pre-service teachers with no classroom experience. As such, item four was removed from the TPACK-OP in case study three's analysis.

Domain One: Orientations Towards Teaching Science (item 1)

In the domain of orientations towards science teaching it can be seen from table 7.7 that the pre-service teachers' in this study achieved a mean score of 1.80, indicating that their lessons focused on the development of process skills. Table 7.7 shows that three pre-service teachers were ranked at a three for using hand on activities to engage the students'.

Item 1: The teacher's goals and purposes of teaching the subject guide/frame the development and implementation of the lesson.

	Criteria	TPACK-OP PSTs 1-10
0	Not Applicable	0
1	The lesson centres around transmitting the facts of the subject.	5
2	The lesson asks students to engage in activities to develop process skills.	2
3	The lesson provides opportunity for students to engage in "hands on" activities.	3
4	The lesson asks the students to define and investigate problems, do and/or design an "experiment", and present the data to others for debate, discussion, and/or evaluation.	0
	Mean ($\bar{x}$)	1.80

Table 7.7 Table showing the scores in domain one for the pre-service teacher participants)

Domain Two: Teachers' Knowledge of Assessment in Science

Domain two contains two items - two and three, which examined the extent to which the "*assessment methods aim to evaluate important dimensions of science learning*" and, also whether "*student's complete assessments that require them to use critical, in-depth or higher order thinking*". The results from table 7.8 show that in item two the pre-service teachers achieved a mean score of 1.60. While in item three, the pre-service teachers scored on average 1.50. In item two, nine of the teachers were unable to appropriately align their assessment with the aims of the lesson while in item three, seven pre-service teachers' asked questions which required straight forward facts. Interestingly, one pre-service teacher achieved a score of four in item three, meaning they used higher order thinking questions on more than three occasions during the observation. Furthermore, this score was achieved by PST10 who has one extra year experience in their teaching degree, possibly hinting at the development over time of pre-service teachers' TPACK domains.

Item 2: Assessment methods aim to evaluate important dimensions.

	Criteria	TPACK-OP PSTs 1-10
0	Not Applicable	0
1	All assessment methods aren't used to evaluate students' learning in a particular topic.	5
2	some assessment methods aren't aligned with learning objectives to evaluate students' learning in a particular topic.	4
3	all assessment methods are somewhat aligned with learning objectives to evaluate students' learning in a particular topic.	1
4	all assessment methods are aligned with learning objectives to evaluate students' learning in a particular topic.	0
	Mean ($\bar{x}$)	1.60

Item 3: Students' complete assessment that require them use critical, in-depth, higher order thinking, e.g., organize, interpret, evaluate, or synthesize complex information, and/or develop alternative solutions, strategies, perspectives or points of view.

	Criteria	TPACK-OP PSTs 1-10
0	Not Applicable	0
1	the assessment asked mostly for facts, straightforward answers.	7
2	the questions required application in a slightly different situation, one higher order thinking questions asked, mostly lower higher order thinking questions.	2
3	the questions involved synthesis and analysis and/or presented a new situation, two higher order thinking questions asked., mix of higher and lower order thinking questions (See lower half of Blooms)	0
4	the questions used evaluation and/or higher order thinking, three or more higher order thinking questions asked. (See higher half of blooms)	1
	Mean ($\bar{x}$)	1.50

Table 7.8 Table showing the scores achieved in domain two; items two and three

Domain Three: Knowledge of Students'' Understanding of Science

In the original TPACK-OP domain three consisted of two items, items four and five. However, as noted at the beginning of this section it was decided to remove item four from the TPACK-OP. As can be seen in table 7.9, this cohort of pre-service teachers tended towards a rating of two which indicated that they used between two to three modalities during their lessons. The most frequent modalities used by these pre-service teachers were oral and written instructions as well as pictorial/graphical.

Item 5: Using multiple modalities (e.g., kinesthetic/tactile, oral/verbal, written, numerical, graphic, pictorial, tabular) allows students to feel as though they and all of their peers (with different gender, ability, etc.) have had their needs met.		
	Criteria	**TPACK-OP PSTs 1-10**
0	Not Applicable	0
1	1 modality is used in the lesson presentation.	1
2	2 or 3 modalities are used in the lesson presentation.	9
3	the lesson is presented using 4 modalities.)	0
4	the lesson uses multiple modalities (more than 4) in an integrated way to achieve for students' understanding of the content	0
	Mean ($\bar{x}$)	1.90

Table 7.9 Table showing the scores achieved in domain three, item five.

Domain Four: Knowledge of Instructional Strategies.

The results contained in table 7.10 shows that the majority of these pre-service teachers were rated as a two, which indicated that they used a limited range of representations and activities somewhat appropriate to facilitating the students' learning. This was seen during the observations as the students' either used one resource throughout the whole lesson or a variety of resources which were only loosely related to the topic or covered it in such minute detail that it was inconsequential.

Item 6: The lesson allows students to engage in representations (e.g., illustrations, models, or analogies) and activities (e.g., problems, demonstrations, simulations) that can facilitate their learning in a specific topic.		
	Criteria	**TPACK-OP PSTs 1-10**
0	Not Applicable	0
1	The teacher uses a limited range of representations and activities that are not appropriate to the learning objectives of topic.	1
2	the teacher uses a limited range of representations and activities that are somewhat appropriate to facilitate students' learning in a specific topic	9
3	The teacher uses multiple representations OR activities that are appropriate to facilitate students' learning in a specific topic	1
4	The teacher uses multiple representations AND activities that are appropriate to facilitate students' learning in a specific topic	0
	Mean ($\bar{x}$)	1.9

Table 7.10 Table showing the scores achieved by the pre-service teachers' in domain four, item six.

Domain five: Knowledge of Science Curriculum and Curriculum Materials

Once again, the results contained in table 7.11 showed that the pre-service teachers scored quite low, achieving a mean score of 1.9, which indicated that the pre-service teachers used a limited range of representations and activities which were only somewhat appropriate to facilitate student learning in the subject. As discussed under domain two, possible explanations for this could be due to the stage of their degree the pre-service teachers were at. At the second year of their degree, this cohort would have lacked knowledge and experience of applying curriculum goals and objectives to teaching materials in the classroom. While all pre-service teachers' used materials in their teaching, the majority of these resources were only somewhat aligned with the learning objectives of the topic.

Item 7: The teacher demonstrates an understanding of the goals and objectives for students' in a particular topic that they are teaching, and that is addressed in the national curriculum.		
	Criteria	**TPACK-OP PSTs 1-10**
0	Not Applicable	0
1	There might be some interesting facts, but they are trivial or inconsequential.	2
2	Main concepts are presented and somewhat aligned with the broader concepts of the curriculum goals and objectives at the grade level.	6
3	Main concepts are presented and substantially aligned with broader concepts of the curriculum goals and objectives at the grade level.	2
4	main concepts are presented and substantially aligned with broader concepts of the subject goals and objectives at higher grade levels	0
	Mean ($\bar{x}$)	2.00
Item 8: The instructional materials are relevant to teaching a particular domain of the subject matter and the general learning goals of the curriculum.		
	Criteria	**TPACK-OP PSTs 1-10**
0	Not Applicable	0
1	The teacher uses some materials, but they are trivial or inconsequential.	2
2	The teacher uses a limited range of materials and materials are somewhat aligned with learning objectives of topic.	5
3	The teacher uses a range of materials and materials are aligned with learning objectives of topic.	3
4	The teacher uses a range of materials which substantially aligned with learning objectives of topic.	0
	Mean ($\bar{x}$)	2.1

Table 7.11 Table showing the scores achieved by the pre-service teachers' in domain five; items seven and eight

The results from the TPACK-OP have shown that this cohort of pre-service teachers achieved a low level of TPACK. However, there were several conditions which may have contributed such as previous teaching experience, technological experience in teaching and number of years in degree programme.

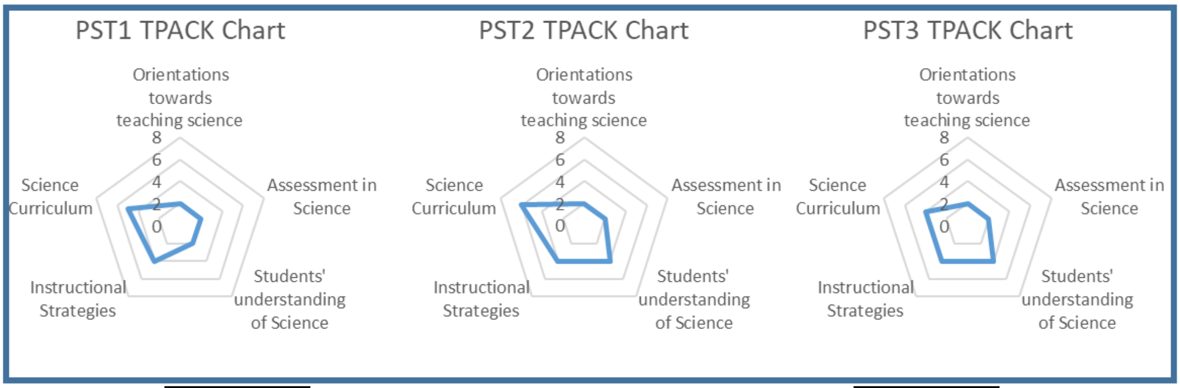
Table 7.12 below shows the collection of the above TPACK scores grouped by the pairing of pre-service teachers' during the observations where yellow was group A, blue was group B, light grey was group C, dark grey was group D and peach was group E. Firstly, it can be seen that no teacher achieves an eight in any of the items, the highest score was a seven achieved by PST 10 in item two, assessment in science. Several teachers attained a score of six in one of the items such as, PST 1 in knowledge of science curriculum, PST 6 and 7 in orientations towards teaching science and PST 10 in both of the previously mentioned items. The item of students' understanding of science and instructional strategies were mostly scored in the average range with all but two teachers' scoring a four in both items. Orientations towards teaching science and assessment in science were the worst scored items garnering mostly below average scores.

Teacher	Item 1	Item 2	Item 3	Item 5	Item 6	Item 7	Item 8	T. Avg
PST 1	1	1	1	1	2	2	3	1.57
PST 2	1	1	1	2	2	3	3	1.86
PST 3	1	1	1	2	2	2	2	1.57
PST 4	2	1	1	2	1	1	1	1.29
PST 5	2	1	1	2	2	1	1	1.43
PST 6	3	2	2	2	2	2	2	2.14
PST 7	3	2	2	2	2	2	2	2.14
PST 8	1	2	1	2	2	2	2	1.71
PST 9	1	2	1	2	2	2	2	1.71
PST 10	3	3	4	2	2	3	3	2.86
Mean	1.8	1.6	1.5	1.9	1.9	2	2.1	1.83
St. Dev	0.92	0.70	0.97	0.32	0.32	0.67	0.74	

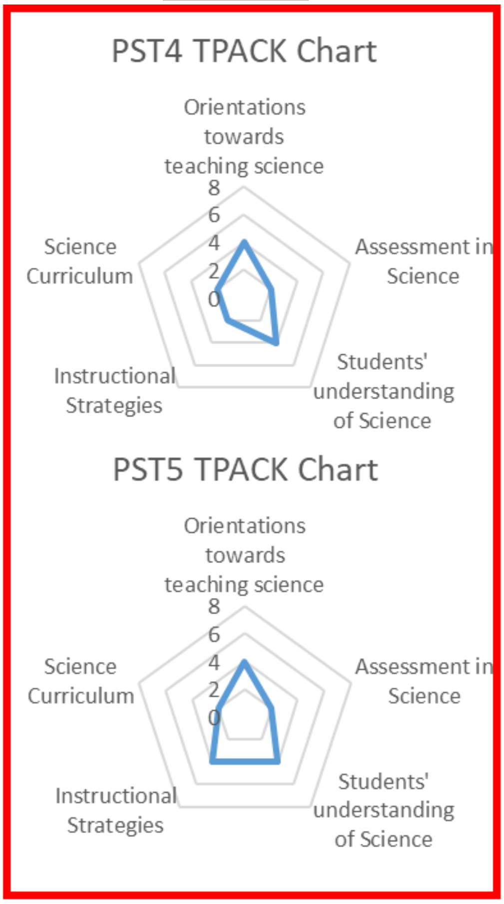
Table 7.12 Table containing the scores (0-4) from the PSTs observations

Figure 7.11 below, displays the TPACK displacement charts of each PSTs in their groups. This chart is a visual representation of the results in table 7.8 and shows the progress made thus far and highlights the domains for development. Examining the figures several observations can be made. Firstly, even though lessons were planned and developed together, within groups there can be variation between the teachers', highlighting the different levels observed. However, in the groups (3 and 4) where the lesson fragments were identical, so too were the TPACK displacement charts. It was already shown in table 7.8 that these PSTs generally had a below average level of TPACK and these charts show that their overall development is clustered and resembles that of a novice teacher.

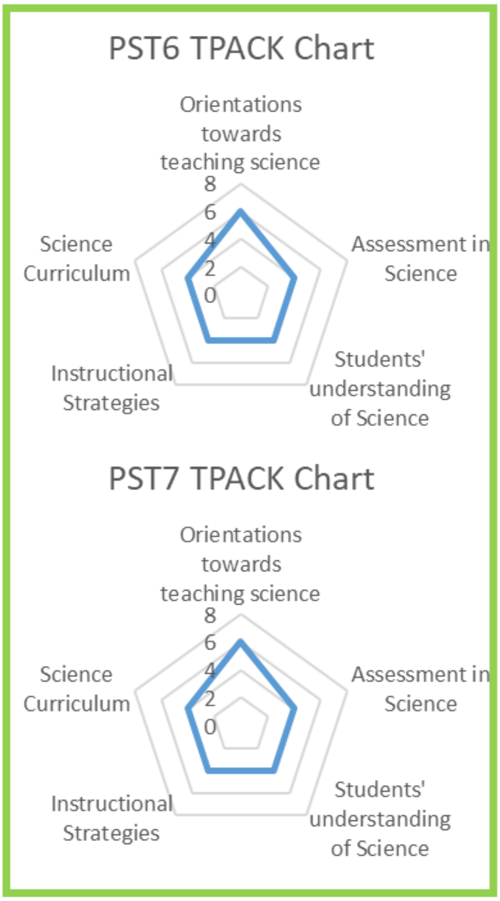
Group A



Group B



Group C



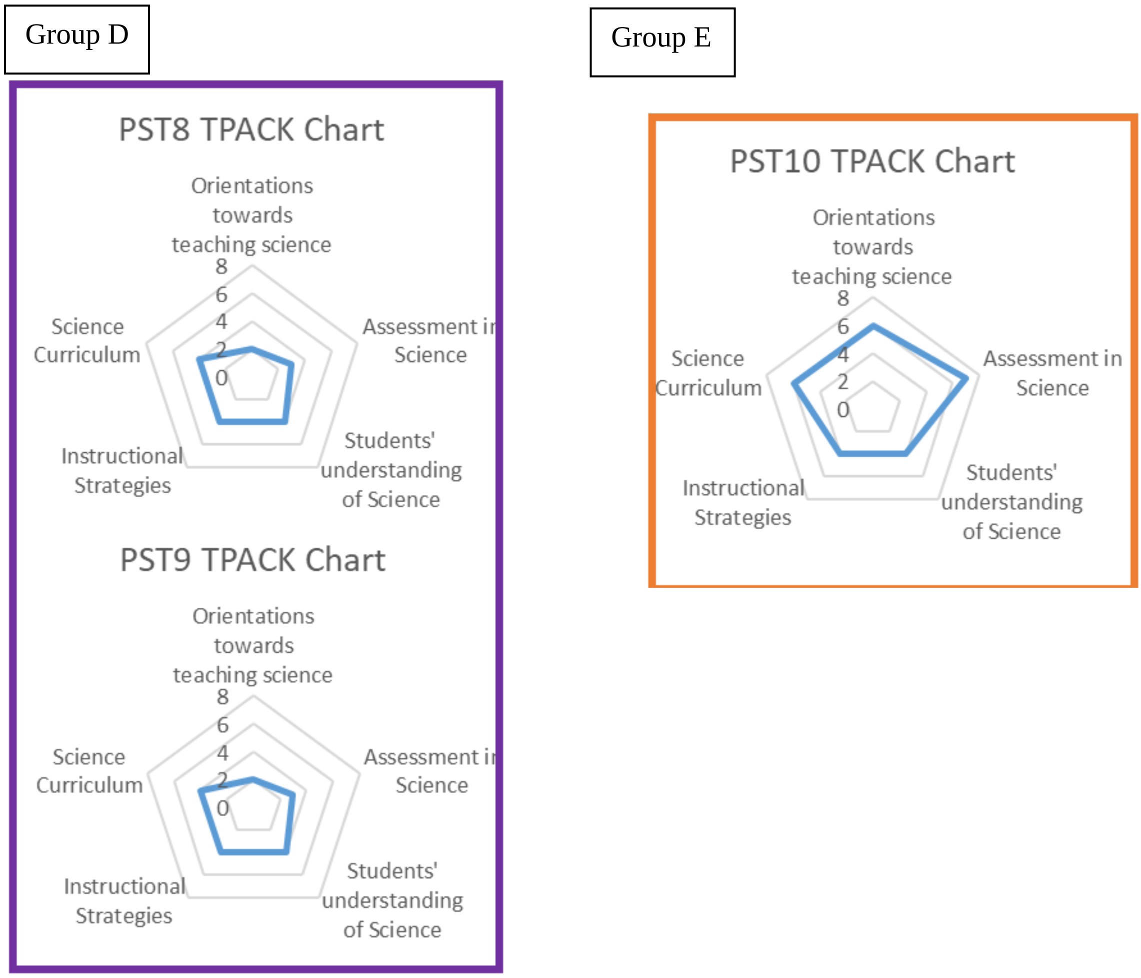


Figure 7.11 TPACK displacement charts for PSTs 1 - 10 arranged by their groups

At the end of the module the PSTs were invited to participate in exit interviews as their group. The next section will present the results obtained from the interviews.

7.7.3 PST Interviews

The PSTs were invited to participate in exit interviews at the conclusion of the module. All of the PSTs agreed to participate, and interviews were conducted in the groups designated for microteaching. The interview was semi structured in nature and included an agree/disagree section.

The interview began by asking the pre-service teachers' if they felt more motivated to use technology in their teaching. The most common response was that the PSTs felt more motivated as a result of participation in this module. PSTS cited being introduced to new technologies and tools as a major beneficial factor. PST 6 however was sceptical of the use of technology citing issues they experienced in school as a student:

"*The school I came from you couldn't rely on anything so then because of that I just learned not to use it. I am aware that there are more technologies out there that I wouldn't have known about, but I still wouldn't really have wanted to use it*."

When asked what issues they experienced in school the PST responded:

"*The internet never worked. If you could get it working two days in a row that was great, and it was always really slow when it did. The electricity always went, and all our lab equipment was all broken and nothing really worked.*"

Asked about what motivates them to use technology in their teaching the PST mostly commented on the belief that students would benefit from the change in stimulus and increase their interest in the learning. Some PSTs spoke about how technology enables them to customise their lessons as well as the perceived ease at which it allows differentiation between the higher ability students' and weaker ability students'.

"*As we have been shown before there are so many different applications you can use to demonstrate different points to convey information indifferent ways is pretty much what you want to do with education because not everyone learns the same way, so it is differentiation for the higher or lower students' is probably best with the diversity of technology which is essential*." (PST 4).

Teachers' were then asked to consider what challenges they believe they might face when using technology in their future teaching career. Two issues were prominent in the teachers' responses, the first was the technical capabilities of the school and their willingness to adopt technology while the second was access to resources and time. Surprisingly, when asked what support these PSTs feel they would need to integrate technology in their careers the majority responded stating they believe they won't need support:

"*I don't really think you need that much support, like if it is there you can figure out how to use it yourself and then you are grand.*" (PST 6).

During the interview with PST 1 and 2 they raised an interesting point concerning planning for technology lessons. The question was put to them "*You said you would look up new technologies, applications and other tools, where do you think you'll get the time to do this*?" to which PST2 responded

"*Probably in the evening. I don't think you get much free time. You only have a couple of hours a day, like in January [teaching placement] we only have a couple of hours a day*".

PST1 jumped in on the end of the sentence to add their perspective:

"*To be honest I think if there was a course or something available or somewhere you could go for an afternoon and be shown an application or something I would go. I feel like I would have to be shown it. Obviously, I would look stuff up myself, but I would like to be shown I as well think.*"

During the interview each PST was asked to comment on what they felt was the benefit to completing this module and for the majority of the teachers' it was the exposure to different tools, technologies and the time given to evaluating and testing tools for appropriateness within the classroom setting:

"*there are so many more exciting, entertaining and interactive things*" (PST10)

"*Well I never knew how to code, I know more about certain things, like I had never really heard of Phet. Even doing that Phet simulation on chemistry, that is very useful too and things like that*" (PST 4)

"*I think we have just learned more about the different resources we can use, obviously they are technological resources… I kind of learned that there is different ways that you can use the technology, like you can base the whole class around it and make the students learn from it or just use it as part of the class. It doesn't have to take over the class, but it can be a big part of it without taking over.*" (PST 2)

The final series of questions were identical to those carried out at the end of the exit interviews with teachers' in case study two of this thesis. Each of the teachers were asked to respond individually to each of these questions. Table 7.13 displays the answers collected from each PST where their responses were numbered to represent

1) Strongly disagree
2) Disagree
3) Uncertain
4) Agree
5) Strongly agree.

In general, the teachers tended provide similar responses with a few exceptions. Most notably is PST6s response to question 4 I think technology and ICT skills were not needed in my teaching. PST 6 responded with A and provided this explanation:

"*Agree, they are not necessarily needed, you can implement them in your teaching, but you don't need them to teach*"

It is an interesting response considering the teacher appears to be answering from a literal perspective, while the teacher recognises that you can use technology to teach, a teacher does not require it to teach. This is the same PST who tended to display more negative attitudes towards technology mostly due to their bad experiences as a student in school with technology. Questions six, seven, eight and nine all provided a variety of responses from the pre-service teachers'. For example, in question six, two of the pre-service teachers', four and five felt they were currently unsure how to ask higher order questions which could be seen in their microteaching session. In fact, even though pre-service teachers' six and eight disagreed with the statement, they did not ask a single higher order question during their observation lesson. pre-service teachers' one and two were unsure and again, there was no evidence present in their observations to support. Question seven was one of the more undecisive questions with the teachers' answering agree/disagree or uncertain. Question eight, was answered in the majority as disagree, which means these pre-service teachers did not feel inadequate as a teacher if they did not know the answer to a student's questions. However, pre-service teachers' 1 and 2 agreed with the response, and of all the pre-service teachers' these teachers attained one of the lower scores within the group, possibly highlighting these teachers' understandable lack of confidence this early into their studies and their teaching career. Question nine was the other mixed response with only three teachers' disagreeing with the statement

"*I am uncomfortable with asking questions in my class where I am unsure of the answer myself.*".

One interesting answer provided by PST 6 was that they felt you shouldn't ask students' a question in which you haven't fully prepared an answer. It was put to them to consider an instance where a student asks a question distantly related to the content but so much so that the teacher does not immediately have the answer to which the teacher agreed but felt that the teacher should be prepared for all possible questions that may be asked.

Question	PST1	PST2	PST4	PST5	PST6	PST8	PST10
Q1. I think the use of technology is appropriate to achieving the aims of the curriculum.	A	A	A	A	A	A	SA
Q2. I think teaching with technology is only suitable for very capable students'?	D	D	D	SD	D	D	SD
Q3. I think technology takes up too much time for me to implement.	D	D	D	D	D	D	SD
Q4. I think technology and ICT skills are not needed in my teaching.	D	D	SD	D	A	D	SD
Q5. If a student gives an unexpected answer I immediately tell the student, the right answer	D	D	D	D	D	D	D
Q6. I am unsure how to ask students' higher order questions that promote thinking.	U	U	A	A	D	D	D
Q7. I find it difficult to manage a classroom where each student group is doing different activities.	A	A	U	U	D	U	D
Q8. If I don't know the answer to students' questions I feel inadequate as a teacher.	A	A	D	D	D	D	SD
Q9. I am uncomfortable with asking questions in my class where I am unsure of the answer myself.	A	A	SA	D	SD	A	D
Q10. I often show students' the relevance of my subject in a broader context	A	A	A	SA	A	A	A
Q11. I think a quiet classroom is generally needed for effective learning	D	D	D	D	D	D	SD

Table 7.13 Summary of responses from PSTs in the final set of interview questions

The results so far have indicated that at this early stage of the pre-service teachers' careers, their attainment of TPACK is quite low and that they hold a mostly positive view towards teaching and teaching with technology. The following section will discuss these findings.

7.8 Discussion.

This section of the chapter will draw upon the results and directly answer the following two pre-service teacher research questions as outlined in chapter three.

1. How do pre-service teachers with no technology integration experience, use technology in their classroom practice?
2. What support do pre-service teachers' need in order to improve their technology integration in classroom practice?

7.8.1 How do pre-service teachers with no technology integration experience, use technology in their classroom practice?

To answer the first research question, we must discuss the results from the classroom interactions and the TPACK-OP.

Figure 7.12 contains all the pre-service teachers' classroom interactions. As discussed in the results section several of the pre-service teachers tended to use what has been identified so far as a traditional approach to teaching - teacher led introduction followed by student centred work/task and either subsequent teacher directed follow-up, or a teacher led wrap up. The assignments and class work developed by the researcher focused on creating resources to encourage the pre-service teachers to implement student-centred tasks. It is evident from figure 7.12 that there was still a high accumulation of teacher-directed interactions. One explanation for this could be due to their level of mastery and experience with teaching (Canbazoglu Bilici, Guzey and Yamak, 2016). While there was no evidence of studies which examined classroom interactions within the context of TPACK, it is clear from the data that these teachers' do not yet possess sufficient pedagogical knowledge to utilise the range of pedagogical practices available to them and as such, rely on teaching via the apprentice of observations (Lortie, 2002). It should be noted that these novice teachers', with no classroom experience, were still able to develop lessons which incorporated sections of active learning via the integration of technology. This is important since research has shown that active learning strategies tend to increase students' motivation, enthusiasm and confidence (Freeman *et al.*, 2014).

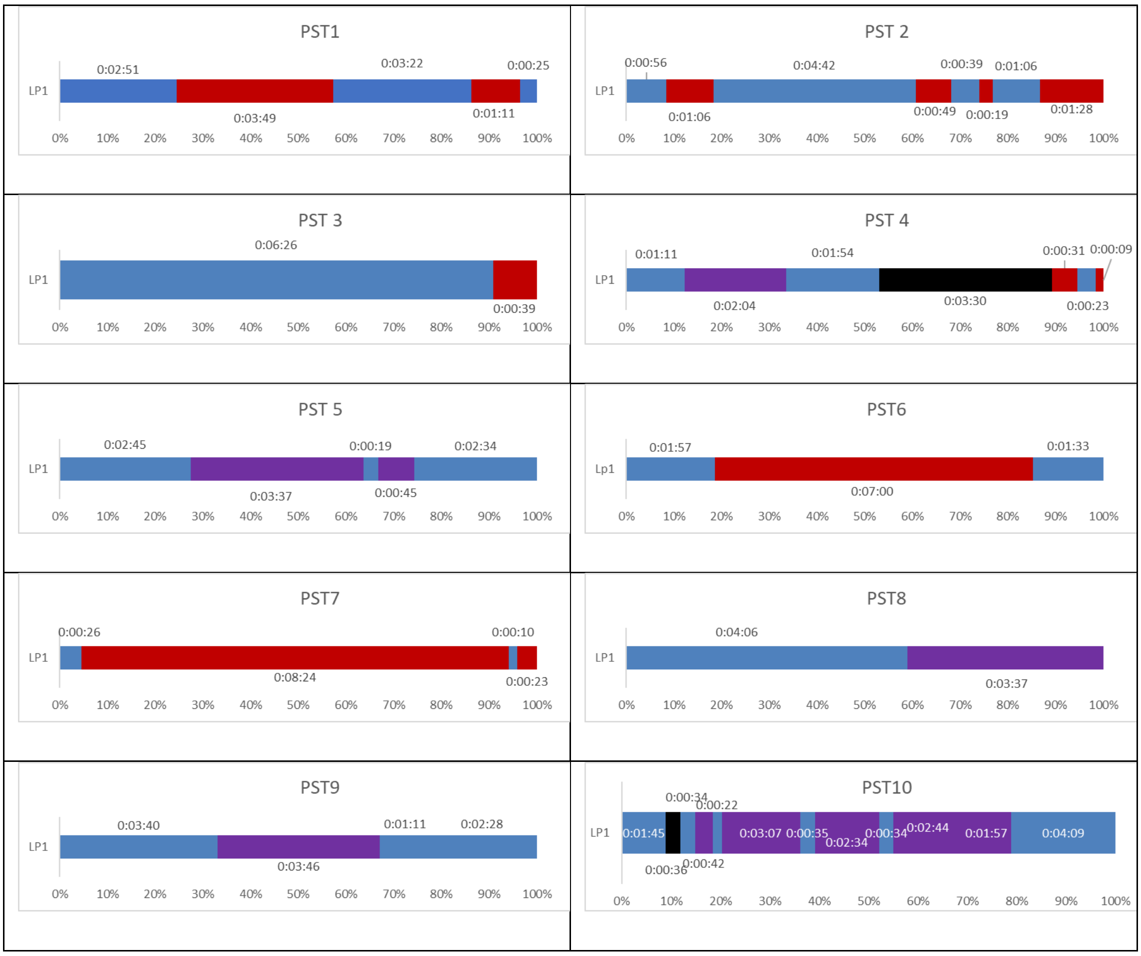


Figure 7.12 Graphic containing all PSTs classroom interactions

Examining the TPACK-OP results shown in figure 7.11 it can be seen that the majority of pre-service teachers attained a low level of TPACK. While one study conducted by Canbazoglu Bilici, Guzey and Yamak (2016) examined pre-service teachers' TPACK development via a teaching with technology module, a comparison could not be made for one reason. The pre-service teachers' in the Canbazoglu Bilici, Guzey and Yamak (2016) study were fourth year post graduate students' with prior teaching experience in addition to their bachelor degrees in science. However, it is worth noting that on average, this cohort of Irish pre-service teachers' were, on average, one whole point behind those in Canbazoglu Bilici, Guzey and Yamak (2016). Suggesting that while more work needed to be done to improve these scores, they were in a good starting position with two years left in their teaching qualifications. The findings from the TPACK-OP and understandings from the classroom interactions show that the pre-service teachers with no technology integration experience, used technology in a low-level form such that their overall levels of TPACK were quite low. They tended to use singular technological tools which became the focus of the lesson and were unable to utilise higher order questioning to challenge their cohort of students'.

7.8.2 What support do pre-service teachers' need in order to improve their technology integration in classroom practice?

To answer this research question, evidence was collected from the exit interviews. Thematic analysis was conducted in the transcribed interviews as previously described in both case studies one and two. The resulting mind map in figure 7.13 was generated from the coding scheme in NVivo 10.

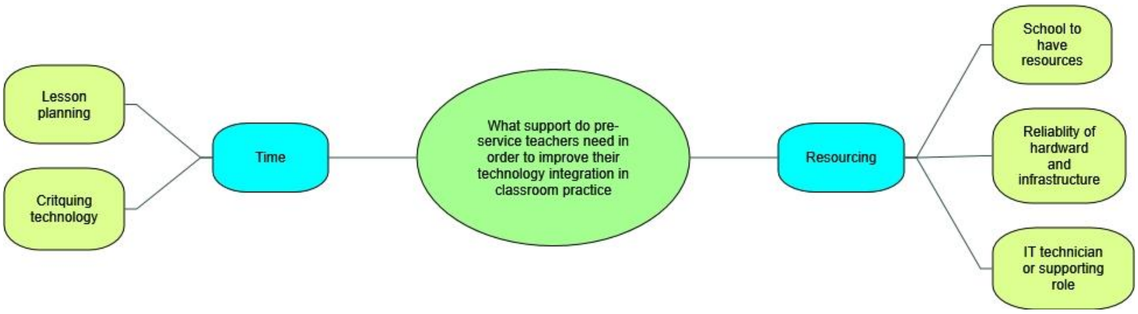


Figure 7.13 Mind map of the final codes and themes generated from the exit interviews.

From the exit interviews two themes where established. These were: time and resourcing. It should be noted that these pre-service teachers were asked to consider what potential challenges they may face when they integrate technology into their future teaching. Therefore, the themes and barriers presented were assumptions; assumptions which were known issues they may face in their careers (Ertmer, 1999; Ertmer *et al.*, 2012; Wang, 2017). Additionally, most of the literature reviewed by the researcher does not discuss future challenges pre-service teachers' may face and as such, most references were to in-service journal articles.

The first theme identified was time. Time has consistently been viewed as a major barrier to teachers' ability to integrate technology effectively into their classroom practice (Kopcha, 2012; Wang, 2017). For example, PST2 felt that they only time they would have to source and develop technology enabled lessons would be in their evenings:

"Probably in the evening. I don't think you get much free time. You only have a couple of hours a day, like in January [teaching placement] we only have a couple of hours a day"

It can be seen from the quote above that unlike previous teacher statements on time, this was more measured. The pre-service teacher recognised that their only available opportunity to plan these lessons will be in their free time after school. Another teacher, PST 2 stated:

"*Mostly people don't have the time or don't want to allocate the time to it and they can't find things that work as well as they want them to in their classes, but that is the same idea of just needing to spend the time on it*."

A bigger, and more impactful barrier to this cohort of future teachers was resourcing. The majority of pre-service teachers' in this study felt that access to hardware, reliability of the schools' hardware and infrastructure and having a person dedicated to supporting the technology were key challenges they were likely to face in their futures as teachers'. One of the main issues the pre-service teachers noted was access to hardware and computer rooms, which were issues they themselves faced as students'.

"*Yeah so like whether or not the school permits access to computer rooms, like if the computer room is just full every time you have a particular class, that could limit getting the kids to work on it. But then also finding the resources, if you don't know about a particular resource and if you don't go out and search for it that can limit your use of it.*" (PST 10).

The above quote captures the essence of what the majority of these pre-service teachers' felt regarding access to hardware within schools. While literature has shown a reduction to access of hardware as a barrier (Ertmer, 1999; Kopcha, 2012), it is still an issue with just under one third (236 out of the 750) of secondary schools being identified as "*digital schools of distinction*" (Digital Schools of Distinction, 2018).

Interestingly, one issue arose which was unexpected, support from an IT technician or dedicated member of staff (See "*A-post*" position comment in section 6.8.5). Several of the pre-service teachers mentioned how having one would reduce the likely hood of barriers to their integration.

"*I think having someone you can ask questions to even if you don't need them to make the stuff for you, but having someone you can ask questions or if there is a little thing that you are stuck on I think is always useful…*" (PST 10)

"*having someone there that you can just ask…*" (PST1)

7.8.3 Outcomes of PSTs Module

The final section of this discussion will discuss the benefits and challenges faced by pre-service teachers' and the researcher in implementing this technology infused module. As discussed in section 7.4.2, there were three aims set out for this module. These were:

(I) To develop pre-service teachers' TPK, TCK and TK.

(II) To provide opportunities for pre-service teachers to engage with a variety of technologies, software and applications.

(III) To provide an opportunity for pre-service teachers to plan, implement and reflect on a microteaching lesson where technology was appropriately integrated.

This was to be achieved by using a variety of teaching methods, exposing the pre-service teachers to a range of tools, software and teaching methods applicable to Science teaching in the Irish setting and providing the students with an opportunity to practice these skills in a microteaching environment. There studies within the literature that cite how undergraduate programmes tend to approach pre-service technology course via the content based approach to teaching with technology, i.e. showing teachers' applications which can help to teach the content rather than understand the concept (Lambert, Gong and Cuper, 2008). The approach used in this module was not conducive to evaluating the PST progression of TPACK as a result of enrolling in this module, instead, the approach was to provide the pre-service teachers with a variety of quality experiences to enhance their content-specific technologies and knowledge (CK, TCK, PCK) and their general technologies (TK). Whereas previous studies have focused on pre-post testing, self-reporting or survey instruments (Lambert, Gong and Cuper, 2008; Graham, Tripp and Wentworth, 2009; Harris and Hofer, 2011) this study utilised observations and interviews to evaluate the successfulness of the module.

In the exit interviews students were overwhelming positive with respect to the content within the course, the delivery of the course and the opportunities it provided them in terms of utilising different technologies, tools and software. One of the main areas pre-service teachers reported a positive change in was their confidence in using and teaching with technology:

"*even being more confident in looking for ways to change things or looking for ways to make something more suited to what you needed it for is definitely something I would do more now*" (PST 10)

One question students were asked was what worked well in the module. Here were a few examples of the responses received.

"*I love the way we actually got to explore the applications and then we got to make them based on something but for me critiquing it was very valuable. So, I think anything I would change would be not having to do the same topic for every single one of them because that just got a bit tedious. If you could pick a topic, it has its benefits doing the same topic because you can compare it better but then if you pick a topic sometimes it just does not fit in with a particular application and you kind of felt you were a bit restricted in that regard. But just being a bit more flexible and saying this is my main topic but I am just going to do this one this week because it suits better.*" (PST 10)

"*Yeah, I kind of learned that there is different ways that you can use the technology, like you can base the whole class around it and make the students' learn from it or just use it as part of the class. It doesn't have to take over the class, but it can be a big part of it without taking over*" (PST 2)

It can be seen that the pre-service teachers' valued the range of technologies and tools presented to them which made them feel more confident in teaching with technology, a finding previous stated that by Canbazoglu Bilici, Guzey and Yamak (2016) that a variety of quality tools is critical to helping students' feel confident in teaching with technology. Some students did suggest however, that since this was their first real experience with teaching, it would be beneficial if either more microteaching was offered or teaching with second level students was available.

"*We were just using it ourselves, but we never really taught it and you won't know until you teach it how you will do. You could have a perfectly good plan and then you go into a class and it just completely changes.*" (PST 8)

"*Yeah and I would like to practice with maybe 1st year students' like we did last year just to see what their reaction is as opposed to how college students' would react to it.*" (PST 6).

One student, PST 10 offered their opinion on what could improve the module. In their experience, they valued the critiques of the tools more so than the tools themselves and felt that each week they could focus on comparing previously used tools/resources as they might be more applicable now than in a previous lesson. They went on to clarify that while the tool may work well for a particular topic, it may not work in other topics. Examples of this could be seen throughout the teaching of the module as certain groups may have hated a particular tool because their topic did not naturally lend itself to the affordances of this tool, while others loved it for the opposite reason. Finally, PST10 also felt that the inclusion of a discussion either at the beginning of the lesson or end would give them an opportunity to see what their peers thought of that week's resource and to share their creations with others to give a greater sense of what is possible with each tool for different topics.

Finally, an interesting theme emerged from the data. While the initial interest was to identify the potential barriers and supports for pre-service teachers' in their future careers, it emerged that this cohort of pre-service teachers' felt empowered. The mind map contained below in figure 7.14 shows this theme and its codes of "*I like using technology*", "*make things the way I want them*", "*modification of resources*" and "*constantly look for new materials*".

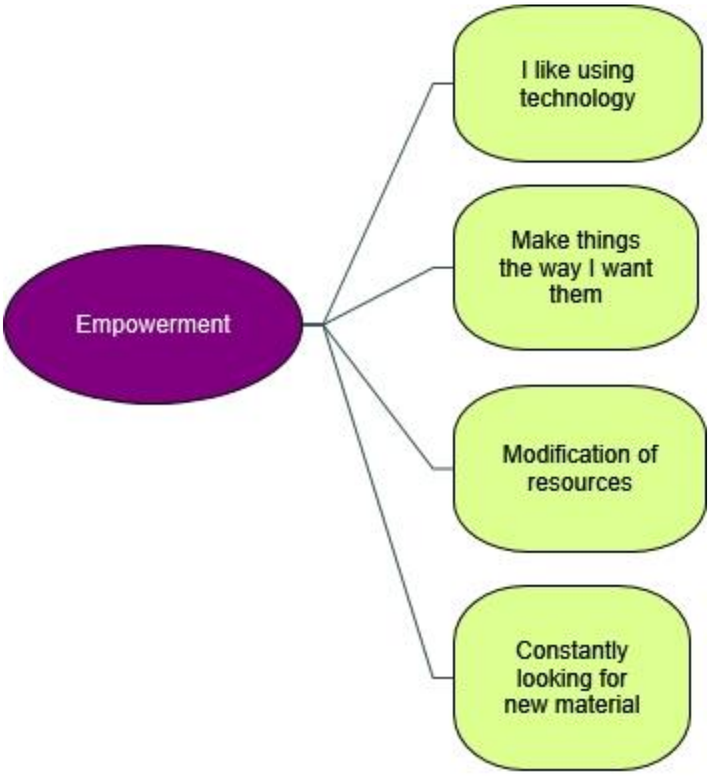


Figure 7.14 Mind map of the side theme of empowerment which emerged during thematic analysis of the pre-service data.

These codes emerged from the data as the pre-service teachers were frequently discussing their enjoyment of using technology and the potentially positive effects it may have on their students' learning. These teachers discussed how they were happy to make their own digital resources because once it was online it only required editing over time.

"*…like once they are online they are there and so you can constantly go back in and alter them so like it may be a lot of work initially, but it is not going to be a lot of work to modify it to suit the class as you become a more experienced teacher*." (PST 1)

"*the kind of thing that if you put a lot of work into at the start it makes it more applicable later on as well, so the work pays off almost*." (PST 10)

While some teachers', were happy to use technology because it was something they always did or were happy to invest more time into as they can see the benefit to the student and their learning.

"*I always kind of used technology to each anyway, it is a very useful resource*." (PST 4)

"*You use different forms of technology in the class and it kind of encourages the students' to learn more*" (PST 2)

Several studies had shown that pre-service teachers' were more willing to engage with technology as a result of participation in teaching with technology modules (Yildirim, 2000; Chai *et al.*, 2010), particularly technology infused modules (Buss *et al.*, 2018).

The results of this case study have shown that the technology infused methodology for improving pre-service teachers' TPACK was effective. Even though their levels of TPACK remained low, their attitude and beliefs regarding technology and technology integration were positive. The pre-service teachers praised the exposure to different types of technology, even to those they may never use again. These results compliment the literature which postulates that teachers' who view technology integration positively were more willing to use it in their own teaching (Wang, Lin and Liao, 2012; Wang, 2017; Buss *et al.*, 2018)

This study uniquely contributes findings on pre-service teachers' immature assumptions of their challenges they may face in their future teaching careers. The findings showed that the perceived challenges these pre-service teachers' believe they may face align with those identified in in-service research (Ertmer, 1999; Ertmer *et al.*, 2012; Wang, 2017)

7.9 Summary

In this study, 10 pre-service science teachers participated in a science technology infused methods course, which was designed to enhance their TPACK over a period of 10 weeks. The findings showed that this cohort of pre-service teachers demonstrated low to middle levels of TPACK in their microteaching lessons. The teachers utilised a lot of the technological tools which were taught over the course of the module, with one or two examples of tools not covered in the course. The pre-service teachers were observed as utilising a mixture of teacher-directed and student-centred classroom interactions with an even mix between individual student work and group work present.

The first eight weeks of the module introduced students to a variety of resources which the pre-service teachers' felt developed their confidence in teaching with technology. At the beginning of this study, pre-service teachers' TK were measured using the NorthStar Digital Literacy online test, the results showed that these pre-service teachers had mostly above average attainment of technological knowledge, however, specialised knowledge in excel and PowerPoint were below average.

Overall, the pre-service teachers' felt that through their participation in this module, they increased their confidence with technology, especially in teaching with technology. This was attributed to the exposure of different tools and technologies as well as the opportunity to develop a technology enabled lesson and perform the lesson to their peers. While no pre-post-tests was conducted to measure the effect of pre-service teachers' TPACK levels, previous research has indicated that pre-service teachers' TPACK levels increase when they were given the opportunity to practice and learn with technology tools (Guzey and Roehrig, 2008; Buss *et al.*, 2018). This study shows that a technology infused teaching approach, utilising a wide variety of technological tools has a positive impact on pre-service teachers' attitude towards teaching with technology and may have an impact on their TPACK levels.

Chapter 8 Discussion and Conclusion

This chapter summarises the findings from each of the case studies contained in chapters five, six and seven, as well as a cross case summary and finally implications for in-service and pre-service teachers' TPACK and use of technology in second level education.

8.1 Outcomes from Case Study One: School one

This three-year study was integrated as part of the SMARTCLASS initiative award from Intel Education in Ireland. The winning school was awarded a set of devices for each teacher and student in the first-year cohort of 2012/2013. The research began in the academic year 2013/14 after an initial attempt failed due to the incompatibility of the devices. The research consisted of three phases. Phase one began with a whole school approach which explored the teachers' attitude and beliefs towards, teaching, technology and teaching with technology as well as other relevant background information. Teachers' also participated in two workshops which were used to capture the subject departments wishes and wants for their students' and technology in their subject. Once these concepts were captured a list of technologies which were tested and identified as appropriate for integration were shown and tested by the teachers'. During this phase it was found that the teachers generally held a positive view of technology, teaching and teaching with technology. These teachers also rated themselves quite highly in terms of their attainment of 21st century skills especially in information synthesis, communication, lifelong learning, research and selecting appropriate learning tools. Ten teachers cited that they were never able to troubleshoot technology issues and nine stated they were unable to apply their current knowledge of technology to the learning of new technologies. In these two-technology related 21st century skills a much higher proportion of teachers were noted as selecting sometimes indicating that over fifty per cent of teachers were not comfortable with technology, in particular, new technologies.

The second phase examined how a small cohort of these teachers utilised the tools and knowledge gained from the two workshops into technology enabled pilot lessons. Nine teachers were initially observed and findings from these observations suggested that teachers needed more support than originally anticipated. Some of the lessons were cut short due to technical difficulties such as connecting to the internet. The majority however were of a low level of integration and contained teacher-directed interactions which were not conducive to constructivist learning. As a result of these observations, a second smaller cohort of teachers were asked to participate another round of observations which were heavily supported by the researcher. The lessons were planned, and resources designed for the majority of teachers by the researcher and these lessons demonstrated more student-centred learning interactions, teachers' felt more confident in using technology as a result.

The final phase of this study also known as case study one (chapter 5), expanded the core group of teachers to nine and each teacher was asked to develop up to three technology enabled lessons for observation. At least one lesson was observed from every teacher however, only three teachers completed three observations. The findings from these observations showed that teachers used a predictable lesson sequence; teacher introduction, student-activity, teacher intervention and/or answer gathering, continuation of student activity ended by teacher closure. Teachers' used a mixture of student group work or individual work, but rarely in the same lesson, or even across multiple lessons, i.e. a teacher would tend to stick to group work or individual work throughout their series of lessons. One teacher, S1T2 (Home Ec.) was observed running lessons which were teacher directed in nature allowing for minimal student interaction. In terms of TPACK scores, these teachers tended to be average overall with a wide variety of displacements. One major issue these teachers faced was with assessment as the majority of teachers failed to include some form of assessment in at least one of their lessons. In the lessons were assessment was included it was generally in the form of simple recall or low-level cognition such as knowledge or understand question types. Conversely, the strongest TPACK domain was in the teachers' understanding of their students' prior knowledge, indicating that the teachers were aware of students' prior knowledge and difficulties and were themselves knowledgeable enough to overcome any misconceptions present.

In the interviews it was found that teachers still perceive certain barriers to technology integration. The most frequently cited barrier was time. Teachers' felt that time was the deciding factor whether or not technology would be used. Time was coded into three different examples, preparation, exam pressure and administration. Time has been a major barrier identified in the literature as early as Ertmer (1999) and continues to be a major barrier to this day (Ertmer and Ottenbreit-Leftwich, 2013). The only other barrier cited by the teachers was device management, in several of the lessons devices were broken or their battery was depleted, teachers were understandably frustrated and even with device control handed to the teachers' and deputy principal, these issues were still prevalent. Finally, all teachers agreed that more professional development needs to be deployed and available to teachers to cater for all levels, currently most technology related professional development workshops either focus on a specific tool or were only aimed at the very basic of users. However, even if these workshops were available, teachers still cite time as a contributing factor to the low engagement levels seen in technological workshops.

8.2 Outcomes from case study two: School Two

This one-year study was conducted at the conclusion of case study one with the aim of examining the TPACK levels of teachers' in a school with no previous experience with tablet devices. School two is an urban post-primary school whom were selected to participate in the study due to their lack of experience in using tablet technology in teaching but expressed a desire to do so in the near future. At the beginning of the year an open call was made to the staff and a total of six members were chosen for participating in the project. These six teachers covered a range of subjects including History, Geography, Science, Business and Technical Graphics. Similar to the professional workshops run in school one, the participants in school two were provided with one full day of professional developing. This workshop included the administration of the NorthStar Digital Literacy Test, the four questions about the teachers' wishes and wants for their students' and finally some time to interact with various tools and software which were selected based on their usage in school one. After the professional development teachers were then asked to plan and develop at least two lessons in which they integrate technology. The teachers were provided with a set of 15 devices from the research centre which could be used as they see fit in their lessons.

All six teachers completed two observations, and these were analysed in accordance with the methodology set out in chapter three. The results from these observations showed that half of this cohort of teachers failed to include any form of assessment in their lessons. In the lessons which did include assessment, the majority scored four or more, there was one case were a teacher scored one. There was also a case in lesson of from S2T6 (Physics) were they scored an eight in the assessment domain. This was due to the inquiry-based nature of the lesson in which it was observed that one particular group of students were heard reasoning the law of the lever based on their experimental observations. Results from the classroom interactions showed that this particular cohort of also followed the predictable lesson sequence first observed in school one. It can also be seen from the results that these teachers' tended to utilise groupwork more so than individual student work, however, the teachers' were only provided with fifteen devices and even though the typical teacher-student ratio for post primary teachers' in Ireland is 15.7 (Department of Education and Skills, 2017) the average number of students' in these observed classes was 19. Half of these teachers were observed as conducting teacher-directed lessons accumulating a vast amount of teacher instruction through the lesson while the other half were student-centred lessons. One teacher conducted two lessons accumulating 100 per cent teacher direct interactions.

In their exit interviews this cohort of teachers once again highlighted time as a perceived barrier to integration. However, exam pressure was not mentioned as a barrier, instead it was the administrative duties associated with carting around, handing out and collecting the devices that was the major barrier, with teachers' citing that this resulted in short lessons and therefore could not cover as much content as needed. These teachers' also cited access to hardware as a barrier noting that having fifteen devices was not enough and more would be needed should the school buy-in to tablet devices. The most widely cited barrier however was professional development, the principal of school even highlighted it as a barrier to their teachers' ability to integrate technology effectively. Three of the teachers' expressed negative views on the professional development on offer to them, citing issues such as the level of the workshops (basic) and the focus on particular applications. While two teachers expressed neutral opinions citing that they were not aware of what professional development was available.

With time and professional development being highlighted cited by both cohorts of teachers' in studies one and two, it was decided that an intervention should be developed to target pre-service teachers'.

8.3 Outcome from case study three: Pre-service teachers'

Case study three was created in response to the results of studies one and two highlighting that professional development and time were key barriers hindering teachers' ability to integrate technology into their teaching. As such, a second-year undergraduate science teaching methods course was designed with three guiding aims in mind.

1. to develop pre-service teachers' TPK, TCK and TK.
2. to provide opportunities for pre-service teachers to engage with a variety of technologies, software and applications.
3. to provide an opportunity for pre-service teachers to plan, implement and reflect on a microteaching lesson where technology was appropriately integrated.

To achieve these aims, the ten enrolled pre-service teachers participated in a 10-week teaching and learning methods course where they utilised technological tools. These tools were selected by the researcher and organised into themes around key skills and competencies as highlighted in the Junior Certificate Key Skills Framework (Department of Education, 2015). After several weeks of content, the pre-service teachers were provided with a planning week to develop in their groups a twenty-minute lesson utilising technology.

The results from the microteaching observations showed that the majority of pre-service teachers scored below average in all TPACK domains with two notable exceptions. The first was from PST7 who displayed an above average knowledge of orientations towards science teaching (domain one) rivalling the scores of most ISTs from studies one and two. The other notable exception was PST10 who scored average to above average in all domains and even outscored a significant proportion of ISTs from studies one and two. It should be noted however, that unlike the other nine pre-service teachers' who have no classroom experience, PST10 had completed an extra year in a previous teaching degree which included microteaching elements, and this may be an influencing factor. From their classroom interaction charts it could be seen that even these pre-service teachers followed the same lesson sequence observed in studies one and two, which is interesting given the fact that these lessons were team taught and not individual lessons. There was no bias towards individual or group work between this cohort of pre-service teachers'. Some pre-service teachers accumulated more teacher led instruction time than other showing some tendencies towards teacher-directed learning while others were comfortable allowing their students' the time to work in groups or individually. The results of these pre-service teachers were compared to a recent study similar in nature. The result of this comparison showed that the Irish pre-service teachers scored lower on average than the Turkish pre-service teachers', however, the Turkish teachers were further into their teacher education and covered more methodological and technology courses.

In their exit interviews the pre-service teachers highlighted how this module developed their confidence to use technology in teaching and provided them with key skills to critically assess whether a technology is suitable for inclusion in a lesson or not. The majority of pre-service teachers were noted as having a positive disposition towards technology with only one teacher bearing any negative view on teaching with technology and this was attributed to the previous bad experiences with technology as a student in post-primary education.

8.4 Addressing the research questions

This section will answer the research questions originally set out in chapter three. There were four questions in total. The first two examined in-service teachers' usage of technology, and the supports needed for further integration. These were addressed in case studies one and two. The last two research questions examined pre-service teachers' usage of technology and what supports they felt may be needed in their future careers. These were addressed in case study three. The four research questions addressed below are:

1. How do in-service teachers with minimal experience of technology integration, use technology in their classroom practice?
2. What support do in-service teachers' need in order to improve their technology integration in classroom practice?
3. How do pre-service teachers with no technology integration experience, use technology in their classroom practice?
4. What support do pre-service teachers' need in order to improve their technology integration in classroom practice?

8.4.1 How do in-service teachers with minimal experience of technology integration, use technology in their classroom practice?

In this section, I will draw from each case study with the in-service teacher cohorts in school one and school two. Since the methodological approach in each case was the same, i.e. the use of the TPACK-OP to measure TPACK attainment in with in-service teachers'.

In case studies one and two, two separate groups of in-service teachers were observed and measured using the TPACK-OP. These groups of teachers came from two different second level schools, across a range of subjects and experiences, but used the same devices with similar goals i.e. develop two or more lessons in which technology is used in ways not before achieved by the teacher. A table comparing the two groups TPACK displacement charts can be found in appendix D. Alternatively, the figures contained in appendix D can be found in sections 5.5 and 6.6.

As presented in chapters five and six there was little subject overlap between the teachers' in the two schools. The only overlap was between S1T29(History) and S2T2 (History) as both were observed during History lessons. Examining these two teachers' it can be seen that overall S1T29(History) has a much broader attainment of TPACK domains compared to S2T2 (History), they both however, have the same level of attainment in domain three, knowledge of students' understanding of subject specific knowledge. One thing is very clear from examining each of the charts in case studies one and two, (Chapters five and six), that no two teachers exhibited the same approach. In fact, even between lessons the approach adopted by the teachers' tended to be variable, with only S2T2 (History) and S2T3 (TG) being observed as attaining identical TPACK profiles in their lessons. In general, teachers struggled with technology enabled assessment, in most cases utilising low levels of cognition such as recall or knowledge questions. This presents a major issue, particularly if Ireland is to press forward with technology integration at second level. Research has shown that one of the most successful ways for students' to learn is through, personalised instruction which provides flexibility in assignments and pacing (Keefe, 2007). Furthermore, with advances in machine learning and increased interest in automating assessment and learner analytics, teachers' may face mounting pressure to utilise assessment which may not reflect best practice (Davies *et al.*, 2017). In a study of teachers' tablet integration strategies, ChanLin (2017) found that teachers' who successfully overcame the barriers to integration identified assessment strategies as an area for future development in their practice. While the results in case studies one and two showed teachers were below average for TPACK assessment, research should focus on how to integrate assessment practices for technology enabled classroom in Irish post-primary schools.

The majority of teachers displayed a strong attainment in domain one, showcasing that their lessons did not focus on transmitting facts to the students', rather, their lessons provided the students with an opportunity to engage with hands on activities. Surprisingly, teachers' knowledge of the curriculum and curriculum materials was quite low; however, it should be noted that the researcher is not a subject expert in all of the subjects observed and as such, even when consulting with the relevant curricula, the scores may not accurately reflect those given by a subject matter expert.

The findings from case studies one and two showed that this cohort of teachers', who had little to no previous experience of technology integration, generally attained average to low attainment of TPACK. The use of technology was mostly as a tool which their students' utilised to answer a prescribed set of questions (Lei and Zhao, 2007) or, as a platform for research (Bebell, Russell and O'Dwyer, 2004), using the internet to find resources and information to mostly create revision artefacts for themselves or other year groups (Bebell, Russell and O'Dwyer, 2004). In their study, ChanLin (2017) categorised four types of activities which were observed throughout the participating teachers' in their classroom practice. The TPACK Observation Protocol demonstrated that the participants in these studies have obtained low to average TPACK with some examples of excellent attainment in domains such as curriculum materials, orientations towards teaching their subject and in particular students' understanding of content. These results were similar to those found in Koh (2013), Ling Koh, Chai and Tay (2014) and ChanLin (2017). However, the results also found that assessment seems to be an area that requires immediate attention as a number of teachers often excluded any form of assessment or used low-level questioning such as knowledge and understand questioning from Blooms Taxonomy. Therefore, this work has shown that teachers with minimal technology integration experience, use technology in a low to mid-level manor, focussing on replacement of technology activities such as desk research, simple assessments and information retrieval. More work needs to be done examine whether assessment is indeed an issue worth address, but findings from this work point to it being a current problem.

8.4.2 What support do in-service teachers' need in order to improve their technology integration in classroom practice?

The results from case studies one and two found that in-service teachers cited two major barriers that have, and will continue to, hinder their ability to integrate technology. These were: time and professional development (Ertmer, 1999; Kopcha, 2012). Time was cited in several formats including, exam pressure, preparation and administration. Teachers'' felt that the added time require to plan and implement technology enabled lessons reduced the amount of class contact time available which in turn would have a negative impact on the amount of content covered in class thereby creating undue pressure to accelerate the pace of the lessons to ensure adequate exam preparation. A similar result was found in ChanLin (2017). In their study of tablet technology adoption processes, one barrier was "*time and effort needed*" (p. 1948). This in turn had a direct impact on teachers' participation in the study, similar to concerns raised in case study one. In relation to exam pressure, while lower second level students' face terminal exams in their final year, the issue of exam pressure is not an uncommon one in the research, but it is often cited in the context of time (Zurlo, Pes and Cooper, 2007; Kyriacou and Sutcliffe, 2011) or achieving curricula aims and objectives (ChanLin, 2017). Should we wish for teachers' to succeed in embedding technology into their teaching practices, more needs to be done at governmental level (Ertmer and Ottenbreit-Leftwich, 2013). One of the most effective ways to increase teachers' chances of successful integration is through professional development (Lawless and Pellegrino, 2007; Choudhary and Bhardwaj, 2011; Bradshaw, Twining and Walsh, 2012). Nearly every single IST highlighted the perceived dearth of professional development available to them. Some teachers' felt that the professional development workshops were either tailored to a basic user of technology or focused too heavily on one tool or piece of software. While those who could be identified as a basic user were unaware of the courses on offer or lack the time required to attend such workshops. This dichotomy of users identifies a serious issue in how professional development is structured and presented to teachers' of all levels (Guskey, 2002). The results from case studies one and two clearly show that more needs to be done to decrease the amount of time teachers spend on, or at least were perceived to spend on planning and implementing technology enabled lessons. To achieve this, teachers' should engage in professional development which is structured and tailored to their experience levels (Donnelly, McGarr and O'Reilly, 2011). Professional development also needs to allow teachers' to experience technology as a learner so that they may begin to change their own attitudes and beliefs (Guskey, 2002) which will lead to effective technology integration (Ertmer and Ottenbreit-Leftwich, 2013). At the time of writing the Professional Development Service for Teachers' (2017) website revealed that their current professional development offerings were advertised for the basic user. The majority of courses were now online and with four courses under the heading "*local face to face*" courses. These courses were:

- Creating digital resources – basic
- How to use subject specific tools - basic
- Applying the interactive whiteboard tools available in your school – basic
- Use of online tools for ICT co-ordinating teachers'

It is clear from the list above that not only were the course aimed at beginners, but the titles offer little to no insight into what the course entails. There is however, a clear focus on using specific applications and creating resources possibly using said applications which is in line with teacher feedback. Teachers' in school one stated a need to see first-hand use of technology or examples of best practice. In line with the results obtained from case study three, the inclusion of a critical analysis framework when selecting technologies could be of benefit especially as it cuts down on the time needed in the planning phases by teachers'. Another step which could be taken to improve the quality of technology integration is to address the issue of time. We have just stated that the inclusion of a framework for evaluation the viability of a piece of technology in a lesson may reduce the time teachers spend planning technology enabled lessons. However, the issue of exam pressure and administration of the devices would not be addressed. In their study Liu (2011) commented on the culture of high performance expectancy in end examinations in Taiwan - and to some extent the same may be true in Ireland. The "*points race*" in their final year of post-primary education for a position at third level, and the inclusion of league tables were indicators that high performance is desirable in end of education exams. This often leads to teachers' abandoning their constructivist approaches to teaching and resorting to more traditional methods (Liu, 2011). However, it was noticed in the results of study one that teachers' firmly hold this belief that technology speeds up administrative tasks but slows down learning. However, as seen in S2T6 (Physics) lesson one, students' can derive their own understanding of a concept which is more fulfilling to the student (Buckner and Kim, 2013). It has been documented that using higher order thinking skills can improve learning (Lam, 2011), however, the teachers' in these studies tended to use lower levels of thinking, which may result in the perception that technology is slower than traditional learning. One way to reduce this belief is through participation in workshops Guskey (2002). In his paper, Guskey (2002) states that teachers' beliefs and attitudes will only change once they have experienced a change in their students' learning. Therefore, and continuing from the first point in this section, a programme of sustained and substantial professional developed is warranted to improve the quality of technology integration in Irish second level education.

8.4.3 How do pre-service teachers with no experience of technology integration, use technology in their classroom practice?

In case study three the pre-service teachers competed a 10-week technology infused module which had three aims.

(I) To develop pre-service teachers' TPK, TCK and TK.

(II) To provide opportunities for pre-service teachers to engage with a variety of technologies, software and applications.

(III) To provide an opportunity for pre-service teachers to plan, implement and reflect on a microteaching lesson where technology was appropriately integrated.

To achieve the aims of this module, the pre-service teachers were required to complete a 10-minute technology enabled observation which was assessed using the TPACK-OP. The results of the study found all but one pre-service teacher was observed as displaying low levels of TPACK attainment. The one exception was PST 10 whom had an extra year of college covered. While research has shown that pre-service teachers' who engaged in modules to develop their technology integration tended to display higher levels of TPACK (Koh and Divaharan, 2012; Mouza *et al.*, 2014; Canbazoglu Bilici, Guzey and Yamak, 2016; Buss *et al.*, 2018), this was not the case for this particular cohort of teachers'. One possible explanation was the difference between the pre-service teachers' in the research and those in this study. While the pre-service teachers' in case study three were second year undergraduate students' enrolled in a concurrent science and teaching programme, those in the research were often final year undergraduate students' or postgraduate students' obtaining a teaching qualification (Koh and Divaharan, 2012; Canbazoglu Bilici, Guzey and Yamak, 2016; Buss *et al.*, 2018). The implication – this cohort of pre-service teachers' TK, CK and PK were immature and underdeveloped compared to those in the literature. Nevertheless, enough data was collected this cohort of teachers to answer the research question.

The pre-service teachers' in case study three were observed as using low levels of technology integration, often using one technological tool which permeated the lesson. Where students were asked questions, they were simple recall or understanding question types. One could argue, since these pre-service teachers' knowledge domains were so immature, they relied on the apprentice of observation (Lortie, 2002) and imitated how they themselves were taught. It was anticipated that data would be collected from the pre-service teachers' two months after the conclusion of this module as this was when they were on school based placement. However, it was not possible for the researcher to collect this data and as such, inferences on the effect teaching placement may have had on their TPACK levels could not be made.

8.4.4 What support do pre-service teachers' need in order to improve their technology integration in classroom practice?

At the end of the 10-week, technology infused module, the pre-service teachers were invited to participate in an exit interview. During this interview the teachers were asked about their perceptions of the possible challenges they may face in their future careers regarding technology integration. While these teachers had no classroom experience, they still identified time as possible barrier to their integration. Time was coded as lesson planning and critiquing technology. Interestingly, while they identified time as a potential barrier, the teachers were still willing to put in that time and effort to develop technology enabled lessons, should they deem them appropriate to the aims of the lesson. This positivity was noted throughout the majority of the interviews and as such developed a separate theme known as empowerment. This cohort of teachers' felt empowered to use technology, not just because they were more confident in using it, but because they could see the appropriateness of some technologies and the potential benefits they could have on student learning. This result is actually somewhat back up by Buss *et al.*, (2018). They found that after participation in a technology infused TPACK module, the pre-service teachers reported having stronger beliefs and attitudes towards technology integration. The research has shown that participation in modules - such as the one used in case study three, have an overall positive impact on the development of pre-service teachers' TPACK and technology integration (Lambert, Gong and Cuper, 2008; Graham, Tripp and Wentworth, 2009; Koh and Frick, 2009). Therefore, to improve pre-service teachers' technology integration, more modules should adopt the technology infusion approach outlined by Buss *et al.*, (2018). The constant exposure to technology infused methodologies (Buss *et al.*, 2018), mixed with the ability to critique the use of technology (Greenhow, Dexter and Hughes, 2008) should prepare the pre-service teachers' to integrate technology into their classroom practice.

8.5 A critique of Technological Pedagogical Content Knowledge and a new framework for observing TPACK

This work heavily relied on the use of TPACK and the TPACK-OP develop by Canbazoglu Bilici, Guzey and Yamak (2016). As such, the author has developed a familiarity with the framework and over the years developed their own criticism of TPACK. These criticisms were mostly aimed at the operational functionality of TPACK-OP and the limitations of the instrument.

The first criticism was with the science specific nature of the framework. The framework was originally designed to be used with pre-service science teachers' and as such, the language and terminology used limited its functionality to science. While the framework was easily manipulated to be used for a wider audience, that itself brought its own set of problems. That problem highlighted the key role a subject matter expert in the observing of classroom practice. While the researcher could make judgements based on their own teaching experience, it was clear that certain domains heavily relied on expert knowledge of the subject in order to make these judgements valid. Therefore, while the TPACK-OP was modified into a multi-subject observation tool, its use cannot be limited to one researcher should we want to obtain empirical evidence from the tool. However, Niess *et al.*, (2009) aligned TPACK to a four theme framework which focuses on TPACK development across the subjects. Therefore, it would be advantageous to use Niess' model over TPACK-OP for cross subject observations.

The second criticism of the tool refers to its shortcomings. While the tool does accurately reflect the knowledge domains of TPACK, it does not present a method for capturing the level of technology integration and/or the level of cognition achieved within the lesson. It is the researcher's belief that these measures reflect the holistic and intricate nature of teaching and learning with technology. To address this issue, the researcher developed their own operational variant of TPACK-OP which integrated Bloom's Taxonomy (1956) to capture the cognitive aspect, and Hughes (2005) technology supported pedagogies to identify the level of technology integration achieved. While during the case studies these were seen as somewhat independent measures, it is the researcher's view that these actually form together to create a new variant of TPACK-OP, a more holistic framework – reflective of the intricate nature of teaching and learning. Additionally, this framework also address some of the major concerns regarding the SAMR model (Hamilton, Rosenberg and Akcaoglu, 2016). The SAMR model is seen as a technocentric model which encourages the teacher to use different forms of technology to climb up the SAMR taxonomy and disregards the pedagogical implications of such integration. The TPACK-OP shifts the focus back to pedagogy and the implications of technology integration. Below in figure 8.1 is a representation of the TPACK-OP framework developed as a result of the research conducted in this study. As can be seen in figure 8.1, the representation includes the displacement chart output which was generated from the TPACK-OP, it also includes the classroom interaction chart(s) and includes the level of technology integration and Bloom's achieved.

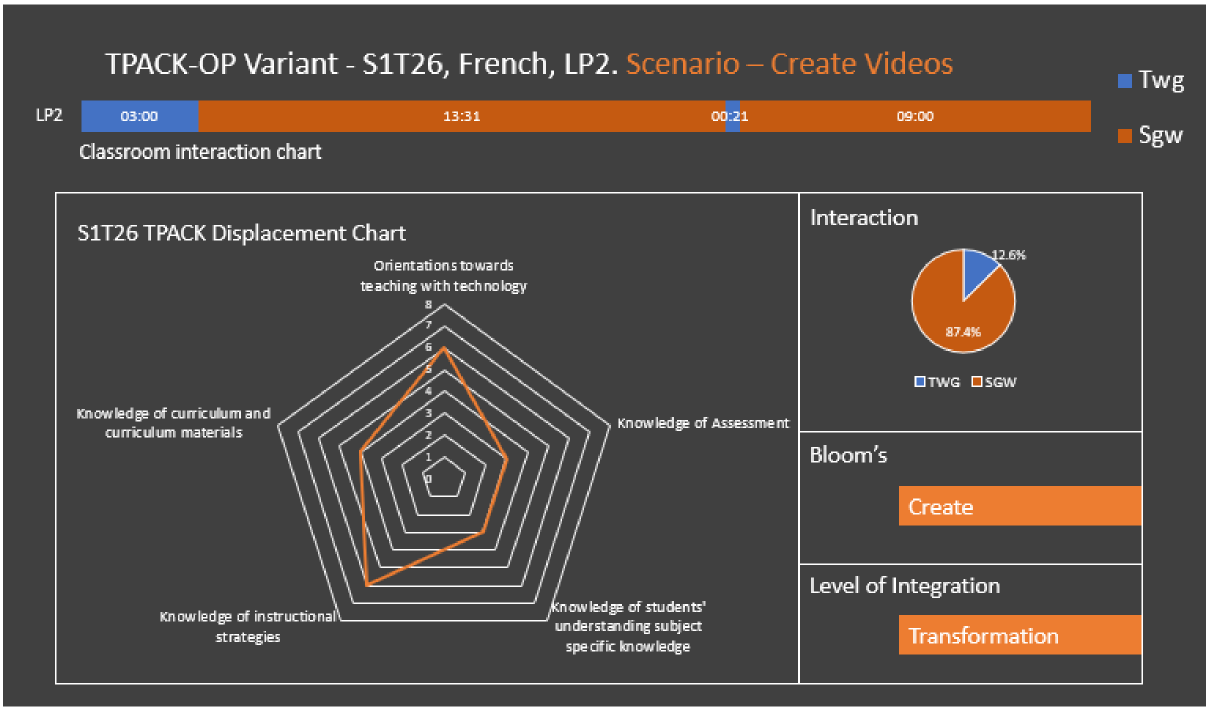


Figure 8.1 New variant of the TPACK-OP developed as a result of the research conducted in this thesis.

8.6 Limitations of Study

There were several limitations to this piece of research which will need to be addressed if future research were to be conducted.

As discussed in chapters four, five and six, teachers required significant support to be able to use technology in their teaching and when this support was not forthcoming, teachers found it difficult to continue with technology integration. Using this knowledge, the researcher originally planned to incorporate elements of co-design into the methodology of this study based on the recent work been done by Kyza and Nicolaidou (2017). In case study one it was planned that each of the nine teachers would "*recruit*" a co-design colleague to facilitate the development of more technology enabled lessons. While teachers' originally agreed and co-designers were found for each teacher, there was no engagement with one another or the researcher, as such this element of the research was removed for the subsequent study conducted in case study two. Teachers' cited time and other factors as reasons for not developing these lessons, further solidifying time as a major barrier to Irish second level teachers' technology integration. It would still provide an interesting research project especially considering participants in school two spoke about the lack of in-school support structures as well as the lack of appropriate professional development.

One general limitation to this study as a whole is that TPACK is still contested within literature research. Many studies have demonstrated that teachers' and students cannot differentiate between certain domains. For example teachers' cannot differentiate between TPK and TCK as the line appear to become blurred between them (Koh, Chai and Tsai, 2010). This debate also includes criticism regarding Shulman (1986) concept of PCK and as such researchers may be dismissive of TPACKS merits.

This analysis framework included in this thesis consisted of thematic analysis (Braun and Clarke, 2008), developing a case description and explanation building (Yin, 2009). One limitation of case study research is the extensive amount of time needed to conduct them which makes replication difficult to achieve (Yin, 2009). Another limitation is the small sample size means generalisations cannot be made to the wider population (Yin, 2009). The final limitation is to acknowledge that my own subjective bias may have influenced the analysis of the data, even though every step was taken to ensure the elimination of this bias, research has shown that researcher bias may still permeate throughout the analysis (Yin, 2009; Swanborn, 2010).

8.7 Implications and future research

In this thesis I have extensively used several frameworks and taxonomies to develop an operational framework for observing both pre- and in-service teachers' attainment of Technological Pedagogical Content Knowledge. These included:

- Hughes (2005) technology supported pedagogies
- Bloom's Taxonomy and
- Technological Pedagogical Content Knowledge Observation Protocol (Canbazoglu Bilici, Guzey and Yamak, 2016)

This newly developed observation protocol is the first of its kind to objectively measure the constructs of TPACK. Originally developed for second level pre-service science teachers', the TPACK-OP has been adapted to become an instrument which can be utilised in all subject areas as well as between pre-service and in-service teachers'. The research and analysis contained in this thesis further develops on this framework to add in the dimensions of classroom interaction and integration. The findings from case studies one, two and three shows that the framework can successfully distinguish between individual teachers' and also between specific teacher's lessons. Additionally, the inclusion of classroom interactions provides an overview of the type of lesson being observed; while the combination of Hughes (2005) technology supported pedagogy and Blooms Taxonomy of learning cognition provides clarity to the level at which the observed technology has been integrated as well as the cognitive load placed on students'. One interesting insight from the merging of these frameworks was the identification of an apparent link between the level of cognition and the level of technology integration.

This thesis examined how teachers' pedagogy influences their use of technology. It was found that teachers tended to adapt technology in line with current pedagogical practices, rather than enhance and explore new pedagogical knowledge. This raises the question of what can be accomplished with appropriate support for the teachers? The case studies found that with support from the researcher teachers were able to develop and implement lessons which incorporated at least replacement levels of technology integration. Moreover, the teachers' felt that with this support technology integration could be achievable. From these findings the researcher examined co-design methodology, however, it was not within the scope of this research to conduct such further studies. Instead, this research has laid bare the needs of Irish second level teachers' in their pursuit of technology integration. The findings of these studies should be used to examine how a co-design methodology could be deployed in lower second level to improve teachers' technology integration.

Finally, this thesis adds to the growing body of literature surrounding perceived barriers to integration. As Ertmer and Ottenbreit-Leftwich (2013) correctly stated, the majority of perceived barriers have been removed, especially extrinsic barriers. However, two barriers were still persistent within Irish in-service teachers', time and professional development. The research in these studies has shown that teachers were willing to use technology in their teaching but lack the time to plan these lessons as well as the necessary support from a professional development service. One of the most effective methods to overcoming these intrinsic barriers is through sustained and focused professional development. Guskey (2002) put forward a method for changing teachers' attitudes and beliefs. In this research he states that teachers' must first experience success with the prescribed change before they reassess their attitudes and beliefs. Whereas traditional professional development focusses on trying to win teachers' over and forcefully change their beliefs, often having the opposite effect on the participants, especially if their experiences in the classroom do not reflect the message of the professional development body (Guskey, 2002). The model of professional development proposed by Guskey (2002) could also be integrated with the Co-Design methodology which has been successfully implemented for science educators (Reiser *et al.*, 2000; Kyza and Nicolaidou, 2017). The work contained in this thesis presents the needs and wants of lower second level in-service teachers' and could be used by future researchers in the development of professional development which supports the development of teachers' technology integration.

Finally, the findings contained in chapter seven which examined the development and implementation of a second-year undergraduate teaching with technology module showed positive changes to pre-service teachers' attitudes and beliefs were made, paving the way for long term development of TPACK and ensuring future success. However, it was not within the scope of this study to follow up with this cohort of pre-service teachers'. One possible avenue for future research may be to conduct a longitudinal study on pre-service teachers' and track their development of TPACK throughout the course of their school-based work placements.

Chapter 9 References

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Appendix A Background teacher survey

Section A: Background Information

All information will be anonymised once completed

*Required

1. **Full name** *

   ____

2. **What is your gender?** *
   Tick all that apply.

   - [ ] Male
   - [ ] Female

3. **Which of the following do you currently hold?** *
   Tick all that apply.

   - [ ] Bachelor Degree
   - [ ] Masters Degree (Research)
   - [ ] Masters Degree (Taught)
   - [ ] Doctoral Degree
   - [ ] Other: ____________________

4. **Please give full title of degree(s)** *

   ____

5. **Please indicate which subjects you teach at Junior Cycle level** *

   ____
   ____
   ____
   ____
   ____

Section B: Target Cohort

The following questions should be answered focusing on a particular second year cohort identified as your target class. Pick the first class you have after 11am on a Tuesday with a second year cohort. This will be your target class. (If you do not teach on a Tuesday pick the next second year class you have after 11am Tuesdays)

6. **What is the name of the target cohort?** *
   Example: JC1, SC1, MOB2, etc.

   ____

7. **What subject is the target cohort?** *

   ____

8. **How many students are in this class?** *

9. **How would you describe the average ability of the students in this target class?** *
Mark only one oval per row.

	Much lower	Slightly lower	Same	Slightly higher	Much higher
Compared to other current second year students in this school					
Compared to previous second year students in this school					

10. **With this target cohort...** *
Mark only one oval per row.

	Not at all	About 25% of the classtime	About 50% of classtime	About 75% of classtime	All the time
I use lecture style presentations					
I present a short summary of the previous lesson					
I prompt students to recall specific knowledge					
I facilitate individual students learning					
I allow students to work individually with the worksheet/textbook					
I allow students to work in small groups to come up with a joint solution to a problem or task					
I allow students to work in groups based upon their ability					
I check by asking questions whether the subject matter has been understood					

11. **With this target cohort** *
Mark only one oval per row.

	Never	Every week	Every topic	Every term	Every year
I assign my students projects that require at least one week to complete					
I ask my students to write an essay in which they are expected to explain their thinking or reasoning at some length					
I hold a debate where students argue for a particular point of view which may not be their own					
I administer a test or quiz to assess their learning					

12. **What skills do you consider are important in your target cohorts subject?** *
E.g. Group work, Literacy, Numeracy, Organisation etc.

13. **With respect to your target cohort, please rank the previous skills in order of your perceived importance** *
For example 1) group work 2) Literacy etc..

14. **Explain how you address your highest ranked skill in your target cohort** *

15. **Do you believe technology, in particular 1:1 technology*, can improve with the attainment of your target cohorts key skills?** *
*1:1 technology is defined as one tablet/laptop per child
Tick all that apply.

- [ ] Yes
- [ ] No
- [ ] Undecided

16. **If undecided, please explain why.**

17. **If you used technology with the target class, please outline what you did.** *

18. **If you used technology in your target class, please outline what your students did** *

Section C: Experience With Technology

19. **Please indicate the level of your agreement with the following statements** *
*Technology Pedagogical Knowledge is the methodology of teaching with technology
Mark only one oval per row.

	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
The use of technology is appropriate to achieving the aims of the curriculum.					
Teaching with technology is only suitable for very capable students					
I think technology takes up too much time for me to implement.					
Technology and ICT skills are not needed in my teaching					
I need more training in technology and ICT skills					
I am interested in developing my technology skills					
I am interested in developing my Technology Pedagogical Knowledge (TPK)*					
There are sufficient Professional Development Courses available for Technology and ICT skills.					
There are sufficient Professional Development Courses available for Technology Pedagogical Knowledge					

20. **Briefly explain any experience you have with technology training** *
If you are currently using tablets in schools then answer this question with reference to the tablets.

21. **Briefly explain any experience you have with pedagogical technology training** *
This refers to any training you may have received which dealt with strategies for using technology effectively in your lessons

22. **Please indicate how you use technology for personal use** *
When answering this question please provide approx time spent

23. **Please indicate how you use technology for planning a lesson** *
When answering this question please provide approx time spent

Section D: Classroom Practice

24. **Please indicate how much you disagree or agree with each of the following statements.** *
Mark only one oval per row.

	Strongly disagree	Disagree	Uncertain	Agree	Strongly Agree
If a student gives an unexpected answer/result I immediately tell the students the right answer/result					
I am unsure how to ask students higher order questions that promotes thinking.					
I find it difficult to manage a classroom where each student group is doing different activities.					
If I don't know the answers to students questions I feel inadequate as a teacher					
I am uncomfortable with asking questions, in my class, where I am unsure of the answer myself.					
I often show students the relevance of my subject in a broader context					
I think a quiet classroom is generally needed for effective learning					

Section E: Collegial and management

25. **How often, if at all, do you do the following in the school?** *

Mark only one oval per row.

	Never	Less than once per year	Once per year	2-4 times per year	Monthly	Weekly
Discuss and decide on the selection of instructional media (textbooks, software, apps etc.)	⬭	⬭	⬭	⬭	⬭	⬭
Exchange teaching material with colleagues	⬭	⬭	⬭	⬭	⬭	⬭
Ensure common standards in evaluations for assessing student progress	⬭	⬭	⬭	⬭	⬭	⬭
Engage in a discussion about the learning development of specific students	⬭	⬭	⬭	⬭	⬭	⬭
Teach jointly as a team in the same class	⬭	⬭	⬭	⬭	⬭	⬭
Observe other teachers' classes and provide feedback	⬭	⬭	⬭	⬭	⬭	⬭
Engage in joint activities across different classes and age groups (e.g projects)	⬭	⬭	⬭	⬭	⬭	⬭
Discuss and coordinate homework practice across subjects	⬭	⬭	⬭	⬭	⬭	⬭

Section F: Your skills

26. **How would you rate yourself with respect to these 21st century skills?** *

Mark only one oval per row.

	Never	Sometimes	Often	Very often	Always
I can locate, organise, analyse, evaluate, synthesise and ethically use information from a variety of sources					
I am able to effectively select the information required from a body of text					
I can generate new ideas from information sourced online					
I can represent sourced information					
I can effectively communicate my ideas with others					
I can use models and simulations to explain complex issues					
I can identify trends and forecast possibilities					
I can process data and report results					
I can identify and define authentic problems					
I can collect and analyse data to identify solutions and/or make informed decisions					
I can use multiple processes and diverse perspectives to explore alternative solutions					
I demonstrate personal responsibility for lifelong learning					
I can select and use applications effectively and productively					
I can troubleshoot systems and applications					
I can transfer current technology knowledge to the learning of new technologies					

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Appendix B Overview of Case study one in-service teachers'

Teacher	Subject	Year	Time (mins)	Lesson Objectives	Observer Summary
S1T29	History	2	27	6. Identify the meaning of selective breeding. 7. Analyse the difference before and after. 8. Identify new inventions during the industrial revolution. 9. Analyse the impact of these inventions. 10. Why were these inventions necessary?	Teacher begins lesson be detailing the students' tasks; which consisted of several questions on a PowerPoint for students to research. Teacher quickly checks with the class if all their tablets are working before asking them to begin the research. As students begin task the teacher reminds students to put their answers into a PowerPoint. Before that however, they should put their answers down on a sheet of paper. While the students continue working the teachers ask the class "how could you narrow down your search?" "causes/images/identify" were shouted out. The teacher then asks students' to be more specific in their research and to now look up "the causes of the industrial revolution". After a couple of minutes, the teacher puts a question on the board and asks a student to come up and write down one answer. They repeat this with one other student. The teacher now gets the whole class's attention to the board. They begin going through the points on the board but in a narrative style. They link the points students wrote down together to make a compelling story; "why did we produce more food? To meet the increase in population" etc. The teacher now asks students to look up graphs/statistics during the industrial revolution. Students' begin the new task while the teacher examines some students' work and asks them to put their graph onto a PowerPoint opened on the teacher's pc. Once again, the teacher calls for the students' attention. They are now looking at the PowerPoint with information inputted from some students'. Students' resume task Teacher asks students' what they have found so far. After a brief discussion the teacher sets a new task; "what changes took place during the agricultural revolution?" Students' begin this new task and the teacher can be heard answering individual student's questions aloud for the benefit of others. Teacher ends recording themselves.
			29	To gain insight into the industrial revolution using data from online primary sources.	Teacher begins with a recap from the last lesson. S1T29 is asking students' questions and their answers were written up on the board. The teacher then writes "where would you rather live, industrial England or Famine Ireland, going through the problems with

				• To compare and contrast the living and working conditions in Industrial England with Rural Ireland	both". The students are asked to go to the 1840s and show the differences between famine Ireland and industrial England and save their work to a PowerPoint. Students' now begin finding pictures online as the teacher walks around checking on each student. There is a problem with one students' tablet so S1T29 pairs the student with another one. After 10 minutes S1T29 asks a student to save their images to a USB and connect it to the desktop. The student shows their images on the projector and the teacher asks everyone to look at the board. Students' are then asked to show evidence supporting that the images depict famine Ireland. "No windows in house due to window tax". Another image is shown which now depicts London from the sea and students asked what changes occurred to London at this time. The final image shows a crowded poverty-stricken London street. Teacher makes a connection between what they have learned and the relevance to the junior certificate exam before asking their students to look up what the mortality rate was and to find any differences between children and adult rates. For the next three minutes students' research the mortality rates. S1T29 asks a student to lend them their tablet so they can show the class the graph the student found. The teacher spends a minute quoting some information from the graph. S1T29 explains how the mortality rate of children increased until 1910 then steadily declines due to the introduction of working rules regarding child labour. Students' asked to look up information on the life of a factory worker at this time for homework.
			33	To gain insight into the industrial revolution using data from online primary sources. • To compare and contrast the living and working conditions in Industrial England with Rural Ireland	Teacher begins this lesson by asking students to recap what they covered in last week's class. The teacher sets the task for today "you are a worker in industrial England around 1850, what is life and the working conditions like? How is life in the city, pastimes and entertainment"? Using online resources to create a mind map and essay. For the next seven and a half minutes the students' work on their task while the teacher walks around the room before sitting down at their desk to type up something. The teacher gets the students to look up at the board where there are pictures depicting the quick growth of factories and the pollution that came with it. While also showing how unchanged rural Ireland was at this time. For the next 14 and half minutes the students continue with their work. After seven minutes the teacher calls a student up to the top of the class where they are transferring files over to the desktop. Two minutes later another student goes to the top and transfers files, this is repeated with two more students'.

					Teacher calls for all students' attention and asks the student at the desktop to present their work and read from the slide they developed. Afterwards the teacher asks questions to the class about what was just read out. This is repeated twice more where each student is presenting different information
S1T12	Business Studies	1	20	4. To learn what is insurance 5. To understand how insurance works 6. To identify the different types of household insurance	Students' were directed to go to school.ie business section and launch the insurance lesson they were also asked to make sure volume is off. Students' begin the task as the teacher is walking around checking on each student. Students' are shouting out questions for the teacher to answer and the teacher encourages each student to help another if they are stuck. Teacher has to stop the activity to direct the students to the activity through the website. One student asks a question which S1T12 opens up to the class to answer, but S1T12 swiftly answers the question. Seven minutes later S1T12 asks students to power down the devices and bring them to the trolley while S1T12 puts them away. The teacher spends five minutes putting the devices away after which they begin asking students' around the room to see what key words they have learned from the exercise.
			25	3. To identify the different types of insurance available for households 4. To improve IT skills by communicating information on a poster	Class begins with a recall of the types of insurance. This then leads into the task which is to create a poster of the different types of insurance with pictures. Teacher highlights the key features of a poster such as the title. Students' will be given 20 minutes and teacher answers several questions. Students' begin task. The teacher can be seen/heard helping some students locate word on the pc. While students are working the teacher calls the role and then begins to walk around the classroom checking on each student. Every so often the teacher will speak to the group giving them advice or answer a student's question loudly enough for everyone to hear. While out of shot the teacher can be heard getting the students' attention. The teacher is at the projector and showing students' how to move and resize images in word and how to remove the outline from pictures. Students' continue with the task and the teacher has a quick glance around the classroom before sitting back down out of shot (printer can be heard going off beside camera). Teacher asks students to begin finishing up and to save their work and shut down the pcs. The teacher starts using flash cards with words on them, the students' put up their hands if they know what insurance that word covers and how it covers it. Words include health, life, auto and home.
			23	3. To understand the forms of business ownership available to businesses 4. To distinguish between limited and unlimited liability	Teacher tells students to go to business studies online and complete the ownership task. Students' begin the task while the teacher walks around and answers students' questions. When students' finish, they move onto crazy word search or crazy crossword. After 13 minutes the teacher asks students to power down their device and

					store them away. Two students bring the trolley back to the principal's office. Teacher begins recall exercise which is going through the crossword. Teacher notices a clue which students' may find hard to interpret and so explains further what it means.
S1T2	Home Economics	2	68	[redacted]	Teacher introduces new topic asks questions such as list, lower order and knowledge and recall: brainstorming. Teacher passes out hand-outs Students' fill in the hand-outs with the answers on the board and teacher's confirmation of answer. They appear to be filling in the answers from their earlier brainstorming session. "not overly asked in the exam"/" ask questions in a minute"/Look at the numbers and tell me which one is less". Students' are asked to get one tablet between two. Teacher then sets out the tasks, students are to go online and look up uses for cheese. The teacher provides them with the website to use where they can find the recipes. Once they have selected a few they are asked to find more on another website. In their groups of two the students are looking up recipes. While the students are working away S1T2 is addressing the whole group at the top of the class showing them where to find the recipes. Afterwards S1T2 gives out more hand-outs. After several minutes the students are told to find 8 recipes and write down their answers (the food in which cheese is used) into the hand-outs. Teacher then reminds the students to go to other websites as well. The teacher now looks for feedback from the students' and writes their answers on the whiteboard. Class then goes quiet for three minutes before teacher begins to write down the classifications of cheese. The teacher gets the students to move to the back of the class where several cheeses are out on a cheese board. Teacher then shows examples of hard/soft cheese etc. and allows the students to taste them. Teacher then gives the students' work sheet with a crossword on it and says it's a race to finish it the fastest. Students' work in pairs to complete the crossword as fast as possible. Teacher goes through the answers for the crossword. Teacher sets new task: students to look up countries and their cheese (Ireland, Italy, UK, France) Students' start task while teacher walks around to ensure they are on task. As students begin to finish up the teacher asks them to shut down the tablets.

				[redacted]	Teacher asks students to begin putting away the devices. Then asks the students to give two cheeses from each of the countries. Teaching then gives out homework and students begin to pack up.
			34	[redacted]	Open lesson with the learning objectives Asks students' questions to gauge their previous knowledge in respect to what they will cover in today's lesson. At the five-minute mark the teacher asks students to read from the PowerPoint slide, students are also asked to copy the points on a slide into the hand-outs they have. Teacher begins asking lower order questions again Teacher sets students' the task of finding out how cheese is made and to evaluate the website they use. Teacher suggests students' use the search term "how cheese is made". Students' start searching online for the common steps involved in cheese making and are asked to write these steps onto the hand-out they have. Teacher asks the students to stop and begins to hand out more sheets of paper to the students'. Students' read their answers and the teacher asks other groups to confirm if they have the same steps etc. The teacher then plays a video on the projector and asks students to watch carefully and fill out the answers to the questions on the sheet. Students' watch the video and answer the questions on the sheet. During the video the teacher signals to the students to power down the devices. Teacher checks the answers from the students', all of which are recall questions. Teacher returns to PowerPoint and asks students to copy down the content on a slide. Students' set homework.
S1T4	Art	2	66	[redacted]	As students' come into the class the teacher asks them to pick up a laptop, go to their seats and power on the device. After a few minutes the teacher calls for the students' attention at the board where S1T4 asks students' questions about graphic designing and designers. Teacher then shows five examples of graphic designs which use a personalized font. The students' task is to create their own graphic design and personalized font using their name. S1T4 then spends seven minutes going through how Pilar works. Over the next 46 minutes the students are working away on the task. At several stages S1T4 can be heard assisting students as required. With two minutes left of the task, S1T4 asks all students to walk around and view each-others work.

				[redacted]	For the next minute and a half S1T4 asks the students about their preference of tablets over laptops. Students' prefer tablets, but teacher explains how they were inappropriate to use for Pixlar. The final four minutes of class are spent tidying away the laptops
S1T34	Physical Education	2	31	5. Demonstrate the skills of basketball to each student's best ability. 6. Demonstrate the application of these basketball skills in a game situation. 7. Work together to ensure each student is able to create a movie clip that best demonstrates their basketball skills. 8. Make the best use of the tablet in recording and then observing, analysing and refining their individual work. 9. To assist the students' both in the best use of the tablet during the class.	The lesson begins with S1T34 instructing the students on today's task. It should be noted that while not in shot, there are a set of instructions written on a whiteboard. It is also quite difficult to hear the conversations which are going on. One student from each group of three is asked to grab a tablet. When the groups return the teacher gives each group individual instructions before they go off and record their skill demonstrations. For the next twenty minutes the groups begin their task which is to record each member performing one of the several key basketball skills listed by S1T34.While the students are performing their skills the teacher can be seen walking around to each group and assisting them with their recording or skill. The groups can be seen reviewing their recordings after each skill and some can be seen re-recording certain skills to improve the video. In the final four minutes of the lesson the teacher calls all students to the middle of the hall to sit down. One member from each group puts the basketballs away. The teacher asks the students to take note of the number on their tablet because on Thursday another teacher will show the students' how to edit the videos together to showcase their skills. Students' then shut down the devices and store them back in the cabinet.
S1T26	French	2	28	3. To reinforce vocabulary of "les meubles/pieces" (furniture/rooms) in French. 4. That pupils (in pairs) will create a word document containing each item in French / images and cost for a particular room in the house.	Teacher begins the class by detailing what the task is to the students' in French. Using the tablets, the groups then begin the task by going to the IKEA.fr website After several minutes the teacher draws the students' attention to let them know there are eight minutes left to complete the task. Students' resume the task and six minutes later S1T26 asks students to complete the task for homework. To do this, students' have to save their work onto a USB or email it to themselves.
			26	3. To reinforce vocabulary of "Les Prépositions" in French. 4. That pupils (in pairs) will create a video dialogue to further encourage conversational skills and understanding of key words...	During the opening few minutes of the lesson, S1T26 performs a recall task of the prepositions with the students' as well as detailing the task for the lesson. Over the next 13 minutes students broke into their groups and began placing props on/beside/under etc. tables/desks and recorded themselves using the preposition in a sentence. The teacher then reminds students to watch their videos and for the second

					member of the group to begin recording themselves speaking the prepositions. This continued for several more minutes before the class ends.
			27	3. To review and reinforce the vocabulary "Les Pièces" in French. 4. That pupils (in pairs) will create a poster displaying 'Une Maison Idéale" (as an A4 WORD document)	At the start of the lesson, S1T26 called the role before moving some students' around the classroom. S1T26 then conversed with the students' in French to set out their task for the class. During the group work segment, several students approached S1T26 with their tablets. These devices turned out to either be faulty or not charged. Near the end of class-time S1T26 asked the students to complete the poster for homework and to submit it via email before the Sunday of that week. Students' then wrote up their homework and put the devices back in the trolley before leaving the room.
S1T18	Spanish	1	31	3. Recognise and interpret new words and phrases in Spanish 4. Express/communicate ideas related to 'I like/ I don't like' using some new words and phrases	Teacher begins class by picking two students to get the tablets and pass one out between two students'. While this is happening, the teacher is writing on the whiteboard. The teacher then gets the students' attention and details their task which can be found in a post on Edmodo. After they finish detailing the task the teacher remarks that there isn't a full class and asks that all student have a device each now. The role is then called, and students are asked to leave their homework on the desk. Teacher goes to whiteboard once again speaking in Spanish before letting the students' attempt the task. As students are working away on the task the teacher can be seen walking around the classroom helping students solve technological issues. After several minutes the teacher removes the affected devices and asks students' to once again work together. Teacher still walking around and checking student's homework. For the final five minutes of class the teacher asks two students to put the devices back and connect them to the chargers.
			25	3. Recognise and interpret phrases that use the verb 'tenner' 4. Be able to express/communicate ideas that use 'tener' using some new words	Teacher begins class by calling the role and writing on the white board before speaking to the class in Spanish. S1T18 is asking students' questions in Spanish and they are answering back in Spanish. S118 then introduces a new word/verb and writes it on the board. The students' task will be focused on the verb to have. Teacher gives a student the homework sheets and asks them to pass it around. While this is happening the teacher logs into Edmodo and can be seen searching Google images. There is no clear instruction from the teacher that the task has begun then five minutes later the teacher turns on the projector with the Google image on display. Teacher then walks around the classroom and can be heard speaking to students' individually. This continues for five more minutes. For the final four minutes of the lesson the teacher focuses the students' attention to the Google image. S1T18 asks students to speak the word in the image. Teacher then

					asks students to translate some sentences before calling for the devices to be shut down.
S1T13	Irish	2	13	5. Search the internet and select pictures for movie. 6. Create a drobox account. 7. Save pictures onto drobox. 8. Order pictures	Teacher begins the lesson by going to the desktop and asking students to find windows movie maker and open a new project. Teacher then checks that everyone has it open and direct them to their drobox. S1T13 does this on the projector so students' can follow along. Teacher then allows students' time to import the files from drobox. Teacher walks around the classroom to check on student's progress. Teacher can be seen helping some students until the class ends at twelve minutes and forty seconds.
			34	[redacted]	Teacher begins lesson by asking students to open up drop box and windows movie maker. In today's lesson the students' will develop their picture sequence and line it up with their audio recording. The teacher then begins to circulate around the class and check on each student's progress. This continues for a significant portion of the lesson. The teacher eventually calls for the students' attention and begins speaking in Irish to them, the teacher then translates saying the students' need to save their work to drop box and finish it for homework. The next five minutes are spent with the students' saving their work while the teacher walks around to ensure everyone knows how to save the file to drop box. After a while the teacher goes to the projector to walk students' through how to save the files to drop box. The teacher ends the class by recapping what they did today and what their homework is for tonight.
S1T31	English	1	27	5. Become competent in the use of tablets to access Google Images 6. Competent in Word Document 7. Use prior knowledge of Media Studies to create a front cover template 8. Successfully create a front-page cover for a newspaper independently	Teacher begins class by walking students' through how to navigate the tablet. Teacher asks students to open word and then tell tells them what the task is. Students' are to design a front page of a newspaper and then S1T31 recaps the main sections of a front page. Teacher then tells the students' how to search for word as well as how to open the browser. Students' are given the option to do a pictorial front page or a written column. Most students agree to do a pictorial front age. Over the next 20 minutes the students begin the task individually as the teacher walks around the class. Some students are asking questions which are irrelevant to the class work, while another asks how to insert a text box. Teacher helps this student before addressing the class and detailing how to copy and paste images from the browser into word. One student can be heard helping another to format the page layout. Another student can be heard helping a peer with how to change the font size. Teacher then picks up the camera to show off some students' work. The bell interrupts the class and teacher asks students to take note of which device is the one they used so they can save their work on the tablet and resume the next day.

					Teacher reminds students to shut down devices and put them back on charge in the cabinet.
			29	6. Become competent in the use of tablets to access the Camera function 7. Work in pairs to create the report 8. Confident in the recording and storage of their activity 9. Use prior knowledge of Media Studies to create a news report to record 10. Successfully create a TV ready news report	This observation contained two video recordings. The first video was stopped by the teacher due to some misbehaviour by the students'. The first video mainly contains the instructions given by the teacher to the students' regarding the lesson. S1T31 explains how to record using the tablets and gives them an opportunity to record themselves being silly to get it out of their system. Students' are to work in pairs to record themselves speaking a news report. The report is to be recorded in front of the whole class with total silence. Teacher gives a 5 second countdown after which the first group records. Once completed the teacher asks the group to silently review their video and notice what mistakes were made and note how they could be corrected. The cycle is then repeated with all groups until the class ends.

Appendix C Overview of Case study two in-service teachers'

Teacher	Subject	Year	Time	Summary
S2T1	Geography	3	22:47	Lesson begins with teacher introducing the topic which is to put together a presentation on the earth, rivers and economy. Students' to include ten slides, diagrams, video clips etc and teacher has provided the success criteria. Teacher then goes through the criteria for the river presentation. Teichert hen goes through the primary economic things (fishing etc). Students' are to present to the class when finished. Students' begin task in their groups, creating the presentations. Teacher is walking around to the groups. Teacher interrupts class to let students know they are working in this lesson and another and will present in the third lesson. Students' begin task again. Teacher interrupts class again to remind students of task. It should be good enough, so students could revise with it for their Christmas exams Students' continue with their task Teacher asks students to ensure they save all their work. Then teacher gives students' the email address to which the students are to send the final presentation. Students' go back to task Teacher calls for student's attention again. Teacher talks to students about case studies and how important they are. Teacher then tells students' about finding case studies on the national broadcaster's website. Teacher tells students' they have one-minute left and they should save their work and turn off the devices. Students' start shutting down their devices and saving their work.
S2T1	Geography	3	20:28	Teacher introduces the lesson and how the presentations will work, including a q and a First group of students' present their presentation. Then a q and A starts at the end of their presentation which is chaired by the teacher. Teacher asks students' a question also Teacher calls for next group of students to setup for presentation. The video cuts off. Next group present followed by QandA camera cuts off just before teacher is about to set up for next group Teacher sets up for next class Third group presents their presentation.
S2T2	History	2	27:51	Class begins with teacher asking students to open PowerPoint and telling them in their first slide they need to put in the title age of exploration. And then to pick an explorer; "a presentation on the voyage of Christopher coulombs" Some students' are asking questions regarding the tablet and teacher has gone down to help them, while other students' ask questions. Teacher checks that students' have completed the task so far. Then has point on the board for students to discuss such as "navigation of the journey" etc. Find images and place in new slides etc.

				Teacher instructs students to do next slide and then walks over to a group to help with device issues and then helps other students' who have their hand raised. One student approaches teacher and teacher ask student to change devices. Clear some students' not comfortable with ppt and teacher is mainly helping with these issues. It appears some tablets don't have PowerPoint and there are issues connecting to the internet. Teacher does a quick check with the students' and then goes through additional points regarding the ships etc. Students' continue their work while teacher goes back to checking each group work so far. Teacher starts walking around asking students to write their names on a stick note and place it on the devices, so they can use it next week. Teacher gets class attention and asks them to save the PowerPoint to the tablet and ensure the sticker stays on the front of the tablet. Teacher then says if students' want they can email to themselves also. Teacher then asks for students to shut down the devices also and put them back on the trolley.
S2T2	History	2	17:08	Class begins with teacher handing out devices from last day as the students' come into the class. Teacher then gets the students' attention stating they want the students to finish the project today and gives additional details on what is expected from them. Students' begin task while teacher helps solve technical issues with someone's device, Teacher stops class to quickly call the role Teacher quickly recalls what is expected from the students' Students' are continuing with their work while the teacher walks around to each group ensuring they all understand the task. Teacher gets students' attention and asks students to save the files again and shut the devices down. Teacher goes on the explain how they were delayed and so will need to continue into another lesson.
S2T3	Technical Graphics	1	24:05	Lesson begins with teacher introducing solid works. Teacher talks how it is used in the industry. Then talks about how current sixth year group are designing blenders and how solid works allows the students to test certain aspects of the build to ensure it will work when built. teacher then tells students' their objectives which including introducing SW, opening the Interface and setting up a drawing sheet. Teacher then asks students to look up at the screen and shows them how to open the software. Teacher then goes through how to open a new drawing sheet. Teacher then runs through other introductions. Teacher waits for a minute or two while some students' laptops haven't loaded the software yet. Teacher then asks students to go to the left top plane. Teacher then goes through how to sketch. Teacher then asks s Teacher asks students to try the sketch rectangle on their own while the teacher walks around and checks. Teacher calls for classes attention as they are not following the instructions given to them. Teacher then Teacher correcting some discipline issues Teacher goes back to desktop to walk students' through the next steps in their sketches.

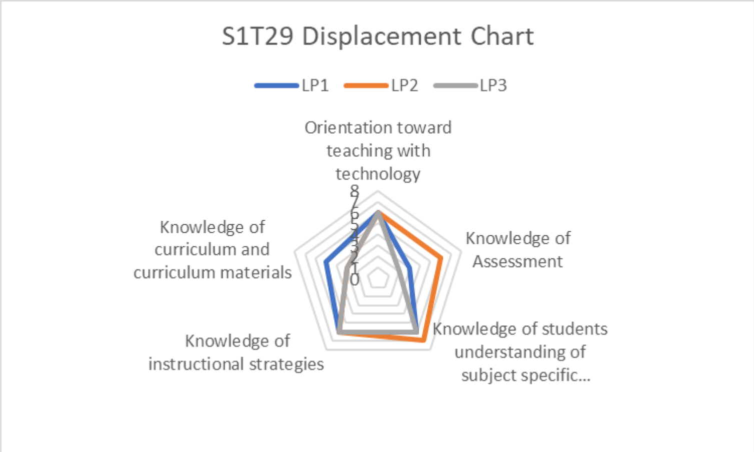
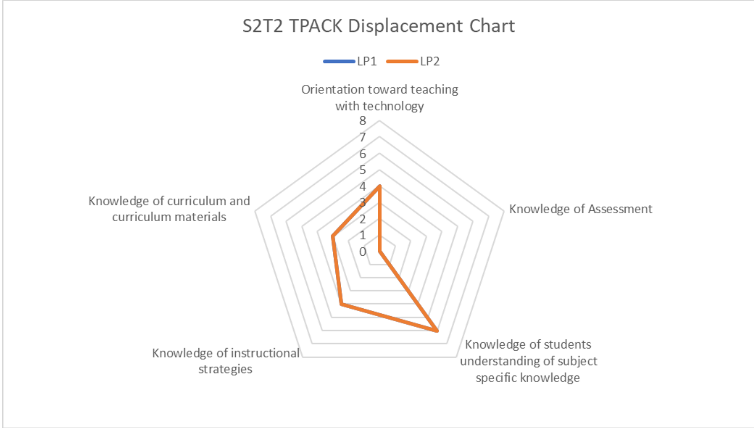
				Teacher walks around to see if students' have caught up to where they should be and then continue to the "side" Teacher then goes through the next part, but there are issues with some students' laptops. Teacher then moves onto the features section. Teacher asks students to mess around with the features section. Class ends.
S2T3	Technical Graphics	1	41:07	Lesson starts with teachers' introducing todays lessons objectives, sketch on a feature, draw shapes on feature and cut it away all of which is done in solid works. Teacher then recaps on what they did yesterday in solid works. Teacher continues through what they did yesterday, and teacher checks that all students' have their cube open from yesterday and teacher going to show them how to rename something. Teacher continues with the walkthrough. Teacher now talks about cutting a circle through the top of the cube. Student asks why sketch in 2d if it is a 3d image. teacher explains 2d becomes 3d after adding a feature. Teacher continues with walkthrough. Teacher checks who is where the teacher is currently. Teacher then checks on an individual student Teachers' set students' a brief task while the teacher is checking on a student. Students' to draw the centre line of the circle. Teacher then instructs the class to do another task in sold works. While teacher is walking around. Teacher gives some advice for circles that won't move. teacher goes back to desk and shows the students' how to draw the centre lines and how to leave the circle loose. Then shows how to make the circle coincident with the centre. Teacher then shows students' how to add a relation. Some students don't have the option appearing in their dialogue box. Teacher then shows how to extrude the cut and shows how the circle is removed from the 3d cube. Teacher walks down to a student to help them, no instructions given to class, but most appear to be following what the teacher just did. Teacher gets students' attention to recap on what they did. Teacher explains they'll do another day of solid works. Teacher goes back to helping students' will the others are continuing with their task. Class end
S2T4	Business Studies	2	30:09	Lesson begins with teacher calling for attention and explaining the task for today. They are revising bank statements by doing a quiz online and then teacher will go through the test results online and then finally go through a template in word for creating a bank reconciliation statement. Teacher now instructs students to go to internet explorer and go to Kahoot.ie and await further instructions. One groups tablet won't work so teacher swaps them out, another groups device is updating, and another doesn't seem to be working at all. Teacher then does a whole class check to see who is up and running. Teacher is asking some students to switch to the desktops if the tablets aren't working. Teacher then opens Kahoot quiz and asks students to put in the pin and their name as the ID. Teacher checks to see which groups are not connected and then explains how the Kahoot works. One student still has not joined but teacher needs to press ahead with the quiz. Students' don't appear to understand

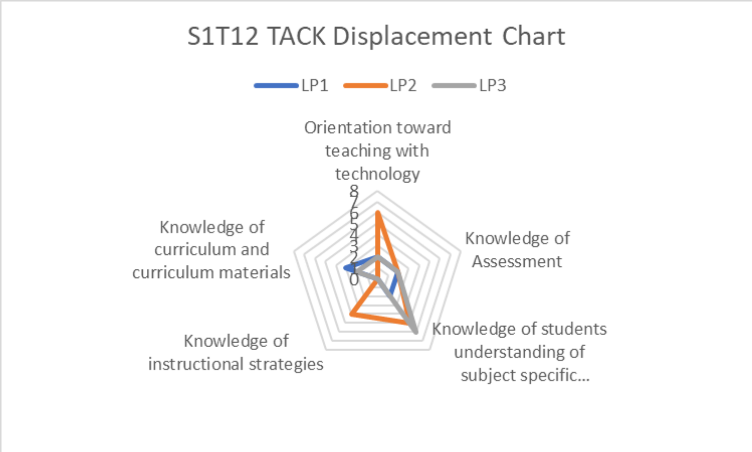
				how the quiz works during the first and second questions. Students' more engaged by the third questions, so far questions are simple recall. Questions continue to be understanding questions. During the quiz, the teacher starts handing out what appears to be homework or the results of a previous test. When the quiz finishes the teacher explains the quiz was a bit of fun because the test results were poor. Teacher then directs students to Edmodo to find the results of the test online. Some students are having issues connecting to Edmodo due to firewall, so teacher asks students to look up at the smartboard and shows students' where the question and solutions are. Teacher runs through the format of the test, questions and answers and talks students' though how to do the question. Teacher then explains how the Kahoot questions revolved around the test. Teacher now asks students to shut down the devices and put them back on the trolley. Teacher then talks about what they are doing in class tomorrow and details what they need to bring with them to class.
S2T4	Business Studies	2	28:02	Teacher begins class by quickly checking the roll. Teacher talks about how there seems to be some confusion on the household budget and as such the teacher wants to show students' a template on excel. The students are using the desktops in this lesson. Teacher realises that the wrong file is in the shard folder and is putting in the new updated file for the students to retrieve. The excel is based on a question which was set for homework the night before. Again, wrong file is added to shared folder, so teacher is finding the file. The excel is a recreation of the template in their book. Teacher then shows the students' how they created a formula for summing the costs and how they copied it down. Teacher then goes through how to add cells together to get the total estimate. Teacher then shows how they did the total expenditure. Teacher then says they need to type in for June to December. Explains how when adding to total it adds over all due to the auto sum function. Teacher pulls up the eBook and tells students' they need to read the question and write down in pencil the items to be added. For example, in June Person A gets a 4% increase so students are to work that out and add it where relevant in the excel. Teacher continues through the question and adding the information to excel. Class ends and recording stops.
S2T5	Science	3	23:47	Class begins with teacher telling students to open the Phet simulation and shows them on what they should be looking at on the projector. Teacher then asks students to take out their copies and draw a table (but also must correct students' quite a bit). Teacher is also drawing table on the smart board. Teacher then discuss what will happen in the simulation and what the table will be used for. Teacher then goes through how to use the simulation. One group don't know what to do so teacher goes down to show them. Teacher then discusses about the pH scale in the simulation. Teacher is walking students' through step by step what to do in the simulation. As they go through the different substances the teacher is checking with the group what the pH is.

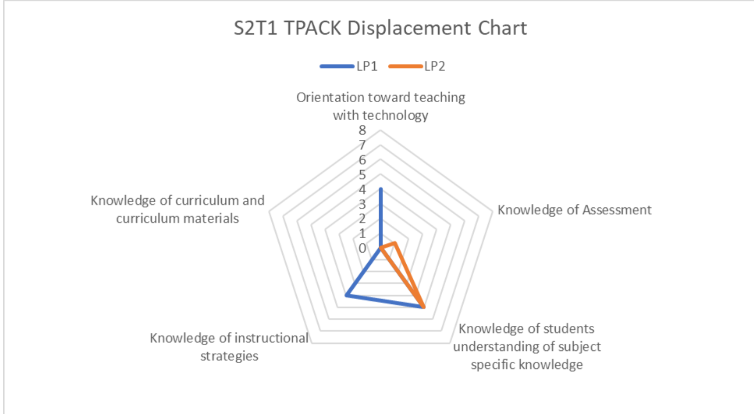
S2T5	Science	3	30:47	Teacher begins lesson by asking students to check their battery levels. One student claims "it was deleted", most likely referring to the Phet. Teacher then walks off camera whole the students are all chatting to one another. Teacher checks everyone has sim open and then goes to call the roll. Teacher opens a document on the projector (starts correcting students for behaviour). Then begins asking students for the pH values from the last day and is filling in the table on the smart board. Teacher then goes back to the simulation and discusses the OH and H ions in Phet. Then teacher tells students' what they have to do next. They are to follow the same table as last class. Teacher goes back to table and writes the volumes and red, blue in the tables, which students are to copy down. The class goes quiet for several minutes while students are writing down the table. Teacher now goes back to the sim and runs it, telling students' what to do and how to follow. teacher then talks about how to count the blue and red for the table. Students' then asked to count the red and blues and put them in their table. teacher then says move to 1.2 and do the same. Students' are left to count the Red dots Teacher tells students to switch to battery acid when finished with previous substance. Teacher explains how to do the blue counting this time. Students' are left to count the blue dots. Teacher then walks around the classroom Teacher quickly checks progress. Teacher then gives homework which is for students to use a phone/tablet/pc at home to look up the word hydronium.
S2T6	Science	1	43:45	Lesson begins with teacher checking if students are on the balancing act simulation. Teacher then checks on one group before checking all others are where they are supposed to be. Some devices are not working so teacher is trying to fix these issues. Teacher then calls the class to attention and asks if the students' want a tutorial on how to use the simulation or would they rather play around themselves. Students' take second option. Teacher then highlights a few points which they might miss if not shown. Students' are to answer the questions on the sheet by drawing their answers and then confirming with the simulation As the students receive their handout they start on their task. Students' are to work in pairs but answer individually. Teacher asks the group if anyone is not sure of what to do and if, so they can come down to a particular student whom the teacher is going to help. Teacher is helping two students' and the rest of the students are working away on the task again. Later when one group finish the task the teacher asks them did they notice any patterns. The students could describe the relationship between mass and distance. Teacher calls for attention and asks students to shut down and put the devices back on charge at the top of the room.

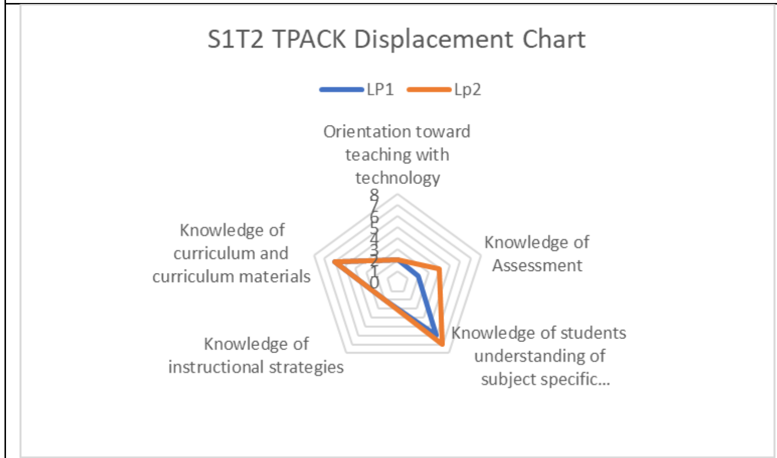
				teacher calls for attention again and congratulates the students’ and then spends the next few minutes looking for and receiving feedback on how the lesson went compared to their "normal" lessons.
S2T6	Mathematics	5	29:25	Teacher begins class by telling students’ the password to the tablets and then checking that everyone has signed in, but some students cannot sign in. Teacher organises the students into five groups of two with five people individuals. Each group shares a tablet between each other. Teacher then directs students to an activity file on the project maths page on complex numbers. While students are navigating the website, the teacher is handing out the worksheet. Students’ begin working on task which is to find the modulus of a complex number and use the website to plot and then draw the argand diagram, while teacher heads over to a student who still can’t log into the tablet. Later the teacher can be heard making a connecting between animation and complex numbers to help explain the concept to a student. The teacher calls for the students’ attention and discuss with them the key difference between what they are doing today compared to a similar concept presented to them last week. This, the teacher states are key to answering a particular question later in the worksheet. Teacher then makes a connection to a physics concept for those in the class whom are doing physics. Teacher then asks for students to turn off the devices and pack them away Teacher asks students to sit back down while they discuss the homework. Teacher asks students to complete the worksheet and they can find the link to the webpage on Edmodo

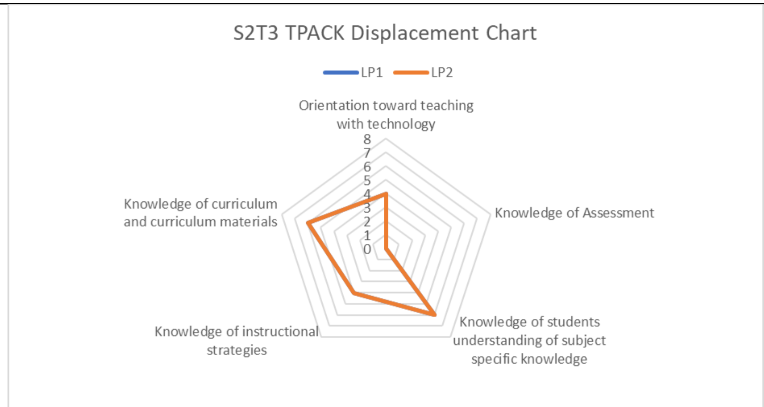
Appendix D TPACK comparison chart for case studies one and two

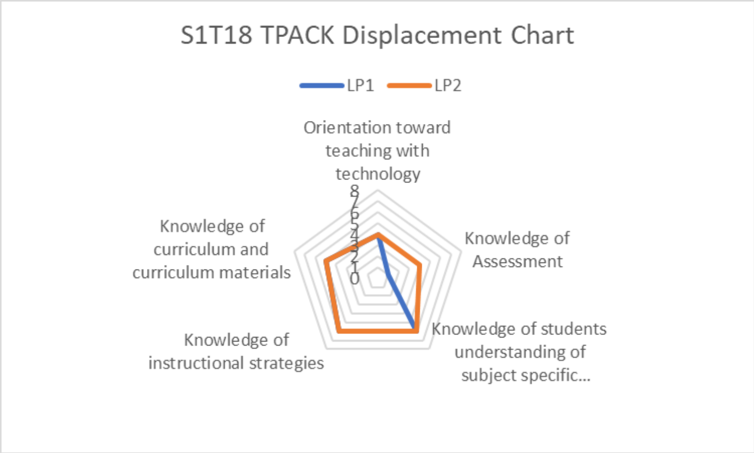
School One	School Two
	

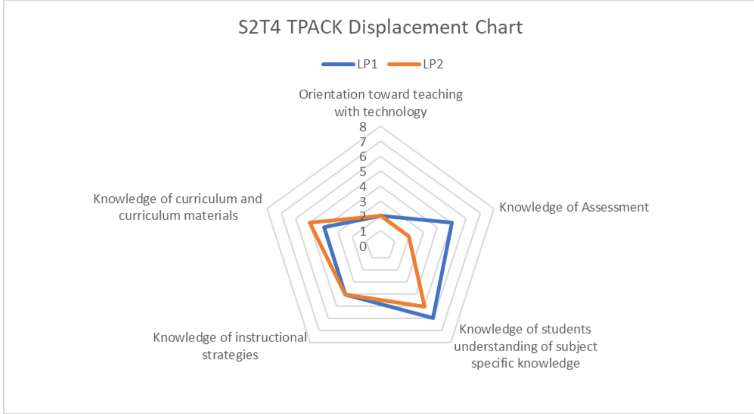

S1T12 TACK Displacement Chart
LP1 LP2 LP3
Orientation toward teaching with technology
Knowledge of Assessment
Knowledge of students understanding of subject specific...
Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials

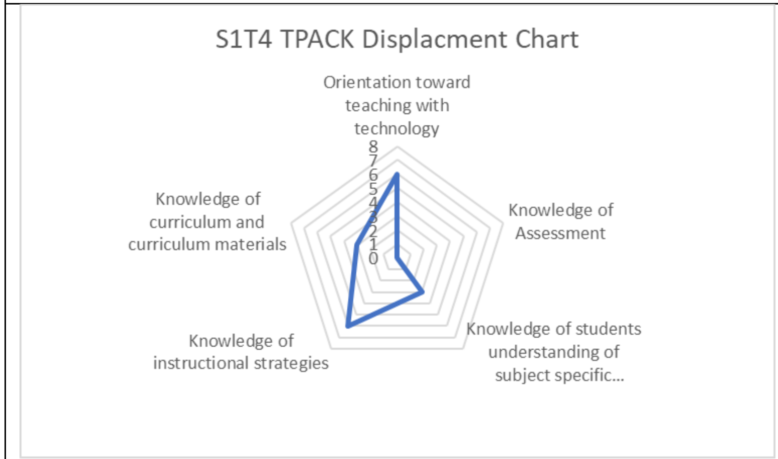

S2T1 TPACK Displacement Chart
LP1 LP2
Orientation toward teaching with technology
8
7
6
5
4
3
2
1
0
Knowledge of Assessment
Knowledge of students understanding of subject specific knowledge
Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials

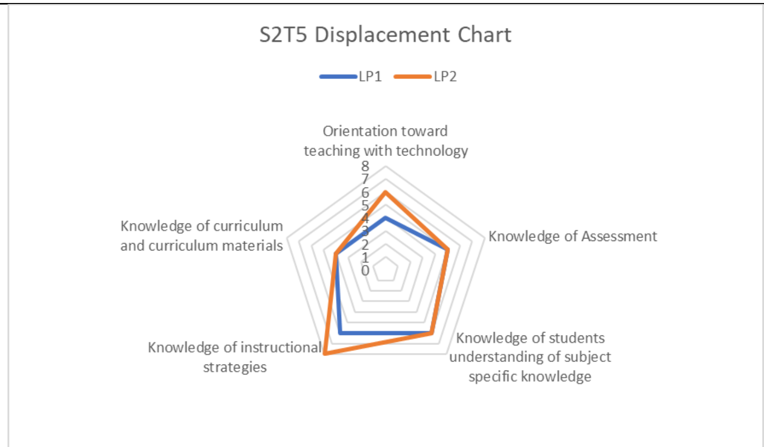

S1T2 TPACK Displacement Chart
LP1 Lp2
Orientation toward teaching with technology
Knowledge of Assessment
Knowledge of students understanding of subject specific...
Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials

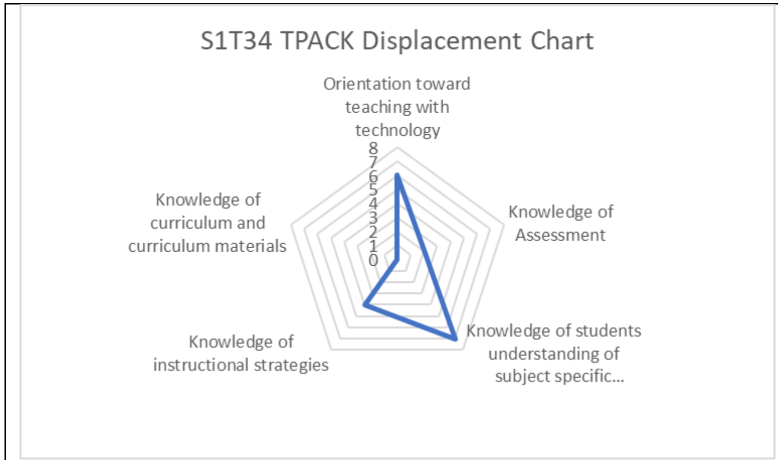

S2T3 TPACK Displacement Chart
LP1 LP2
Orientation toward teaching with technology
8
7
6
5
4
3
2
1
0
Knowledge of Assessment
Knowledge of students understanding of subject specific knowledge
Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials


S1T18 TPACK Displacement Chart
LP1
LP2
Orientation toward teaching with technology
Knowledge of Assessment
Knowledge of students understanding of subject specific...
Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials


S2T4 TPACK Displacement Chart
LP1
LP2
Orientation toward teaching with technology
Knowledge of Assessment
Knowledge of students understanding of subject specific knowledge
Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials


S1T4 TPACK Displacment Chart
Orientation toward teaching with technology
Knowledge of Assessment
Knowledge of students understanding of subject specific...
Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials


S2T5 Displacement Chart
LP1
LP2
Orientation toward teaching with technology
Knowledge of Assessment
Knowledge of students understanding of subject specific knowledge
Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials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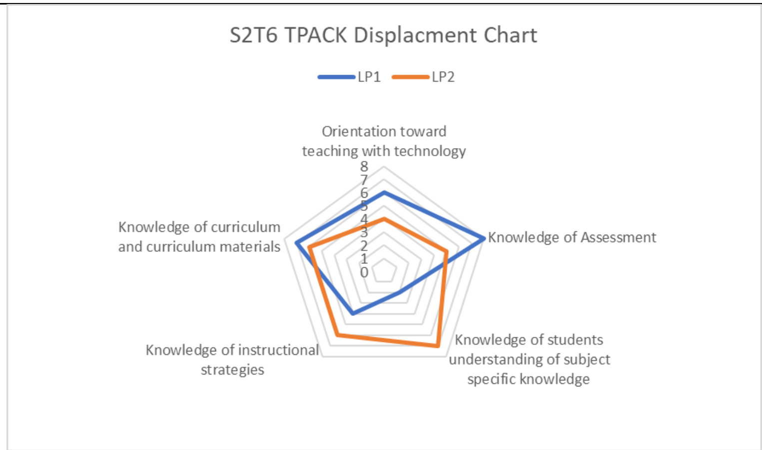
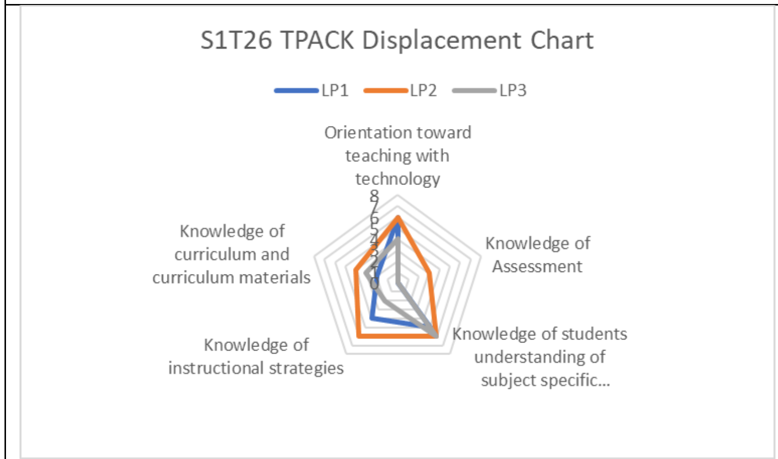
Knowledge of students understanding of subject specific...
Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials


S2T6 TPACK Displacment Chart
LP1
LP2
Orientation toward teaching with technology
Knowledge of Assessment
Knowledge of students understanding of subject specific knowledge
Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials


S1T26 TPACK Displacement Chart
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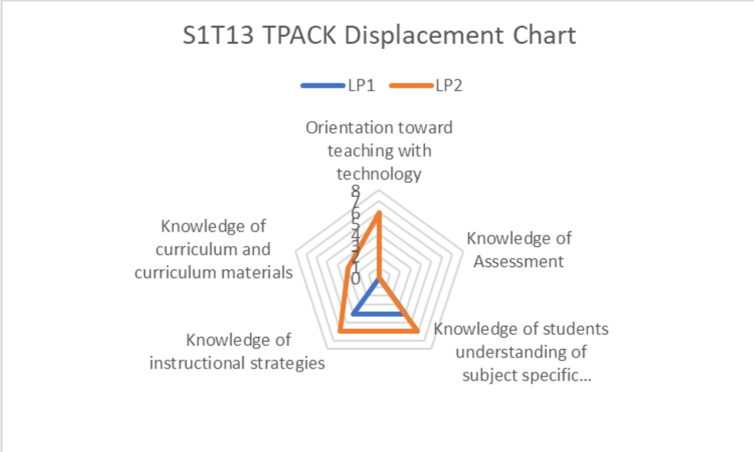
LP2
LP3
Orientation toward teaching with technology
Knowledge of Assessment
Knowledge of students understanding of subject specific...
Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials


S1T13 TPACK Displacement Chart
LP1
LP2
Orientation toward teaching with technology
Knowledge of Assessment
Knowledge of students understanding of subject specific...
Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials
8
7
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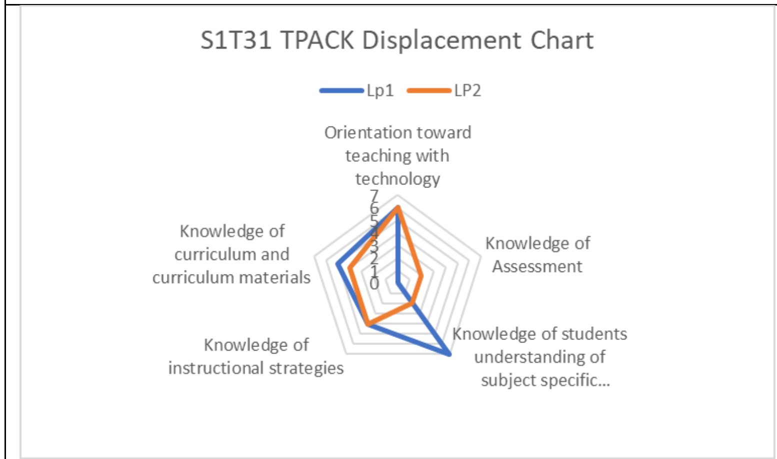
S1T31 TPACK Displacement Chart
Lp1
LP2
Orientation toward teaching with technology
Knowledge of Assessment
Knowledge of students understanding of subject specific...
Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials
7
6
5
4
3
2
1
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Appendix E TPACK Comparison between case study one, two and three teachers

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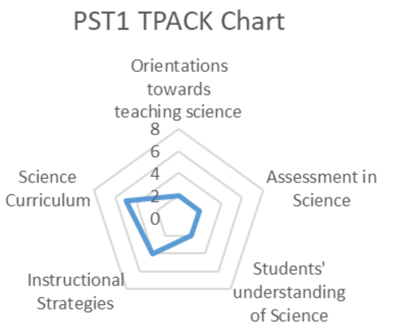
<td>
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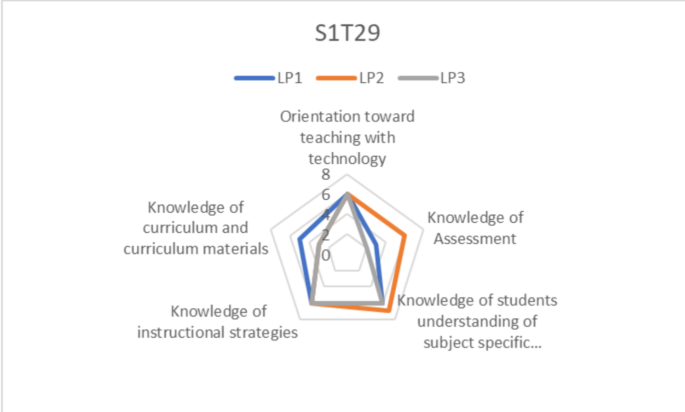
<td>
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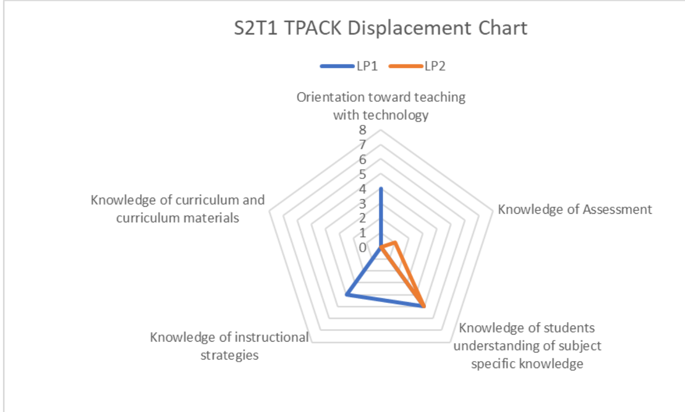
<td>
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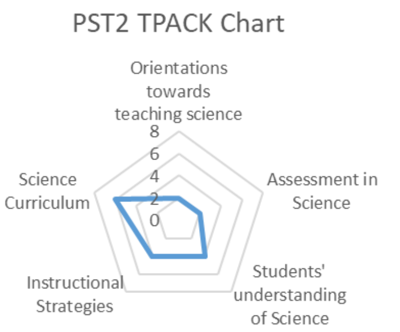
<td>
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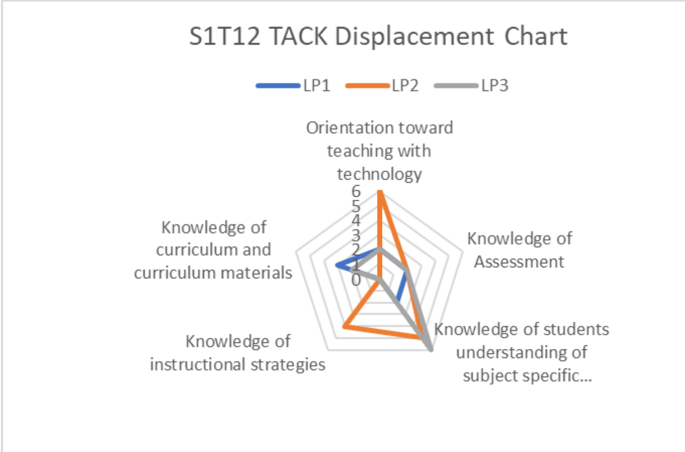
<td>
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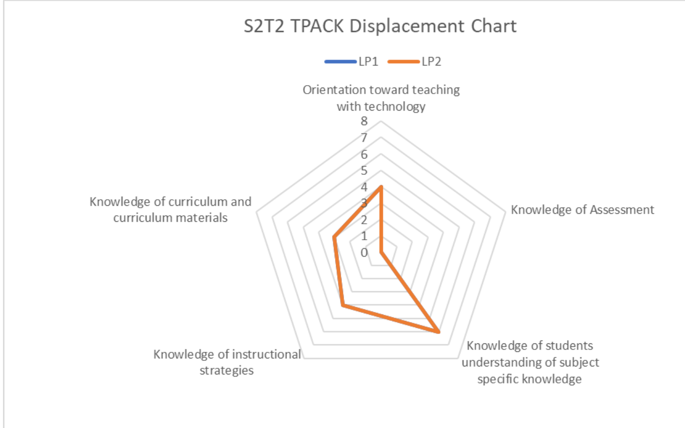
<td>
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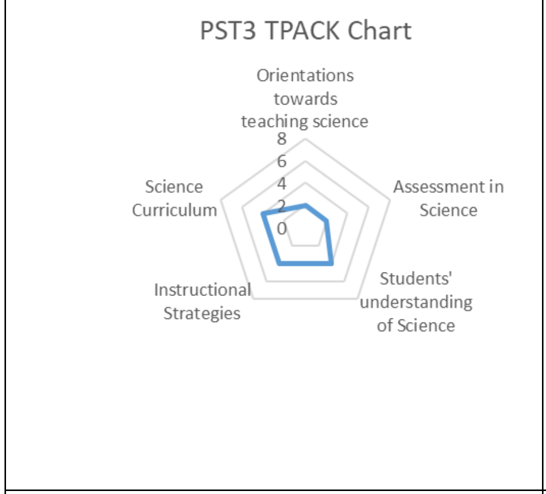
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Orientations towards teaching science
Assessment in Science
Students' understanding of Science
Instructional Strategies
Science Curriculum
8
6
4
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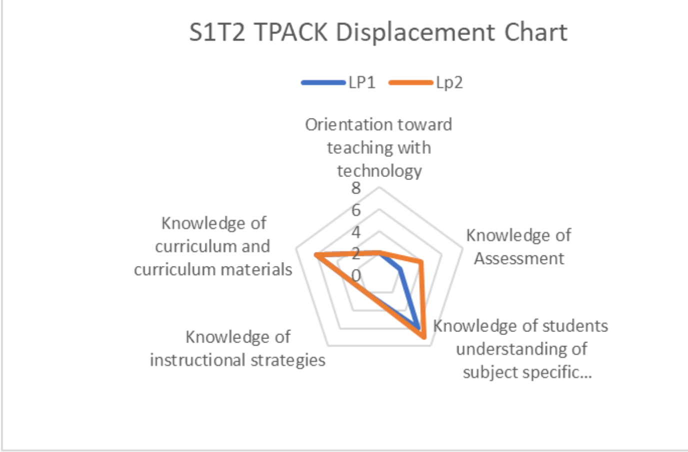
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Lp2
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Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials
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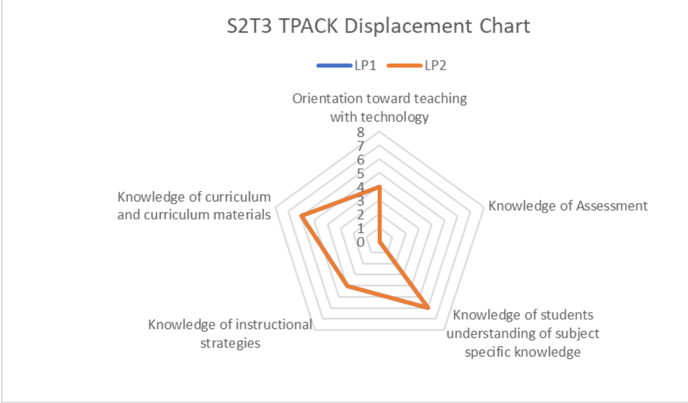
S2T3 TPACK Displacement Chart
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LP2
Orientation toward teaching with technology
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Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials
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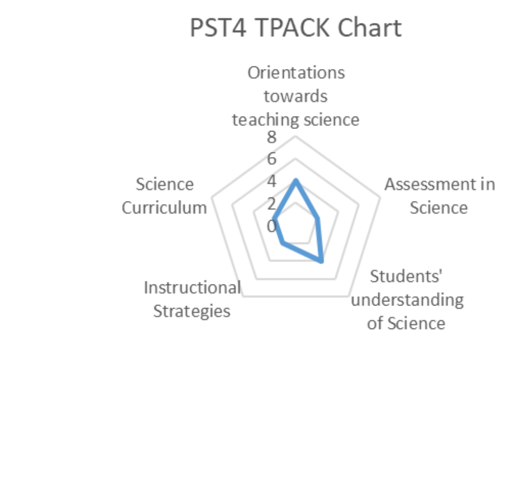
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Orientations towards teaching science
Assessment in Science
Students' understanding of Science
Instructional Strategies
Science Curriculum
8
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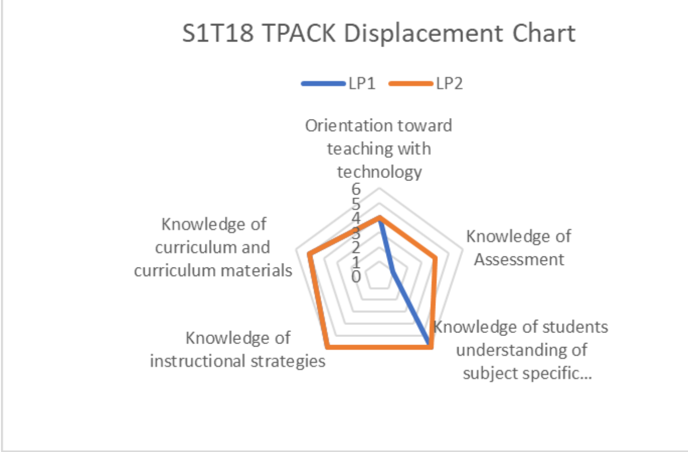
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Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials
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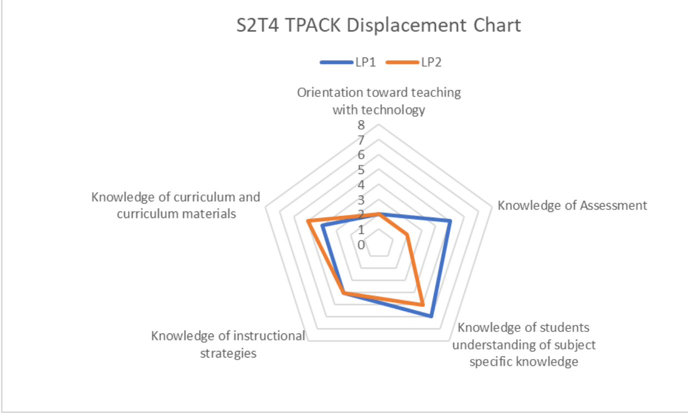
S2T4 TPACK Displacement Chart
LP1
LP2
Orientation toward teaching with technology
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Knowledge of students understanding of subject specific knowledge
Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials
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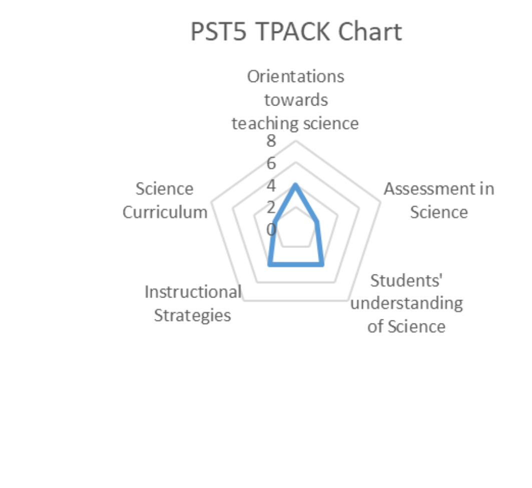
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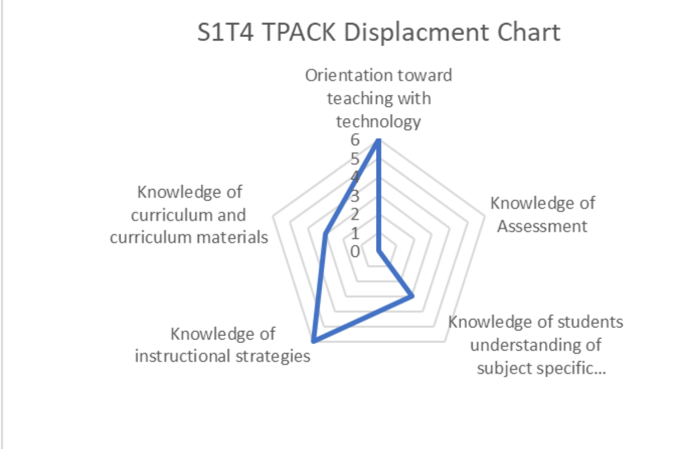
Assessment in Science
Students' understanding of Science
Instructional Strategies
Science Curriculum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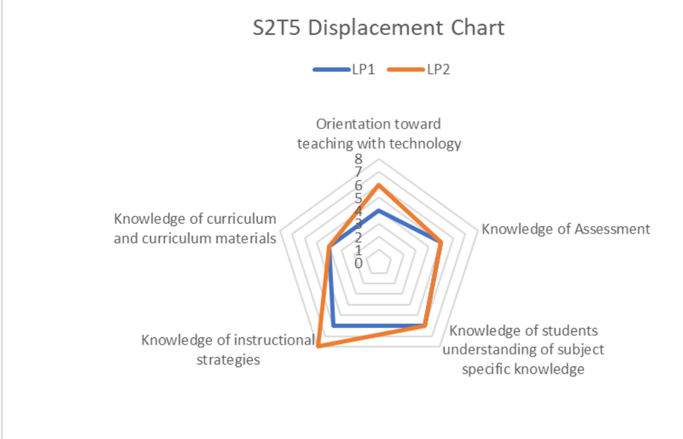
Knowledge of students understanding of subject specific...
Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials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LP2
Orientation toward teaching with technology
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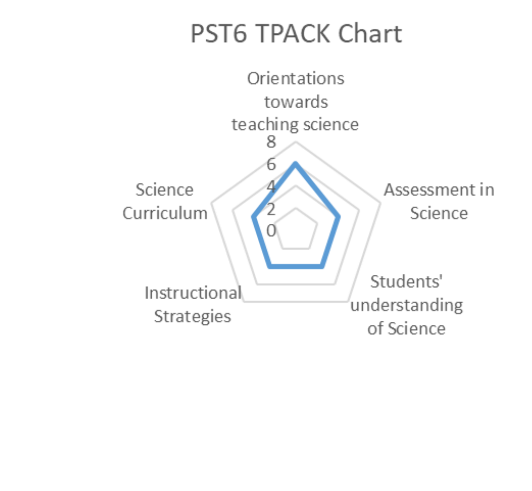
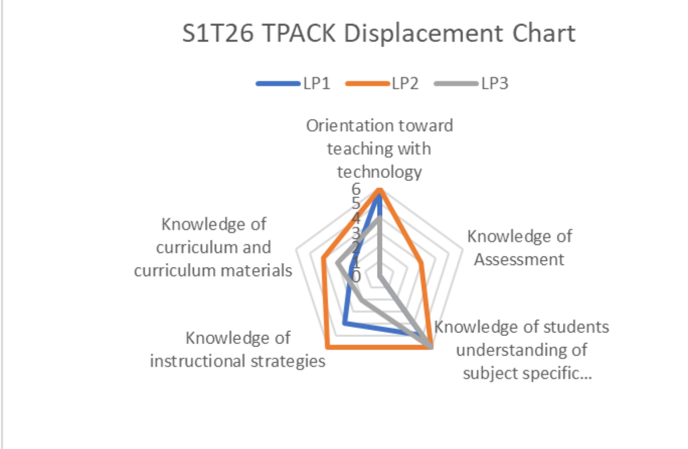
Knowledge of students understanding of subject specific knowledge
Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials


PST6 TPACK Chart
Orientations towards teaching science
Assessment in Science
Students' understanding of Science
Instructional Strategies
Science Curriculum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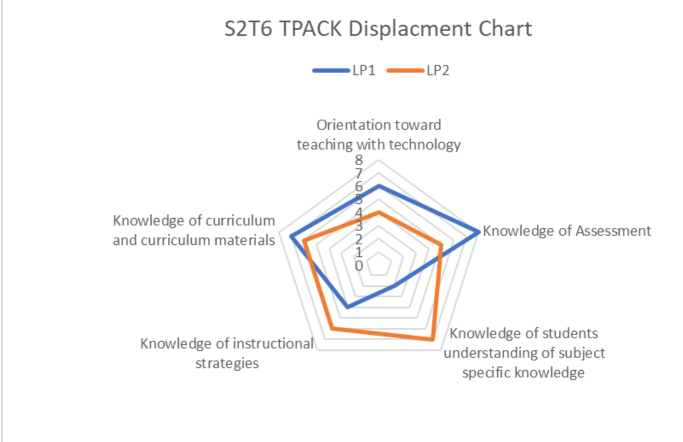
LP1
LP2
LP3
Orientation toward teaching with technology
Knowledge of Assessment
Knowledge of students understanding of subject specific...
Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials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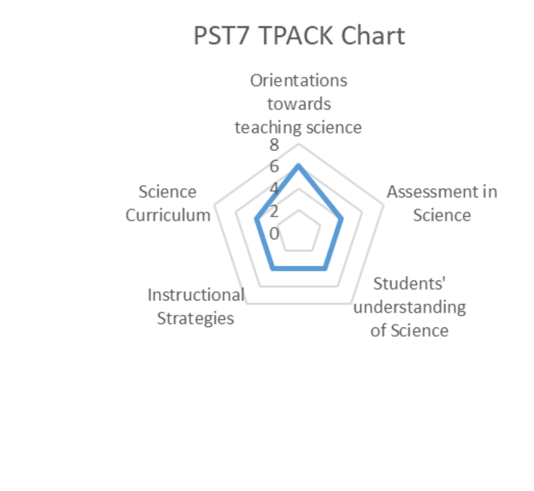
LP1
LP2
Orientation toward teaching with technology
Knowledge of Assessment
Knowledge of students understanding of subject specific knowledge
Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials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Orientations towards teaching science
Assessment in Science
Students' understanding of Science
Instructional Strategies
Science Curriculum
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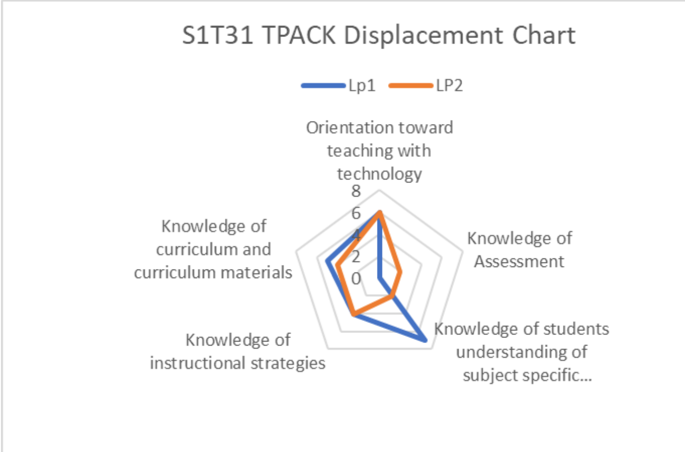
S1T31 TPACK Displacement Chart
Lp1
LP2
Orientation toward teaching with technology
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Knowledge of students understanding of subject specific...
Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials
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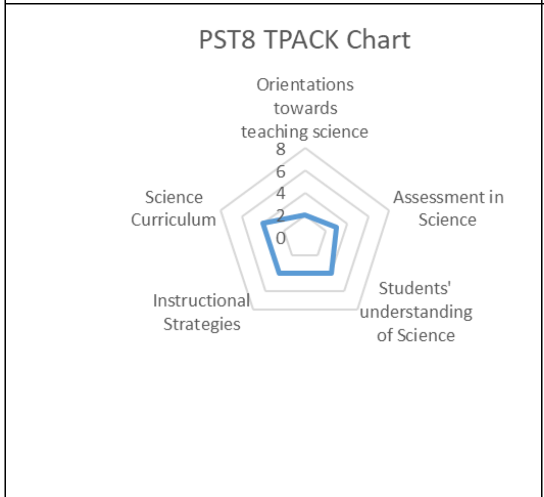
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Assessment in Science
Students' understanding of Science
Instructional Strategies
Science Curriculum
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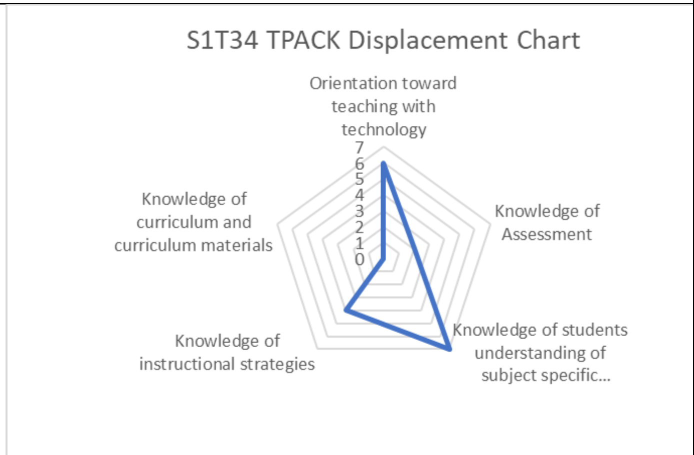
S1T34 TPACK Displacement Chart
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Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials
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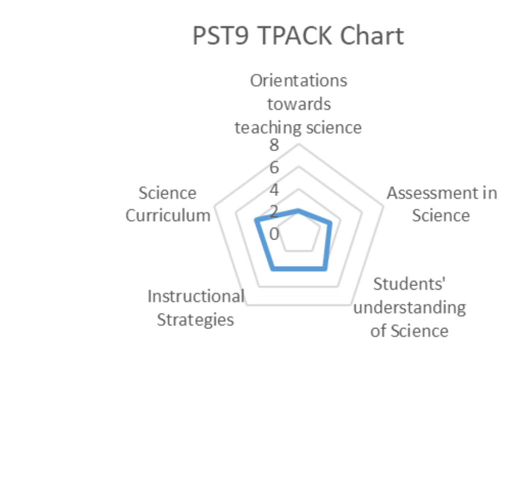
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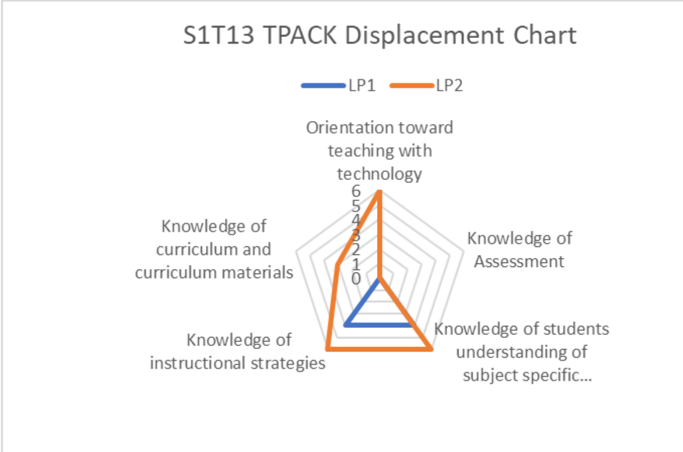
Assessment in Science
Students' understanding of Science
Instructional Strategies
Science Curriculum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LP2
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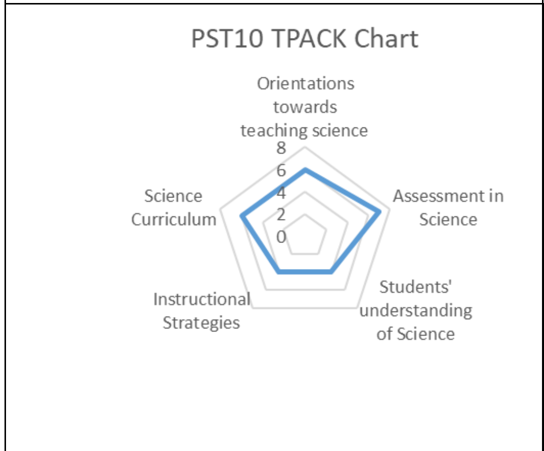
Knowledge of Assessment
Knowledge of students understanding of subject specific...
Knowledge of instructional strategies
Knowledge of curriculum and curriculum materials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Students' understanding of Science
Instructional Strategies
Science Curriculum