Insights into the Professional Learning of Physics Teachers: An Examination of Novice Teachers' Experiences of Transition

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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, and 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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ACKNOWLEDGEMENTS

Five years ago, sitting on a beach in Bahrain, enjoying my more than comfortable life as a newly qualified teacher, I decided I wanted a new challenge. An experience to really push me to my limits and come out of it with something complete, achieved, mastered. How naïve was I? Everyone starts off this section of their thesis with "I couldn't have done it without…", but I don't think I realised the gravity of the support I had over the last five years until right now, writing these acknowledgements and I really couldn't have done it without so many people around me!

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I am very lucky and privileged to be sitting here writing this section of my thesis today and I hope to pay all of it forward in my years ahead, wherever this experience takes me!

LIST OF ABBREVIATIONS

4S	Situation, Self, Support, Strategies
ACK	Academic Content Knowledge
AST	Ambitious Science Teacher
BSC	Bachelor Of Science
CBA	Classroom Based Assessment
CK	Content Knowledge
CKT-D	Content Knowledge for Teaching - Disciplinary
CKT-E	Content Knowledge for Teaching Energy
CKT-P	Content Knowledge for Teaching - Pedagogy
COP	Communities Of Practice
CORES	Content Representations
ID	Identification
IST	In-service Teacher
JC	Junior Cycle
LC	Leaving Certificate
MKT	Mathematical Knowledge for Teaching
NQT	Newly Qualified Teacher
PAP-ERS	Professional Experience Repertoires
PC	Personal Computer
PCK	Pedagogical Content Knowledge
PCKG	Pedagogical Content Knowing
PDF	Portable Document Format
PDSA	Plan, Do, Study, Act
PI	Project Investigator
PLC	Professional Learning Community
PST	Pre-Service Teacher
RPP	Research Practice Partnership
SET	Student Energy Targets
SPHE	Social, Personal and Health Education
ST	Student Targets
STEM	Science, Technology, Engineering and Maths
SWOT	Strength, Weaknesses, Opportunities and Threats
TA	Thematic Analysis
TOT	Tasks Of Teaching
UB	Unconscious Bias
UK	United Kingdom

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LIST OF PUBLICATIONS

O'Neill, D. and McLoughlin, E. 2022 What do novice physics teachers identify as their problems of practice? – Springer 2022 (In Press)

O'Neill, D. and Mcloughlin, E. (2021) 'Examining Students' Interest in Physics at Second Level in Ireland', *Journal of Physics: Conference Series*, 1929, p. 012033. doi:10.1088/1742-6596/1929/1/012033.

O'Neill, D. and McLoughlin, E. (2020) 'Enhancing the Teaching and Learning of Physics at Lower Second Level in Ireland', in *Research and Innovation in Physics Education: Two Sides of the Same Coin*. Springer, pp. 239–247.

McLoughlin, E., O'Neill, D. and Fagan, G. (2020) *Improving Gender Balance in Ireland: Final Report (2017-2019)*. Dublin: Dublin City University, p. 73.

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ABSTRACT

Insights into the Professional Learning of Physics Teachers: An Examination of Novice Teachers' Experiences of Transition

Deirdre O'Neill

This thesis explores the overarching question: *"How can we enhance physics teacher professional learning in Ireland?"* The rationale for this thesis stems from the persistent low numbers of students studying physics and the low number of physics teachers in secondary schools. Professional Learning and Transition Theory underpin the conceptual and theoretical assumptions of this research and a qualitative paradigm encompasses the data collection methods and analytical strategy. This research adopts a case study methodology to examine the experiences of teachers as they transition from being a pre-service teacher to a newly qualified teacher and engage in professional learning opportunities.

Findings from the pilot study presented in this thesis, suggest approaches to enhance teacher professional learning that are focussed on collaborative learning, creative planning, reflective practice and diversity and inclusion.

Two case studies with novice physics teachers explore ways to enhance initial teacher education by gaining a deeper understanding of how they experience the transition from pre-service teacher to newly qualified teacher. Support through collaborative networks, developing a teacher identity, managing expectations and reflective practice are some of the recommendations that this thesis presents, to promote a successful adaptation and a gradual transition into the teaching profession.

1 CHAPTER: INTRODUCTION

"The quality of an education system cannot exceed the quality of its teachers and principals, since student learning is ultimately the product of what goes on in classrooms."

(OECD, 2010, p.4)

1.1 INTRODUCTION TO THE RESEARCH

This thesis explored the overarching question: "*How can we enhance physics teacher professional learning in Ireland?"* In 2010, the McKinsey Report proposed a talent strategy for recruiting and retaining high quality teachers into the workforce (Auguste, Kihn and Miller, 2010). They recognised the need to invest in quality teachers in order to support the economic and social success of countries. "The quality of an education system cannot exceed the quality of its teachers and principals, since student learning is ultimately the product of what goes on in classrooms" (OECD, 2010, p.4). The following introduction has detailed the rationale, approaches and key findings for each of the studies in this thesis.

Pilot Study

To investigate the overarching question of this thesis, examining teachers' experiences of teaching science at junior cycle level was the focus of the first study presented in this thesis. This study was part of a wider project, Improving Gender Balance in Ireland (IGBI), that was concerned with increasing the number of girls studying physics through a holistic approach involving the whole school. The design principles IGBI were based the UK-based Drayson Project, although significant and conclusive results on this project had not been published on this project until after the pilot study (reported in Chapter 4) was conducted. The Drayson Project worked directly with girls, science departments, and senior leadership in schools, with the goals of building confidence, supporting inclusive teaching, and involving the whole school. The number of girls taking AS-level physics in Drayson schools more than trebled over 2 years, soaring from 16 to 52 students, according to the Improving Gender Balance report (Institute of Physics, 2016). Therefore, the design principles of the IGBI project also focused on i) enhancing science teachers' pedagogical content knowledge for teaching physics, ii) providing teachers and students with access to information on a wide variety of career opportunities and future pathways and iii) highlighting the influence of stereotypes and unconscious biases on students' engagement in subjects.

The research aspect of the IGBI project took the form of a pilot study (presented in this thesis) and explored Junior Cycle in-service science teachers' (n=51) experiences of participating in an intervention for teacher professional learning.

Approaches to professional learning such as: pedagogical content knowledge, collaboration and reflective practice. This study was used to map the terrain in order to investigate teaching Junior Cycle science and trial approaches to support teacher professional learning and collaboration addressed through the first research question: *What are science teachers' experiences of engaging in professional learning for physics at Junior Cycle?* Focus groups and one-to-one interviews were conducted pre and post intervention. Findings from this pilot study indicated a need for i) formal collaborative opportunities for teachers and ii) professional learning in physics.

Case Study A

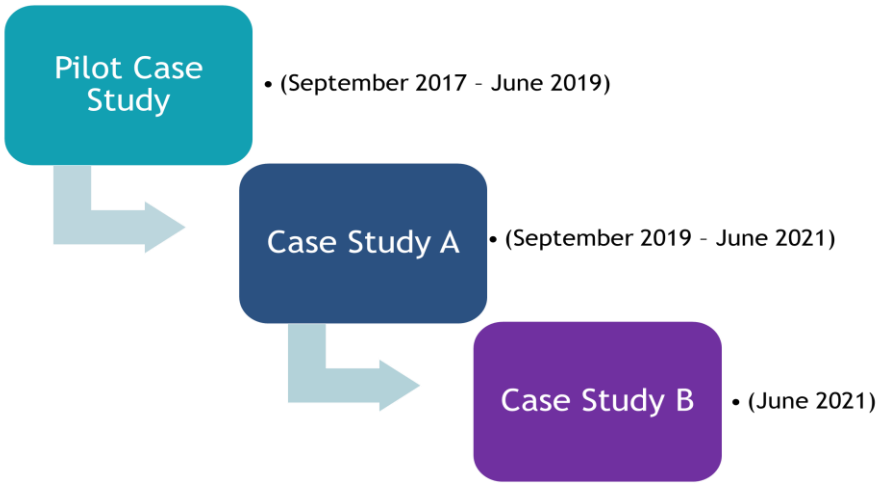
The second study adopted a formal case study approach and focussed more closely on the novice physics teacher experience (n=6), in particular as they transitioned from university and entered into their first year of teaching (See Case Study A – Chapter 5). The research questions examined in this study, explores the experiences of novice physics teachers in the context of their transition from being a pre-service teacher to being a newly qualified teacher; *What are teachers' experiences of becoming a novice physics teacher? What transitions are occurring throughout teachers' experience?* Considering the findings from the pilot study, novice teachers engaged in professional learning (in Year One of the Study) to enhance physics pedagogical content knowledge as part of a module in their final year of pre-service education [adapted from the workshops implemented in the pilot study]. Following teachers' completion of school placement, they formed a Research Practice Partnership (RPPs) with science education researchers (n=2) to continue their professional learning collaboratively (in Year Two of the study). The principles of the RPPs centered around negotiating norms and setting expectations, identifying problems of practice, discussing and expanding these problems into new possibilities, expressing reservations and concerns and sharing artifacts of classroom practice. These collaborations went beyond existing data and generated original analyses of classroom-based data related to specific questions as decided on by the members of the partnership (Penuel and Gallagher, 2017). Reflective journals, one-to-one interviews and qualitative surveys were collected and analysed to explore these novice physics teachers' transition according to Schlossberg's transition theory (Schlossberg, 1981).The findings presented in this chapter

indicated that teachers experience multiple transitions that overlap and span the entirety of their final year in university and first year of teaching. The findings also indicated that the transitions for these newly qualified teachers are ongoing and may extend for several years. Enhancing pedagogical content knowledge, planning and organisation and relevant supports that teachers utilised were some of the themes discussed consistently by teachers over a two year period. Engagement in professional learning and focus on student learning were themes that came-and-went throughout the two years, as teachers described their own professional and personal development.

Case Study B

The third study (Case Study B) explored how teachers adapted to transitions (identified in Case Study A) and how the findings from this study have implications for both practice and policy in teacher education through the research question: *What adaptations do novice physics teachers experience across transitions?* This study focussed on the experiences of the six novice physics teachers through the lens of transition theory as they reflected back over their past two years of their lives. This study placed the teacher voice at the center of the research and focussed on understanding what teachers reveal as their most significant transitions and how they perceive to have adapted to these transitions. One-to-one interviews were designed to examine the teachers' resources (Situation, Self, Supports and Strategies) for adapting to transition and this data was analysed according to their perception of the transition, the environment in which the transition took place, the characteristics of the teacher and the strategies they adopted during the transition. Findings from this study highlighted teachers' experiences of managing stress, maintaining work-life balance and integrating into the school community. Findings from this study also revealed that teachers' adaptation to transition could be supported by improving internal and institutional support structures and management of expectations for novice teachers joining the school community.

Figure 1.1: Summary of Thesis Case Studies



Overall, this thesis contributes to literature through the holistic and systematic examination of novice physics teacher transition using Schlossberg's transition theory. This thesis has shown that transition theory provides insights into the teacher as an individual, the power of transition theory to identify gaps in professional learning as it is lived by the teacher, a holistic perspective of the teacher as more than just "the teacher" but as a person with personal experiences and contextual environments that affect their journey (adding to the literature on teacher identity).

1.2 CURRENT SITUATION IN IRELAND

The Irish Education system is centered around two levels of education culminating in high stakes national examinations, i.e., Junior Cycle and Leaving Certificate examinations. Students in Ireland study an integrated science curriculum (optional subject in some schools) in the first three years of second-level education, called Junior Cycle. The science curriculum was first introduced in 2015 and consists of four contextual strands (Earth and Space, Chemical World, Physical World and Biological World) and one unifying strand (Nature of Science) (National Council for Curriculum and Assessment, 2015, p.10). Science students complete two classroom based assessments (CBAs) in the second and third year of the course and one high stakes exam at the end of the third year (National Council for Curriculum and Assessment, 2015). Students then choose whether to study Physics, Chemistry or Biology (or a combination of these subjects) for two years as part of the Leaving Certificate curriculum. The assessment associated with the Leaving Certificate is mostly focussed on one final high stakes exam with some coursework in the form of completing mandatory experiments related to different topics within the curriculum (National Council for Curriculum and Assessment, 2002).

There is concern in Ireland around the low numbers of students studying physics at upper second-level in Ireland. In 2021, the State Examinations Commission recorded 14% (7988) of the total student cohort (57,952) taking physics for the Leaving Certificate Examination. Only 4% (2182) of this total student cohort were girls (State Examinations Commission, 2021). These statistics have remained so over the past 10 years (State Examinations Commission, 2011, 2021) . By, comparison biology was the most popular subject selected at upper second level in 2021 with 60% (34,888) of the total student cohort sitting the final examination, of which 37% (21,562) of the total student cohort were girls. These low numbers of students studying physics at Leaving Certificate level correlate with low numbers of students entering the teaching profession with physics as their specialist subject (Archer *et al.*, 2020; Du Plessis, 2020; Sheppard *et al.*, 2020). Novice Physics Teachers Entering the Profession

The role of the Teaching Council of Ireland is to "*establish and maintain the standards that underpin all aspects of a teacher's professional practice*" (Ó Ruairc, 2021). Currently, teachers registered with the Teaching Council with any

one science subject in their final degree e.g., Physics, Chemistry, Biology, at Leaving Certificate level are also recognized to teach science at Junior Cycle, to students aged 12-15 years. Given the popularity of Biology at Leaving Certificate level and in pre-service teacher education programmes (Teaching Council of Ireland, 2021), the majority of science teachers teaching science (including physics) at Junior cycle level are qualified as biology teachers. As such, the biology teachers are referred to as out-of-field physics teachers as they are not qualified to teach Physics at Leaving Certificate level. In 2021, 1115 teachers were recognised by the Teaching Council with qualifications to teach Physics, 3544 teachers were recognised with qualifications to teach Biology and 2097 were recognised with qualifications to teach Chemistry (Teaching Council of Ireland, 2021). In particular, only 42 new physics teachers were registered with the Teaching Council in 2020 (Teaching Council of Ireland, 2021). This distribution of science subject specialisms indicates that the majority of Irish students are introduced to physics (as part of the Junior Cycle science curriculum) by out-of-field physics teachers (STEM Education Review Group, 2016). Archer et al (2020) report in their study that teacher specialism, supply and retention strongly impact on students' likelihood of identifying with and aspiring to science, particularly in the case of working-class and minority ethnic students. These persistent low numbers of students studying physics, linked to the low number of physics teachers, needs to be addressed at every level of the education system (early career, primary, second-level and tertiary) and with all of the stakeholders involved (student, teacher, parent, management, lecturer, policy maker).

There have been many interventions implemented over the past 30 years with no long-term effect yet been shown in statistics related to uptake of physics at Leaving cert level and numbers of qualified physics teachers (State Examinations Commission, 2021; Teaching Council of Ireland, 2021). Low numbers of students studying physics at second-level, low numbers of physics graduates and low numbers of physics teachers is a persistent cycle and a matter of international concern, e.g., large numbers of out-of-field physics teachers are reported to be teaching un urban settings in the New York States (Sheppard et al., 2020). Similarly in the UK, physics teaching is reported to be one of the less desirable avenues for physics graduates (Allen, Sibieta and Vignoles, 2018). Researchers have called for effective interventions to address physics teacher

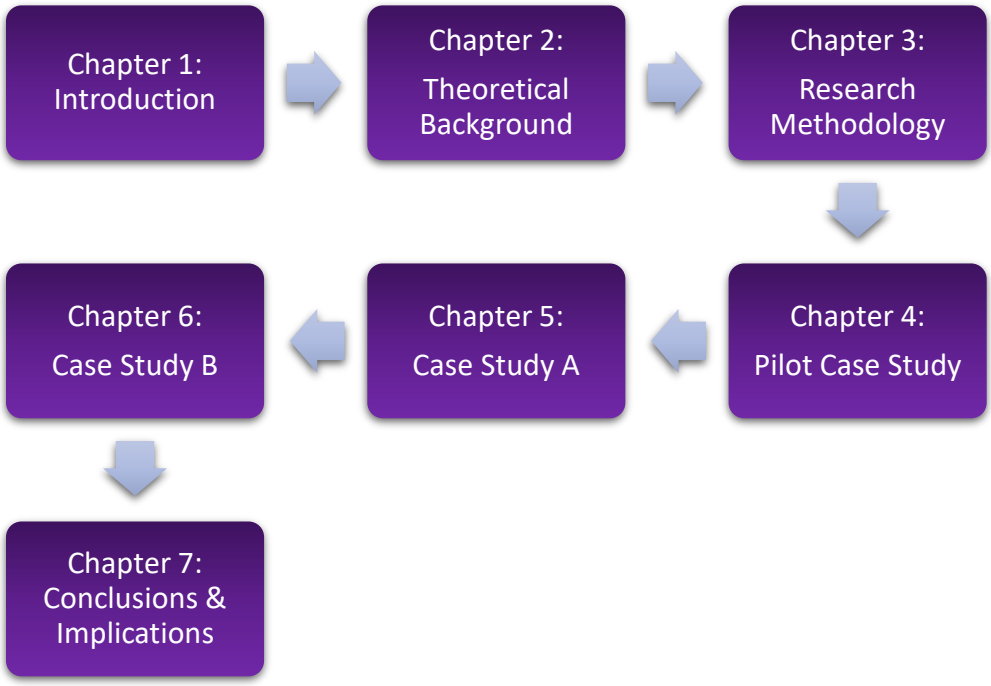
attrition and make the teaching professional more desirable (higher paid and career pathways) for high quality graduates (Luft, 2001; Allen, Sibieta and Vignoles, 2018). Many studies have investigated the issues related to teacher attrition in physics and teaching in general (Doherty, 2020; Krakehl *et al.,* 2020; Palermo, Kelly and Krakehl, 2021). Krakehl *et al.,* (2020, p3) investigated the challenges of teaching and learning physics in high school contexts using a framework centered on workplace tensions for teachers (isolation, teaching out of field and turnover) and equity concerns for students (physics accessibility, resource allocation and school-level poverty). These studies reported that constraints such as poverty and limited resources allocation were associated with physics teachers working in isolation and added to novice teachers workplace tensions in urban schools (Krakehl *et al.,* 2020). Palermo, Kelly and Krakehl (2021, p.6) applied a theoretical framework that combines the formation of physics teachers' professional expectations and satisfaction (created through teacher disciplinary preparation, student performance, school organisations and school physics culture) to predict physics teachers' attrition, retention and migration. They found that professional age (years of teaching experience – mostly novices), school-level socioeconomic status, school locale and course load were predictors for teachers leaving the profession (Palermo, Kelly and Krakehl, 2021).

The research in this thesis examines the experiences out-of-field physics teachers and novice physics teachers engaging in physics teacher professional learning with the aim of enhancing physics professional learning opportunities in Ireland.

1.3 Outline of Thesis

This section provides an overview of the research presented in this thesis (See Figure 1.2).

Figure 1.2: Outline of Thesis



Chapter One introduces the rationale and contextual background for this thesis. Chapter Two discusses findings from the literature related to teacher professional learning, namely, pedagogical content knowledge, teacher collaboration and reflective practice. The theoretical background of this research examines transition theory as a lens to understand the experiences of novice teachers in particular. An outline of the thesis research questions based on the rationale and literature review are presented at the end of the chapter.

Chapter Three outlines the researcher's epistemological and ontological beliefs and describes how their positionality and bias may have influenced the research. The methodological approach of Case Study used in each of the studies is then presented with a detailed description of how it aligns with the literature. Details of each study design, timeline and participants are discussed with particular attention given to the data collection and analysis of each study. Contextual background is given for the professional learning opportunities that teachers engaged with during the course of this research. Finally, ethical considerations of the study are described at the end of the chapter.

Chapter Four presents the findings from the first case study: the pilot case study. The chapter begins by giving details of the broader context of the study and describing the study approach. This study focused on the ***science teachers' experiences of physics professional learning at Junior Cycle level.*** Teachers' views were collected in this qualitative study pre-and post-intervention. Findings from the pilot study are the focus of this chapter as they provide lessons learned for the following case studies.

Chapter Five reports on the ***experiences of novice physics teachers*** and examines their journey from pre-service teacher to newly qualified teacher in Case Study A. Similar to the reporting of the pilot study, here, an overview of the case (teachers' experience) is presented and details of how the key learnings from the pilot study are incorporated into the study design are described. The findings of the case are presented with an overall aim to use teachers' experiences to map their transition of their final year of pre-service teacher education into their first year of teaching. These transitions are then examined according to the theoretical framework and key observations are presented at the end of the chapter.

Chapter Six presents the findings of ***novice physics teachers' adaptation to a transition*** in Case Study B. The key learnings from Case Study A informed the study design, after the transitions experienced by teachers had been identified and could be examined according to the theoretical framework of this thesis. This chapter was focussed on teachers' "adaptation" as the case and used transition theory in the design of the data collection tools and analysis of the data. The findings describe observations related to the teacher's situation, self, supports and strategies that have relevant implications to physics education research.

Chapter Seven concludes this thesis by presenting conclusions and implications of each of the case studies conducted in relation to research, practice (in science education) and policy. Limitations of the research and avenues for further studies are discussed at the end of the chapter.

2 CHAPTER: THEORETICAL BACKGROUND

"What works always depends on where, when, and with whom."

(Guskey, 2002a, p.51).

2.1 INTRODUCTION

The literature review on teacher professional learning that underpins the research presented in this thesis is introduced in section 2.2. The following sections discuss the three core aspects of teacher professional learning in the thesis, namely, pedagogical content knowledge, collaboration and reflective practice. Pedagogical content knowledge (PCK) is defined and explored in section 2.2.2. Approaches used to promote teacher collaboration such as Professional Learning Communities (PLC's), Communities of Practice (CoP's), Research Practice Partnerships (RPPs) and co-design are discussed in detail in section 2.2.3. A discussion on teachers' reflective practice is presented in Section 2.2.4. Each of these three concepts were then investigated in the context of novice teachers and novice physics teachers where the literature was available (See Section 2.2.5). Novice teacher transitions are discussed in Section 2.2.6, where the gap in literature (novice physics teacher transition) emerged and formed the basis for this thesis.

Transition theory lays the groundwork, as a theoretical framework, to understand, analyse and investigate the problems that novice physics teachers may experience during their transition from pre-service teacher to newly qualified teachers. An exploration of the applications and uses of Schlossberg's transition theory is presented in this section. Finally, the conceptualisation of novice physics teacher transition using transition theory in the context of professional learning for physics teaching has been highlighted and an outline of the research questions have been outlined in Section 2.4.

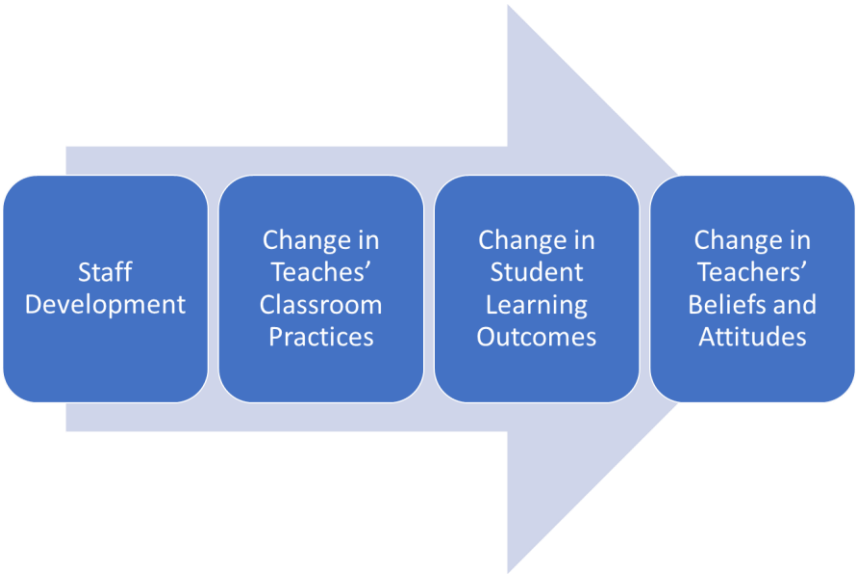
2.2 LITERATURE REVIEW

This section introduces a series of connected concepts (pedagogical content knowledge, teacher collaboration and reflective practice) and examines how these concepts can be incorporated into professional learning opportunities for teachers and examined through a theoretical framework. Section 2.2.1 begins by understanding professional learning and how it is conceptualised by researchers. Aspects of professional learning such as pedagogical content knowledge (PCK), collaboration and reflective practice are then explored as features that could be included through professional learning opportunities in the sections to follow. Some of the concepts (PCK, collaboration, reflective practice) described follow or outline their own particular theoretical frameworks, however, this section focusses on introducing the conceptual ideas and how they can be linked to the theoretical framework is outlined later.

2.2.1 Teacher Professional Learning

In 1986, Thomas R. Guskey presented a model of teacher change through staff development programs. He highlighted that the purpose of professional development programs was to bring about changes in teachers' classroom practices, beliefs and attitudes and the learning outcomes of students (Guskey, 1986, 2002b). Teachers' motivation to engage in professional development and teachers' process of change were two critical factors to consider in designing programmes according to Guskey (1986). Guskey's model, Figure **2.1**, suggests that change in teachers' attitudes and beliefs depends on teachers' observations of a positive influence on student learning outcomes from changes in their classroom practices.

Figure 2.1: A Model of the Process of Teacher Change (Taken from (Guskey, 1986, p.7))



This model proposes that teacher change is a process of learning that is "developmental and primarily experientially based" for teachers (Guskey, 1986, p.7). This idea is important to help in understanding why teachers retain or abandon particular teaching practices. Guskey (1986, p.7) attributes evidence of student levels of achievement, engagement in activities or expressions of confidence in their ability to learn, to significant changes in teachers' beliefs and attitudes.

Following on from this research, Guskey (2000) outlines a model for evaluating professional development programs across five levels. He arranges the levels in hierarchical form in which each higher level builds on the previous one and where success is achieved in a step-by-step process. The first level (Participants' Reactions) focusses on whether or not participants like the program by measuring satisfaction that could help enhance the design and delivery of the program. Level 2 (Participant's Learning) measures the knowledge, skills and attitudes that teachers gained. This information could inform ways of improving content, format and organisation of the program. The Organisation Support and Change is interrogated in level 3 (Guskey, 2000). In this level questions focus on characteristics and attributes necessary for support in the organisation to inform future change initiatives. Level 4 (Participants' Use of New Knowledge and Skills) inspects the use of new knowledge or skills in practice and is often measured after sufficient time has passed (after the program implementation).

Finally, level 5 addresses the impact of the program on student learning outcomes and can inform all aspects of professional development (Guskey, 2000, 2002a). Guskey (2005) later highlights fifteen sources of evidence to inform the impact of professional learning on student learning outcomes. However, he reported that stakeholders' perceptions of the value of these indicators often differ. For example, state assessments and national assessments were trusted more by school management than teachers, who placed more value on teacher observations, homework completion and quality and student behaviours and attitudes (Guskey, 2005).

The introduction of these five levels of evaluation of professional development programs led to Guskey's next revelation of backward planning. He proposed that in order to plan for effective professional learning the five levels could be reversed by "starting where you want to end and working back" (Guskey, 2002a, p.50). In this back-ward planning student learning outcomes should be the first point of focus where planners can gain insight from analysis of the progress of students in different contexts. Hirsh (2012) emphasises the necessity of taking student outcomes into account to drive decisions behind professional learning. She argues that the sole purpose of professional learning is to ensure "all students meet the standards necessary for their success" (Hirsh, 2012, p.72). Instructional practices and policies that influence the intended student learning outcomes must then be considered. In order to implement these practices and policies, Guskey (2014) outlines that sufficient organisational supports need to be in place especially in the case of collecting evidence to convince teachers that these new practices work. Facilitating teachers' depth of knowledge in relation to new practices is the next step in the back-ward planning process. This step is necessary to address the specific and different classroom contexts of teachers and can often require a lot of guidance and direction from the program facilitator. Lastly, the activities and experiences can be planned for the professional learning programme. Here, the focus is on planning to acquire knowledge and skills to meet the needs of teachers and their students (Guskey, 2002a, 2014).

So, what does effective teacher professional learning look like? Garet *et al.*, (2001) indicate that sustained and intensive professional development is more likely to have an impact on student outcomes. Penuel *et al.,* (2007) advocate for reform type professional development as opposed to traditional professional

development. He suggests intervention that is sustained and ongoing and suggest a theoretical framework where teachers and colleagues from the school or district work alongside each other. Timperley *et al.,* (2007) also advocate for teachers' participation in a professional community of practice, ideally with some external expertise and an active school leadership presence. The focus of professional development, should be on general and specific forms of content to support teaching practice (Penuel *et al.,* 2007). Timperley (2007) suggest integrating different aspects of theory and practice and pedagogical content knowledge in professional learning opportunities. According to Penuel *et al.,* (2007), active learning that supports student inquiry and coherence in aligning professional development activities with the learning goals of participants should be included in the framework for effective professional learning. Enhanced teacher knowledge and skills is more likely to occur in professional development programs that focus on "hands-on" experiences for teachers that is integrated into daily school life (Garet *et al.,* 2001). Including a variety of activities that are aligned with the intended learning goals where understandings can be discussed and negotiated is important in facilitating effect professional learning (Timperley *et al.,* 2007). Penuel *et al,.* (2007) emphasize the need to consider the resources that support professional learning and possible barriers to its implementation.

Darling-Hammond (2017) investigated teacher education from around the world and highlighted some leading practices in relation to pre-service, induction and in-service teacher professional learning across countries such as, Australia, Canada, Finland and Singapore. Among these findings, supporting thoughtful professional development to enable teachers to learn from one another and profession-wide capacity building that encourages sharing of research and good practices are two important considerations for successful professional learning (Darling-Hammond, 2017). She also suggests the establishment of induction models to support beginning teachers to build a repertoire of practice through mentoring, collaborative planning and reduced workloads (Darling-Hammond, 2017). Reflective practice has also been reported to enhance teachers professional learning related to planning and preparation, classroom environment, instruction and professional responsibilities (Slade *et al.,* 2019). A common theme across all of the research is the context in which the professional

learning occurs as encapsulated by Guskey "What works always depends on where, when, and with whom" (Guskey, 2002a, p.51).

Based on this literature, planning for professional learning opportunities is best designed starting with student learning outcomes and planning backward to take into account teachers' use of new knowledge and skills, organisation support and change, teacher's learning and teachers' reactions (Guskey, 2002a). Much of the research points to sustained and ongoing (Garet *et al.*, 2001) professional learning through teacher collaboration (Penuel *et al.*, 2007; Darling-Hammond, 2017) focussed on aspects of pedagogical content knowledge (Timperley *et al.*, 2007; Darling-Hammond, 2017). Inherent to evaluating professional learning also is the reflective process undergone by both the participants and the facilitators (Slade *et al.*, 2019).

2.2.2 Pedagogical Content Knowledge

This section presents and overview of pedagogical content knowledge in the literature followed by research related to enhancing novice teachers pedagogical content knowledge.

What is Pedagogical Content Knowledge?

The question of what constitutes "good physics teaching" has been in contention for many years (Lundqvist and Sund, 2018; De Winter and Airey, 2019). Shulman has examined novice teachers across different subjects in their process of learning how to teach, to investigate the knowledge needed to teach that subject (Shulman, 1987). Here, he deduced that, "pedagogical content knowledge (PCK) is the category most likely to distinguish the understanding of the content specialist from the pedagogue" (Shulman, 1987, p.8). Many scholars have worked to refine PCK in an effort to further define the concept and provide a measure to produce empirical evidence to support this conceptualisation (Marks, 1990; Cochran, DeRuiter and King, 1993; Hill, Schilling and Ball, 2004; Loughran, Mulhall and Berry, 2004; Ball, Thames and Phelps, 2008).

PCK was first conceptualised by Shulman, to address the "missing paradigm" in teacher education and initially investigated the subject matter knowledge needed to satisfy teacher competence in a particular subject (Shulman, 1986b). Here, he identified three types of content knowledge: subject matter knowledge (comprehension of a subject relevant to a content specialist), pedagogical

knowledge (understanding of how a subject is comprehended or misconstrued) and curricular knowledge (consideration of how knowledge is organised for instruction) (Shulman, 1986a, p.26). Pedagogical content knowledge, more specifically, was later highlighted by Shulman as one of seven categories of teachers' knowledge: general pedagogical knowledge, knowledge of learners and their characteristics, knowledge of educational contexts, knowledge of educational ends, purposes, values, and their philosophical and historical grounds, content knowledge, and curriculum knowledge (Shulman, 1987, p.8). He defined PCK to be the subject matter knowledge for teaching and understood it to be made up of two particular components: knowledge of instructional strategies and representations and knowledge of students' preconceptions (which are often known as misconceptions) (Shulman, 1986, p.9). Shulman identified this type of knowledge (PCK) to be an understanding of what makes the learning of specific topics easy or difficult (Depaepe, Verschaffel and Kelchtermans, 2013). According to Shulman (1987, p.19), one way in which PCK is utilised is through "a deep grasp of both the material to be taught and the process of learning".

Shulmans' conceptualisation of PCK is not, however, without its criticisms. The lack of theoretical and empirical grounding (Ball, Thames and Phelps, 2008), the static view of PCK, contested by many authors in their studies that take a "situated view" of knowledge embedded in real context (Cochran, DeRuiter and King, 1993; Bednarz and Proulx, 2009), whether PCK and content knowledge (CK) can be distinguished from one another (Marks, 1990; Blömeke *et al.,* 2008; Baumert *et al.*, 2010), the narrow scope of PCK (the need to broaden the concept) (Friedrichsen, Driel and Abell, 2010) and the normative nature of PCK (Ball, Thames and Phelps, 2008; Van Driel and Berry, 2012) have all been cited as limitations of Shulman's PCK (Depaepe, Verschaffel and Kelchtermans, 2013).

Pedagogical Content Knowledge and Student Outcomes

The impact of PCK on student achievement is difficult to measure and hence the links presented in the literature are not obvious. In recent studies, Gess-Newsome *et al.,* (2019) reported that academic content knowledge (ACK - the general factual knowledge that a teacher possesses about a specific topic, p.945) was the only influencing factor on student outcomes. However, they suggest that

their tests may not have been sensitive to the effect of PCK on student achievement and hypothesize that the time it takes to translate teacher knowledge to practices coupled with the narrow focus on a measure of reform-based practices in the instrument may have yielded this result (Gess-Newsome *et al.*, 2019). Keller, Neumann and Fischer (2017) also report the complexity of correlating teachers' knowledge and motivation to student achievement. They highlight that student achievement is often mediated by factors such as cognitive activation (challenging and well-structured learning opportunities) in the form of instructional features impacting student achievement and the teachers' enthusiastic behaviour that impacts students' interest. In their study teacher PCK predicted student achievement and teacher motivation was a predictor of students' interest in the subject (Keller, Neumann and Fischer, 2017). A study conducted by Hill, Rowan and Ball (2005) found that content knowledge for teaching mathematics positively influenced student achievement. They call for measures to investigate teacher learning from professional development focussed on enhancing content knowledge for teaching mathematics (Hill, Rowan and Ball, 2005).

The Evolution of Pedagogical Content Knowledge

Many authors have worked to refine the conceptualisation of PCK in order to address some of these criticisms. Marks (1990) outlines four components of PCK, knowledge of student understanding, knowledge of media for instruction, knowledge of subject matter and knowledge of instructional processes. Cochran *et al.* (1993, p.266), stresses the dynamic nature of PCK in their "pedagogical content knowing" (PCKg) conceptualisation, where pedagogy, subject matter content, student characteristics and the environmental context of learning are all central components. Van Driel and Berry (2012) highlight that PCK could be enhanced if it were to be based on constructivist and situative theories rather than behavioural approaches. They argue that PCK goes beyond instructional strategies and techniques to include an understanding of how students develop insights in specific subject matter. They also highlight that in order for teachers to improve their PCK it must align with their professional practice and teachers must reflect individually and collectively on their experiences (Van Driel and Berry, 2012). Mathematical knowledge for teaching (MKT) was developed in an attempt to refine and empirically validate PCK (Hill, Schilling and Ball, 2004;

Ball, Thames and Phelps, 2008). MKT was defined by Ball, Thames and Phelps (2008, p.395) as the mathematical knowledge needed to carry out the work of teaching mathematics and focusses on teaching rather than teachers. In contrast to Shulman's distinct categories of PCK and CK, Mathematical knowledge for teaching identifies the domains of MKT to be subject matter knowledge (common content knowledge, horizon content knowledge and specialised content knowledge) and pedagogical content knowledge (knowledge of content and students, knowledge of content and teaching and knowledge of content and curriculum) (Ball, Thames and Phelps, 2008, p.403).

There has been much refinement of the concept of PCK within the disciplines of science and mathematics over the past twenty years. Magnusson, Krajcik and Borko (1999, p.97), outline five constructs of PCK related to science education: orientations towards science teaching, knowledge and beliefs about science curriculum, knowledge and beliefs about students' understanding of specific science topics, knowledge and beliefs about assessment in science and knowledge and beliefs about instructional strategies for teaching science. The value of considering PCK as a separate domain in science from other types of knowledge is emphasised, as it represents an important tool for defining what it means to be a competent or expert science teacher (Magnusson, Krajcik and Borko, 1999).

Loughran, Mulhall and Berry (2004), developed professional experience repertoires (PaP-eRs) and content representations (CoRes) to address the absence of language teachers possess in articulating their PCK and gives an insight into teachers pedagogical reasoning. Often, teachers are more likely to share teaching activities, strategies and tips and tricks without exploring the reasoning behind them (Loughran, Mulhall and Berry, 2004).

Leinonen *et al.,* (2020) adapted Ball's MKT model to develop a physics knowledge for teaching (PKT) framework. They used this framework to analyse their teacher education program across the different domains of teacher knowledge. In their study with graduate physics teachers, they reported that domains related to common content knowledge (referring to pure physics content e.g. methods, theories, laws terminology) were appropriately addressed while deficiencies lay in PCK within the various sub-domains (knowledge of content and students, knowledge of content and teaching and knowledge of

content and curriculum) (Leinonen *et al.,* 2020). Nolan *et al.,* (2015) conducted a study with thirty pre-service mathematics teachers to assess their level of MKT and investigate ways to enhance their MKT. They reported an increase in awareness of MKT through an evident role change of the teacher as they focussed more closely on the learner's needs (Nolan *et al.*, 2015, p.58).

Etkina (2010) highlights the particular craft of understanding the "invisible thinking processes behind the scenes" as often the teacher themselves are not aware of it. In her graduate programme they focus on building physics knowledge and physics PCK. She reports evidence of learning physics content, of learning physics processes and of the ability to engage students in active learning of physics. Weekly reflective assignments provide evidence of teachers ability to listen to students and to assess their learning.(Etkina, 2010a). This program focusses on seven philosophical aspects to help students who plan on becoming physics teachers.

1. Learn physics through the pedagogy that preservice teachers need to use when they become teachers.
2. Learn how the processes of scientific inquiry work and how to use this inquiry in a high school classroom for specific physics topics.
3. Learn what students bring into a physics classroom and where their strengths and weaknesses are.
4. Engage in scaffolded teaching in reformed courses before doing student teaching or starting independent teaching.
5. Learn how to plan and assess instruction.
6. Form a learning community.
7. Be prepared for a long time needed for learning (Etkina, 2010, p.21-22).

However, Etkina (2010) errs on the side of caution when she says that much time and effort is required to see changes in pre-service teachers' practice, from her experience in developing this programme over an eight-year period. Etkina *et al.,* (2018) describe a process for operationalising "content knowledge for teaching energy" (CKT-E). Using this process, they assess teachers' knowledge of learning and teaching processes and specific learning targets in the subject matter area of energy, thereby addressing the gap in literature around assessing physics CKT. Key activities that teachers carry out to promote students learning,

called *Tasks of Teaching* (ToT) and *Student Energy Targets* (SETs) highlight the specific content areas of energy and skills and knowledge representations that are important to the student in the specific domain are also outlined (Etkina *et al.*, 2018). These ToT's include six parameters:

i) anticipating student thinking around science ideas;
ii) designing, selecting, and sequencing learning experiences and activities;
iii) monitoring, interpreting, and acting on student thinking;
iv) scaffolding meaningful engagement in a science learning community;
v) explaining and using examples, models, representations, and arguments to support students' scientific understanding; and
vi) using experiments to construct, test, and apply concepts
(Etkina *et al.*, 2018, p.15-17)

It is the intersection of the ToT to achieve SETs that includes student learning in the disciplinary knowledge (CKT-D) and pedagogical knowledge (CKT-P) construction. In their development of CKT-E assessment, Etkina *et al.*, (2018) focus on instructional scenarios based on actual physics classroom experiences to address the challenges of teaching energy. Phelps *et al.*, (2020) analysed the CKT-E assessment to investigate if the assessment reliably differentiates between participants across a range of abilities. The assessment showed dependable measurement qualities that provided support for the developmental process of evidence centered design used in this study. Findings also indicate that teachers who had preparation in areas close to that of energy subject matter had higher levels of CKT-E (Phelps *et al.*, 2020).

The evaluation of teacher's PCK in this thesis utilises earlier conceptualisations of PCK by Magnusson, Krajcik and Borko (1999), where Etkina encompasses teachers learning of physics knowledge for teaching within the PCK domain that relates to topics that teachers will be teaching (Etkina, 2010a). This thesis also builds on Etkina's conceptualisation of physics CKT and in particular adopts her Tasks of Teaching (ToT's) in the design of professional learning opportunities for teachers (Etkina *et al.*, 2018).

2.2.3 Approaches to Teacher Collaboration

Teacher collaboration has been shown to enhance teacher professional learning, with strong links between friendship and outputs, for more than thirty years in education research (Hargreaves, 2019, p.617). In this section we explore three models for teacher collaboration: professional learning communities (PLCs), communities of practice (CoPs) and Research Practice Partnerships (RPPs). Teacher collaboration in the form of professional learning communities and communities of practice are reported to address teacher isolation (Krakehl *et al.*, 2020) and raise teacher satisfaction through sharing of practices and participation in learning activities with colleagues (Vangrieken *et al.*, 2017)), while Research Practice Partnerships offer a model to facilitate meaningful learning for teachers and researcher to collaborate in negotiating problems of practice (Penuel, Coburn and Gallagher, 2013).

Professional Learning Communities

DuFour and Eaker (1998) first introduced the PLC model to increase the impact of school reform initiatives. They highlighted the characteristics of professional learning communities within the school:

> *[A PLC is] characterised by a shared mission, vision and values; collective inquiry; collaborative teams; an orientation toward action and a willingness to experiment; commitment to continuous improvement; and a focus on results* (DuFour and Eaker, 1998, p.45).

McLaughlin and Talbert (2001) identify strong professional communities as those groups of second-level school teachers that share a sense of common mission and negotiate principles, policies and resources for their practice. The generation *of* knowledge of practice is demonstrated by this community of teachers who work together and explore ways of improving practice in order to advance learning (McLaughlin & Talbert, 2001). For example, Friedrichsen and Barnett (2017) describe a PLC of second-level biology teachers who were found to negotiate roles in order to advance their communities' goals in redesigning their curriculum (Friedrichsen and Barnett, 2018).

The characteristics of a PLC have been reported in many literature reviews to include: shared values and vision (DuFour and Eaker, 1998; Bolam *et al.*, 2005; Stoll *et al.*, 2006), collective responsibility for pupils learning (Stoll *et al.*, 2006;

Vescio, Ross and Adams, 2008), reflective professional inquiry (Bolam *et al.*, 2005), collaboration focussed on learning (Vescio, Ross and Adams, 2008), professional learning both individual and collective (Bolam *et al.*, 2005; Stoll *et al.*, 2006), openness of networks and partnerships (Stoll *et al.*, 2006), inclusive membership and mutual trust and respect (Bolam *et al.*, 2005; Stoll *et al.*, 2006; Hord and Sommers, 2008;; Vangrieken *et al.*, 2017). Although it could be deduced that school department meetings meet most of the criteria outlined above, Dana & Yendol-Hoppey (2015) specify that PLC's, unlike department meetings, have a central focus on student learning and teacher professional learning. PLCs engage in deliberate and purposeful professional dialogue to learn from practice with the power to change school culture, teacher impact and student achievement. (Dana and Yendol-Hoppey, 2015).

Bolam et al. (2005) highlight that the effectiveness of a PLC needs to be assessed based on i) impact on student learning and ii) impact on professional learning, work experience and morale of the participants of the PLC. Taking this into account, findings from several studies indicate that teacher participation in professional learning communities are reported to positively impact student achievement where the central focus is on student learning (Berry, Johnson and Montgomery, 2005; Bolam *et al.*, 2005; Stoll *et al.*, 2006). In terms of the impact of PLCs on professional learning, Little (2003), describes how teachers share and apply representations of classroom practice that can be utilised as resources for teacher learning. Teachers are provided with opportunities to challenge and critique their existing assumptions about teaching and learning in a strong PLC (Little, 2003). Effective PLCs have recently been reported to foster active, meaningful and collaborative learning (Levy *et al.*, 2020) to improve teaching quality, improve practice and raise expectations of students and views of colleagues (Gore and Rosser, 2020). McConnell *et al.*, (2013) advocate for virtual PLCs, using videoconferencing software, as a valuable resource for teachers who are isolated in rural areas or the only teacher from a particular subject in their school. They report that teachers in virtual PLCs experience the same benefits as science teachers of face-to-face PLCs (McConnell *et al.*, 2013).

However, literature cautions against creating an insular echo chamber (teachers echoeing their own views to each other) within teacher-led PLCs (Little, 2003; Vescio, Ross and Adams, 2008). Bausmith and Barry call for a scale up of

professional development whereby PLCs focus primarily on pedagogical content knowledge (Bausmith and Barry, 2011). In the arena of virtual PLCs, distractions not present in face-to-face meetings such as pets, family members and telephones can be a disadvantage of remote meetings (McConnell *et al.,* 2013).

Communities of Practice

Vangkreiken *et al.* (2017), highlight that although by definition communities of practice (CoP) and professional learning communities (PLC) differ, in practice they are too similar to separate (Vangrieken *et al.,* 2017). Blankenship and Ruona (2007) compared models of PLCs and CoPs to shed some light on their similarities and differences. They highlighted CoPs focus on improvement of practice with less emphasis on organisational strategy as is in PLCs. Leadership from within the community was reported to be associated with CoPs where PLCs value the external leadership role (Blankenship and Ruona, 2007).

CoPs were originally built on three principles: mutual engagement (creating relationships), joint enterprise (setting a goal) and shared repertoire (professional development) (Wenger, 1998). CoPs are voluntary in nature and defined as "a group of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis" (Wenger, McDermott and Snyder, 2002, p.4).

Wenger, McDermott and Snyder (2002, p.2-7), highlight seven core principles for building CoPs.

- Designing for evolution – CoPs happen naturally and as a result evolve over time in terms of adapting design elements appropriate to the community.
- Inviting inside and outside perspectives – Build on the collective experience of its members (insider's perspective), an external perspective is also necessary to highlight possibilities that could be achieved.
- Encouraging different levels of participation - Core members (take on community leadership), active members (less regular or intense participation than core group) and peripheral members (mostly watch the interaction of core and active members) indicate the different levels of participation that can occur in an effective community.

- Developing public and private community spaces – Access through meetings, websites, one-to-one networking.
- Focussing on value – Create experiences that help potential value to emerge from current problems and needs of community members.
- Combining familiarity and excitement – Offer opportunities that are familiar to members (e.g., patterns of regular meetings) and challenges perspectives to aid in divergent thinking (e.g., controversial speaker event).
- Creating a rhythm for the community – Vary the tempo at which the community interacts to match the activity and design of events and ensure engagement does not wane.

Akerson, Cullen and Deborah (2009) also notice the different roles that teachers assume as part of a community of practice, from marginalized member to full participant to leader. One of the conditions reported to build an effective CoP lies in the ability to create collaborative and effective communication between teachers (la Velle, 2020).

Little (2003), describes how CoPs function successfully when teachers take the time to identify problems of practice, discuss and expand these problems into new possibilities, express reservations and concerns and share artifacts of classroom practice (Little, 2003, p.938). Interventions within communities of practice also include: establishing shared goals and shared group norms, effective role division, adapting a critical reflective attitude, developing mutual trust, encouraging task ownership, enhancing perceived interdependence as well as a collective memory (Brouwer *et al.,* 2012, p.340). Effective Communities of Practice have been reported to enhance the development of knowledge and practice through interactions with other teachers and discussions of their struggles with each other (Blankenship and Ruona, 2007; Akerson, Cullen and Hanson, 2009; Brouwer *et al.,* 2012). Communities of practice in schools that foster a culture of growth by providing sustained induction for early careers science teachers have been reported to develop their professional learning (Mercieca, 2018). This culture of growth ranged from: providing opportunities for teachers to observe more experienced teachers model teaching strategies and approaches, allocation of a mentor who provided feedback and team-teaching with another teacher (more experienced) (Mercieca, 2018). For newly qualified physics teachers, adaptation and integration into their new school is a recurrent

concern. Their willingness to integrate into learning communities, even with professionals other than with other physics teachers, is motivation enough to provide opportunities for these teachers to engage in CoPs (Leite, 2006).

There is also much that can be learned from the failures and shortcomings of some ineffective CoPs. Supovitz and Christman (2005) call for CoPs to focus on instruction and emphasize issues by engaging in systematic inquiry of teaching and student learning. Among other recommendations, they highlight that CoPs need to be supported with blocks of time dedicated to collaboration and discussion on student outcomes based on teaching practices (Supovitz and Christman, 2005). Mercieca (2018) also highlights that the support in CoPs must be timely and appropriate to meet the demanding circumstances that teachers face.

Co-design

One of the modes used in extending professional learning is through the process of co-design. Penuel, Roschelle and Shechtman (2007) define co-design as:

> "as a highly facilitated, team-based process in which teachers, researchers, and developers work together in defined roles to design an educational innovation, realize the design in one or more prototypes, and evaluate each prototype's significance for addressing a concrete educational need" (Penuel, Roschelle and Shechtman, 2007, p.53).

In this process teachers are viewed as professional contributors and become active participants in reform of everyday work practice in classroom contexts (Penuel, Roschelle and Shechtman, 2007). The idea of co-design has evolved from concepts such as "user-design" or "user-centered"(Carr, 1997), "participatory approach" (Muller and Kuhn, 1993) or "co-creation", where the focus of initiatives shifts to solving a problem through the participants eyes to work together in a design development process (Sanders and Stappers, 2008).

Co-design is frequently referred to as a collaborative *process*, but the steps in this process are less frequently defined and this is usually because it depends on the context of the design and the nature of inquiry taking place. Steen (2013) loosely outlines the co-design process in a research and innovation project (40 researchers, designers, and developers from 14 organizations) through activities: exploring and defining the problem, perceiving the problem and conceiving

possible solutions and trying out and evaluating solutions. Looking at this process, it resembles Dewey's model of inquiry, and in the context of this study (Steen, 2013) this was the exact fundamental upon which it was based (Dewey, 1922). However, the focus in this process is the "co" in collaboration which was the backbone of the design process – "a process of joint inquiry and imagination" (Steen, 2013).

The roles of those involved in the co-design process needs to be considered during implementation. Sanders and Stappers (2008) refer to "users" or "consumers" as those that eventually benefit from the success of the design process. The levels of creativity that participants within the co-design process possess will determine the role they play and it is up to the researcher to learn different approaches in involving participants in the design development process in order to utilise all of the skills that are relevant to the goals (Sanders and Stappers, 2008). Penuel, Roschelle and Shechtman (2007), portray teachers involved in co-design as "reformers" who concentrate on broad goals for learning. They investigated teacher experiences at the beginning, middle and end of a co-design process and described their role as changing from passive to active (Penuel, Roschelle and Shechtman, 2007). In the beginning, teachers experienced many demands on their time with little return, they were participants in the research. Once data was collected Penuel, Roshelle and Shechtman (2007) report teachers role shifting to that of designers and practitioners whose role was to find new ways of developing technology that could be implemented in the classroom while being supported by the researcher. At the end of the process teachers highlighted their role shift to the implementation phase with more of a focus on practice: "the teachers found themselves in roles they described as "liaison," "salesperson," and "mentor" (Penuel, Roschelle and Shechtman, 2007, p.68).

Some of the steps in co-design are outlined by Penuel, Roschelle and Shechtman (2007) and include taking stock of current practice and classroom practices, constructing metrics of success and providing opportunities for sharing experiences. These tasks are mirrored in the research of Kelly *et al.*, (2019), where they outline a co-design model over time that satisfies teacher professional development needs for changing learner experiences. They suggest that employing cycles of co-design can enable meaningful collaboration and bring

ideas from past co-design workshops into present workshops in an effort to share resources and in some cases promote knowledge transfer between groups (Kelly *et al.,* 2019). Facilitating co-design within the school cycle, focussing on the educational goals of the process and ensuring quality of resources created are central to successful outcomes (Penuel, Roschelle and Shechtman, 2007). Co-design has been credited with high quality professional learning (Kelly *et al.,* 2019; Juuti *et al.,* 2021), increased collaboration resulting in stronger workplace relationships (Brown *et al.,* 2013; Juuti *et al.,* 2021) and a focus on supporting student learning outcomes (Campbell *et al.,* 2019; Juuti *et al.,* 2021).

Research Practice Partnerships

Building on communities of practice, Research Practice Partnerships (RPPs) offer a more sophisticated and accessible model to facilitate meaningful learning in the context of negotiating problems of practice. They provide another mechanism for facilitating teacher professional learning (Penuel, Coburn and Gallagher, 2013). An RPP is defined as:

> *"Long-term, mutualistic collaboration between practitioners and researchers that are intentionally organized to investigate problems of practice and solutions for improving district outcomes"* (Coburn, Penuel and Geil, 2013, p.2)

Mutualism is the "sustained interaction that benefits both researchers and practitioners", that ensures shared ownership and encourages contributions from different perspectives to define the work of the partnership (Coburn, Penuel and Geil, 2013, p.3). Penuel and Gallagher (2017) describe mutualistic relationships as an open-ended commitment between researchers and practitioners who are working towards a shared goal. Problems of practice that stakeholders involved in the partnership care about solving are the focal point of RPPs. These collaborations go beyond existing data and generate original analyses of classroom-based data related to specific questions as decided on by the members of the partnership (Penuel and Gallagher, 2017).

Research alliances, design research and network improvement communities describe three distinct types of Research Practice Partnerships (Coburn, Penuel and Geil, 2013). Research alliances are partnerships between a region and a research organisation that focus primarily on local policy and practice

concerning the region. They establish distinct (mostly conventional) roles for researchers and practitioners who collaborate primarily at the beginning and at the end of the study.

Design research partnerships study solutions in real time focussed on supporting student learning through the development and testing of activities and curriculum materials. These partnerships emphasize co-design and ongoing collaboration within a single region to advance research and theory. Penuel and DeBarger (2016) discuss design research partnerships' role in creating coherence among standards, curriculum, assessment, and professional development related to classroom assessment in science. They describe horizontal coherence (alignment of curriculum, assessment, instruction, and professional development), developmental coherence (how systems help build and assess student learning over time) and vertical coherence (agreement on the key goals for student learning and on the purposes and uses of assessment across participants in the system) as the dimensions to success in improving formative assessment in classrooms (Penuel and DeBarger, 2016). Here, they highlight the importance of co-design in fostering developmental coherence with a common sense of purpose among the participants and suggest that involving regional leaders in the research and development process would foster vertical coherence.

Network improvement communities are not tied to a single region and emphasize context to understand systematic methods for continuous improvement. These types of partnerships may utilize cycles of Plan, Do, Study, Act (PDSA) to decide on small changes to be tested and implemented in practice and engage in a sustained effort at improvement. Here, researchers and practitioners engage in non-traditional roles that vary significantly from their usual work (Coburn, Penuel and Geil, 2013). Hybrid versions of these types of Research Practice Partnerships are evolving in the research today depending on the context, focus and challenges that present themselves in various countries, regions and schools (Henrick *et al.*, 2017, p.3).

Implementing Research Practice Partnerships

One of the key processes in developing partnerships is establishing good meeting processes, especially with the different cultural worlds of researchers and practitioners (Penuel and Gallagher, 2017). Members of the partnership must first acknowledge the cultural differences of each other's workplace before

engaging in co-design RPPs i.e., the stereotypical roles that researchers usually "design" and teachers usually "test" and "implement". Researchers take time to investigate issues. In contrast, teachers need rapid analysis of activities and materials that can be implemented into their practice (Penuel, Coburn and Gallagher, 2013). Hazzan *et al.,* (2008) have identified these cultural gaps as a weakness in their SWOT analysis of RPPs in STEM education and suggest creating communication channels between researchers and practitioners to emphasize that research is not only for academic purposes but people too. They also advocate employing teachers as researchers in the process to sustain the RPP model (Hazzan *et al.,* 2018).

RPPs must next negotiate problems of practice that are fundamental to all partners. Establishing problems of practice that are related to educational aims rather than those that exist as a result of proficiency based on standardised tests is another challenge to be faced in the early stages of negotiating problems of practice (Munter, Quinn and Nguyen, 2020). Penuel and Gallagher (2017) highlight that to define an initial focus of joint work the partners must work together to explore the nature and dimensions of the problem and its context. Methods such as rapid ethnography, mapping the system to observe components, interactions and mechanisms that contribute to undesirable outcomes in the system, and identifying shared values are some of the systematic efforts that can help to better understand the nature of the problem (Penuel and Gallagher, 2017). Much conversation and negotiation occur at this stage of the RPP. Teachers and researchers then progress to implementation of initiatives, producing findings on multiple timescales and in multiple formats, building on cultures of evidence-based practice (Penuel and Gallagher, 2017; Coleman, Gibbons and Tichnor-Wagner, 2021).

Guerrero-Hernández and Fernández-Ugalde (2020) describe a collaborative RPP between schools and universities in Chile over a one-year period. They outline one of the approaches of an RPP in which the teacher researchers select methods and research approaches according to their specific contexts and the researchers provide information and literature to support these projects. In this report the value of reflection for everyday practice is recognised by teachers as consequence of being involved in an RPP even though this practice was rarely implemented into their own practice (Guerrero-Hernández and Fernández-

Ugalde, 2020). Caution is also warranted where teachers that are part of an RPP still see their role as secondary to the researcher. In these cases an emphasis on mutualism and promoting teachers as researchers in the process is a positive step (Penuel and Gallagher, 2017; Guerrero-Hernández and Fernández-Ugalde, 2020).

Research in RPPs is relatively new and there still exists gaps in the literature. Most of the literature focusses on problems of practices; identifying key dilemmas and highlighting challenges that practitioners face (Coburn and Penuel, 2016). Although there is research on the dynamics of partnerships and the mechanisms by which they work, Coburn and Penuel (2016) suggest that outside researchers (rather than first-person reflections), may be more successful in examining these RPPs in real time. There is a need to investigate further the impact of participation in RPPs on teachers understanding of the research process, appreciation for the value of research to inform decisions and engagement in research informed practices (Coburn and Penuel, 2016). Studying partnership effectiveness is also an area that lacks depth of knowledge on supporting claims of progress of an RPP (Penuel and Hill, 2019). The RPP Effectiveness Framework assesses five dimensions of an RPP: building trust and cultivating partnership relationships, conducting rigorous research to inform action, supporting the partner practice organization in achieving its goals, producing knowledge that can inform educational improvement efforts more broadly and building the capacity of participants to engage in partnership work (Henrick *et al.,* 2017). Within this framework Henrick *et al.,* (2017) outline indicators of success and call for researchers to customise the framework to consider the goals of the RPP. Penuel and Hill (2019) build on this suggestion to include gathering evidence of how each of the dimension's manifest within the RPP in order to support claims of progress. Finally, research related to RPPs must go beyond defining problems to presenting the importance of the problem to all stakeholders, include a commitment to systematic inquiry and evaluate multiple qualities and research products (Penuel *et al.,* 2020).

Teacher collaboration was lived out in this thesis, based on findings from the literature, through sustained engagement with teachers that promoted mutualistic relationships (Coburn, Penuel and Geil, 2013) focussed on shared goals specific to their contexts (Guerrero-Hernández and Fernández-Ugalde, 2020).

Overlapping aspects of PLCs and CoPs were also key features of the design of professional learning opportunities for teachers such as; shared values and vision, collective responsibility for pupils learning, reflective professional inquiry, collaboration focussed on learning, professional learning both individual and collective, openness of networks and partnerships, inclusive membership and mutual trust and respect (Bolam *et al.*, 2005; Vangrieken *et al.*, 2017)

2.2.4 Reflective Practice

The evolution of thinking, learning and experience is strongly linked to critical reflective practice. John Dewey (1910) became renowned for his theories on thought, learning and reflection and his teachings echo through research in present day studies. Dewey described the method of thought as an educative method that was theoretically identical with the essentials of reflection (Dewey, 1922, p.192). To reflect, according to Dewey (1910, p.13), meant: "to hunt for additional evidence, for new data, that will develop the suggestion, and will either, as- we say, bear it out or else make obvious its absurdity and irrelevance". He identified subprocesses of reflection to be a state of perplexity, hesitation or doubt -an investigation of illuminating facts that support or reject a suggested belief (Dewey, 1910). He proposed that thinking was a deliberate action that was evoked from an experience. Dewey concerned himself with the nature of experience, understanding it to have both an active (experimenting to find meaning) and passive (it is undergoing) aspect (Dewey, 1922). Here, he determined the place of thinking and reflecting in experience – an involvement in doing something which has happened upon consequence of thinking about it. Dewey suggested that time was required for genuine reflection to occur and trying to understand the significance in our experiences results in consequences of acting upon these observations (Dewey, 1938).

Following on from Dewey's holistic view of reflective experience, Boyd and Fales (1983, p.101), defined reflection to be "*the process of creating and clarifying the meaning of experience (present or past) in terms of self (self in relation to self and self in relation to the world)"*. In their studies they identified particular shifts of focus that framed a model to examine reflection as a process. The stages in this process included: i) a sense of inner discomfort, ii) identification or clarification of the concern, iii) openness to new information

from internal and external sources, iv) resolution expressed as “integration”, “coming together”, “acceptance of self-reality” and “creative synthesis”, v) establishing continuity of self with past, present and future and vi) deciding whether to act on the outcome of the reflective process (Boyd and Fales, 1983, p.106).

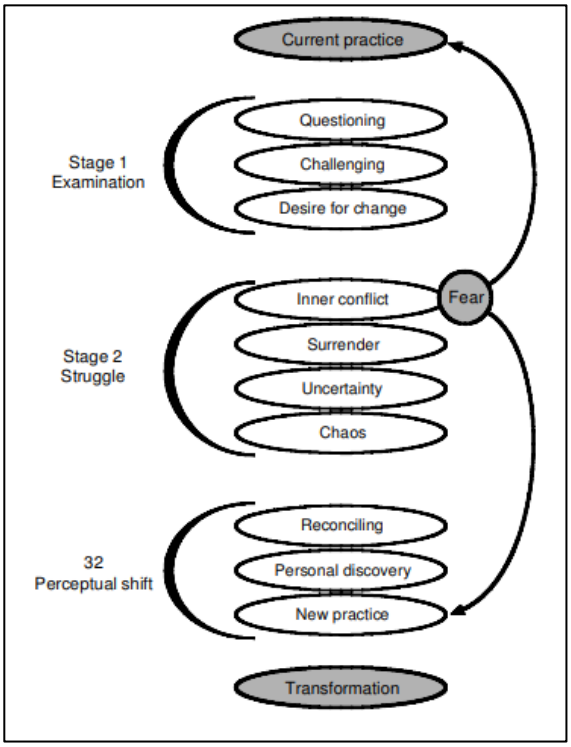
At the same time Schön (1983) developed the idea of the reflective practitioner through investigation of reflection-on-action and reflection-in-action. Reflection-on-action refers to the thinking that takes place about actions that have occurred as practitioners reflect back on a situation they have encountered and try to understand their handling of it (Schön, 1983, 1987). He describes reflection-in-action as the process that takes place as an experience is happening, stemming from the recognition of knowing-in-action (the knowing that is implicit in everyday actions) (Schön, 1983, p.49). This type of reflection happens because of the practitioner’s viewpoint that their case is unique and cannot be solved by applying general theories or techniques. The practitioner goes through a loose process of considering the uniqueness of their situation, reframing the problematic situation, experimenting to discover consequences and implications of the problem, adapting the situation to the frame and reflecting on unintended changes and new meanings (Schön, 1983, p.129-132). Schön suggests that reflection-in-action can act as the bridge between educational experiences in university and in-school teaching practice where practitioners reflect on tacit theories behind practice and compare to formal theories in an effort to encourage practitioners to learn from each other (Schön, 1987, p.321).

This research of Schön (1983) formed the basis for the focus of studies to follow. Whether that was the type, process, impact or assessment of reflection depended on the author. Brookfield (1998) developed the idea of a *critically reflective practitioner* as one who interrogates the assumptions that frame how they work. He called out four complementary lenses through which practitioners view their practice: autobiography as a learner of practice, the learners’ eyes, the colleagues experience and theoretical literature (Brookfield, 1998). The first lens describes the power of recognising aspects of one’s own experience in others’ stories and that individual crises are often collectively experienced in different contexts. The second lens (our learners’ eyes) describes how learners are interpret actions and results in more responsive teaching. Our colleagues’ experiences (lens 3), gives

an alternative perspective to check, reframe and broaden practices. Finally, theoretical literature can help the practitioner understand the consequences of economic, social and political processes that may not be the responsibility of the individual teacher (Brookfield, 2002).

Larrivee (2000) built on Brookfield's idea of the critically reflective practitioner by focussing on conceptualising the development process of a critically reflective teacher. She outlines three practices fundamental to developing as a reflective practitioner: making time for solitary reflection, becoming a perpetual problem-solver and questioning the status quo (Larrivee, 2000). Her framework for the critical reflection process describes a non-linear incremental process that a practitioner weaves through (See Figure 2.2).

Figure 2.2: Stages in the Critical Reflection Process (taken from Larrivee, 2000, p.305)



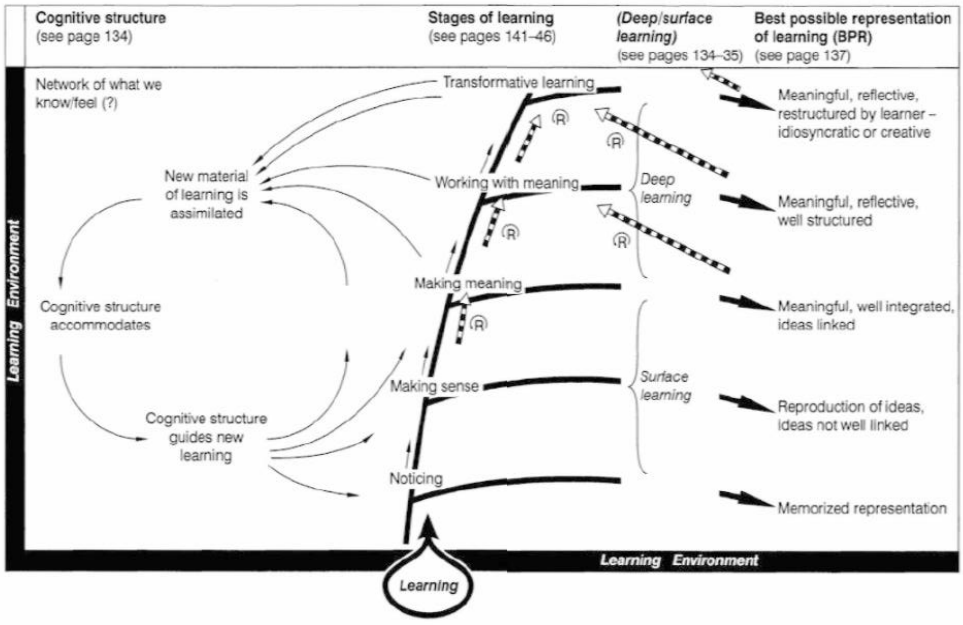
The first stage of examination questions the teachers' actions and analyses the consequences of them. Stage two (struggle) recognises patterns in behaviour and challenges current practice. In the last stage (perceptual shift) there is an acceptance that behaviour needs to change and a desire to change practice (Larrivee, 2000).

Moon (1999) constructed a common-sense definition of reflection from the teachings of Dewey, Schön and others around the notion of learning:

Reflection is a form of mental processing – like a form of thinking – that we use to fulfil a purpose or to achieve some anticipated outcome. It is applied to relatively complicated or unstructured ideas for which there is not an obvious solution and is largely based on the further processing of knowledge and understanding and possibly emotions that we already possess (Moon, 1999, 2004, p.82)

She also provided a map of learning in order to locate reflection in the learning process. The key stages of learning outlined in Figure 2.3 are: noticing, making sense, making meaning, working with meaning and transformative learning (Moon, 1999, 2004).

Figure 2.3: Map of Learning and the Role of Reflection (taken from Moon, 1999, p.154)



She identified reflection in initial learning, reflection in the representation of learning and reflection in the upgrading of learning as the three main areas in which reflection is involved in learning (Moon, 1999). Moon (1999) considered five conditions for reflection: sufficient time and space, a facilitator that understands the nature and purpose of reflection, reflection supported through the curricula or institutional environment, an emotionally supportive environment and consideration of hidden agendas of the environment.

Wallace and Louden (2002) document teachers learning through stories of science education. In their conceptual framework, they describe the dimensions

of *interest* and *forms* of reflection. Technical interest (centered around attending to rule-like regularities), personal interest (connecting experience with understanding of one's own life), problem solving interest (resolving problems of action) and critical interest (questioning taken-for-granted thoughts) highlight the goal of an act of reflection (Wallace and Louden, 2000). The characteristics of reflection are then referred to as forms and include: introspection (looking at one's own thoughts), replay and rehearsal (discussion of events that have occurred), inquiry (involving action and discussion about action) and spontaneity (changing the direction of action in experience) (Wallace and Louden, 2000).

Reflective practice in this review of the literature highlights the importance of reflection to "clarify the meaning of experience" (Boyd and Fales, 1983). Reflective practices were embedded in this thesis building on the approaches of Brookfield's lenses of reflection (Brookfield, 1998) and Moon's map of learning (Moon, 1999).

2.2.5 Professional Learning for Novice Teachers

Considering the low numbers of newly qualified physics teachers entering teaching (See Chapter 1), further examination of the literature related to professional learning was needed in the context of novice teacher education. An examination of novice teacher education within the domains of pedagogical content knowledge, collaboration and reflective practice was carried out. This section explores how novice teacher professional learning is reported as teachers transition into the workplace. Understanding how teacher transition is discussed, using the connecting ideas in the literature review (pedagogical content knowledge, teacher collaboration and reflective practice) helped to identify how professional learning could be explored through the lens of a theoretical framework.

Novice Teachers and Pedagogical Content Knowledge

Persistence of traditional teaching practices, underestimating the cognitive aspects of teaching and little concern about constructing PCK, are some of the challenges that need to be addressed to tackle pre-service teachers preconceived views of teaching (Loughran, Mulhall and Berry, 2008). Foss and Kleinsesser (1996), investigated pre-service teachers' beliefs, conceptions and practices during a mathematics methods course and found that personal history and beliefs (knowledge from their past), rather than course instruction influenced their views on subject matter content knowledge (Foss and Kleinsasser, 1996, p.437). Pre-service teachers also lack a deep understanding of the content they are required to teach as their subject matter knowledge is 'fragmented, compartmentalized, and poorly organized, making it difficult to access this knowledge efficiently when teaching' (Gess-Newsome, 1999, p.63). Etkina (2010) outlines some of the issues pre-service physics teachers face in planning lessons which include: underestimating the time needed to teach a concept, planning logical lesson progression, gaps present in their own content knowledge, difficulty relating content to curricula and assessment practice. Another issue that preservice and novice teachers face in their practice is the tacit nature of teaching (not all elements of good physics teaching such as professional knowledge and beliefs about practices, are transparent and can be observed by the novice) (Kapon and Merzel, 2019). In their study, Kapon and Mezel (2019) categorise pre-service physics teachers' knowledge, practices and

beliefs informing the design of their lessons into three groups: disciplinary content, curriculum and standards and teaching. Disciplinary content, specifically, included a discussion of the difficulties teachers faced in understanding the physics content they were supposed to teach, the correct use of apparatus and measuring tools and concerns the application of physics principles in real life contexts (Kapon and Merzel, 2019). Angell, Ryder and Scott (2005) examined the difference between the conceptual and pedagogical knowledge of expert and novice teachers to find that pedagogic reasoning was the factor that differed between the cohort.

Initial teacher education programmes also have gaps in terms of enhancing and integrating the multiple domains of teaching into a degree programme. Buabeng, Conner and Winter (2015) investigate Finnish teachers' perceptions of preparedness after their initial teacher education. They found that more than a quarter of the cohort of teachers felt that they were unprepared in the use of inquiry-based learning and assessment of students' learning when they began to teach. They also suggest that methods for developing content competencies are needed in teacher preparation (Buabeng, Conner and Winter, 2015). Etkina (2010) emphasises that in order to develop preservice physics teachers' PCK, physics teacher educators need to provide constant help and feedback until the teachers have developed the skills to "go it alone".

Further research is needed on what approaches are effective for developing PCK during pre-service teacher education but recent studies offer useful insights. In a study reported by Loughran, Mulhall and Berry (2008), pre-service teachers' lesson plans were noted to exhibit a stronger conceptual base and teachers developed a sense of confidence in their planning after being introduced to PCK through CoRes and PaP-eRs. They highlight that teachers adopted a language that enabled them to communicate with more experienced colleagues in order to integrate theory and practice in positive ways in their own practice (Loughran, Mulhall and Berry, 2008).

Literature reports that novice teachers often revert back to traditional methods of teaching based on their own experiences as a learner (Hopper, 1999; Kennedy, 1999; O'Meara, Fitzmaurice and Johnson, 2017). When novice teachers begin their teaching career they are faced with many new challenges during their first year's teaching (also known as the induction period). The induction period of

teaching can often undermine pre-service teacher preparation due to its chaotic nature and absence of support, and lead to teachers focussing on instructional strategies to control student behaviour rather than on student learning (Evertson, Hawley and Zlotnik, 1985). There are many reasons for novice teachers' regression to traditional methods, such as difficulty translating content knowledge into learning opportunities, classroom management demands and supporting student learning which becomes especially challenging for newly qualified teachers teaching outside of their subject specialism (Napier, Luft and Singh, 2020).

Angell, Ryder and Scott (2005) investigated novice physics teachers' development of conceptual and pedagogical knowledge in their first three years of teaching (by surveying beginning teachers and expert teachers at one instance). They found that beginning teachers required more support in understanding of student reasoning, teaching strategies and curriculum knowledge (Angell, Ryder and Scott, 2005). Other studies investigated novice teachers use of tools such as concept maps (Suprapto *et al.*, 2018), or an evaluation of their skills such as teaching skills (Karamustafaoğlu, 2007), dealing with student explanations (Touger *et al.*, 1995) or their understanding of student thinking (Levin, Hammer and Coffey, 2009). Etkina, Gregorcic and Vokos (2017) describes the necessity to create opportunities for pre-service physics teacher to create productive habits in order to deal with the demands of the classroom. They highlight that effective teachers need to develop both habits that are general to their teaching and discipline specific (Etkina, Gregorcic and Vokos, 2017).

Novice Teachers and Collaboration

Allen (2009) investigates how novice teachers re-orient their practice in the transition from university to the workplace. She reports that many of the teachers conformed to the status quo of their supervising teachers as they were unconvinced of the strategies recommended to them by their university tutor in pre-service education (Allen, 2009). Alles *et al.*, (2019) outlined that second-level teachers entering the profession from university find the theory-practice gap to be prevalent and the transition incoherent as a result. They also highlight that the level of support received by each teacher varies between schools, teacher educators, mentors and others (Alles *et al.*, 2018). Ma, Chutiyami and Nicoll

(2021) examined early career teachers' (primary and second-level) self-efficacy after their final year in university and first semester of teaching to find that external classroom activities (such as administration duties and building relationships with colleagues and social networks) appeared to be the root of teachers' stress in their first years. They highlight the possible advantage of novice teachers encountering challenges to encourage reflection and growth in their teaching career (Ma, Chutiyami and Nicoll, 2021).

Hammerness and Matsko (2013) describe how their programme focussed on developing an induction programme that was uniquely tailored to their schools' context and setting. Their study concludes that knowledge of the context address important aspects of novice teachers professional learning and support teachers satisfaction and student learning (Hammerness and Matsko, 2013, p.575). Long *et al.*, (2012) investigated extremes cases of novice teacher's experiences in order to reveal more novel information about their school placement journey. They found that pre-service teachers require quality mentoring support or school based supports to negotiate their status as a novice teacher (Long *et al.*, 2012).

Cameron and Grant discuss the importance of mentoring novice physics teachers and describes that in some cases teachers considered the support provided by mentoring as a lifeline in developing their professional identities (Cameron and Grant, 2017). However, there must be a clear understanding of the stages that new teachers experience in order to meet the changing needs of teachers in professional learning communities (Fresko and Nasser-Abu Alhija, 2015). Fresko and Nasser-Abu Alhija (2015) report that communities with teachers of the same professional status (beginning teachers) and outside of school in a familiar surrounding made PLCs non-threatening environments for emotional support. Wynn and Brown (2008), highlight the importance of senior leadership, mentoring and PLCs to the job satisfaction of teachers in their first year of teaching. Beginning teachers in their study emphasise the need for collaboration to provide psychological support and instruction-related support (Wynn and Brown, 2008).

Novice Teachers and Reflective Practice

The idea of forms of reflection, in particular inquiry outlined by Wallace and Louden (2000), sheds some light on the work of Christopher Johns (2009) who characterises reflecting as doing and reflection as a way of being. Johns (2009) describes reflection as "*a critical and reflexive process of self-inquiry and transformation of being and becoming the practitioner you desire to be*" (Johns, 2009, p.3). From the workings of Schön and others, he created a typology of reflective practices that ranges from *doing reflection* to *reflection as a way of being*. Doing reflection suggests using reflection as a device or a tool whereas being reflective focusses more on who the individual is (Johns, 2017). Johns (2017) interest specifically lies with developing the reflective practice of beginning teachers, a skill that will support them in their day-to-day practice. Hopper (1999) shares this interest in his report reflecting on pre-service teachers' experience of being taught. By using a rubric (tool to identify characteristics of student teachers), he exemplifies how teachers can reframe their experiences of being taught to their experiences of learning to teach. He found that pre-service teachers use the grid to "make explicit many aspects of their implicit beliefs regarding effective teaching" (Hopper, 1999, p.57).

Loughran (2002) examines the nature of reflection and how it can be enhanced through teacher preparation programmes. He suggests that reflective practice offers an opportunity for pre-service teachers to interpret problematic situations in practice from the contradictory perspectives of both the student and teacher. Effective reflective practice that creates learning through experience provides opportunities for development of professional knowledge (Loughran, 2002). In recent studies, Liston *et al.,* (2020) applied Brookfield's four lenses of reflection to investigate reflective practice in initial teacher education. They report the challenges that these teachers face in writing reflectively. Surface reflection devoid of critique and honesty was the biggest challenge of successfully embedding critical reflective practice and emphasized the need for significant guidance, support and feedback to teachers during implementation (Liston *et al.*, 2020).

McGarr and McCormack (2014) highlight some of the challenges associated with promoting deep student reflective practices. They emphasise the need to consider the stage of development of student teachers, whether they are focussed predominantly on the "Self", their limited exposure to school and the classroom environment or cultural conditioning of the teachers within the school (related to power relationships with more experienced teachers) (McGarr and McCormack, 2014, p.275-276).

Key findings from novice teacher literature highlights some challenges to be considered when designing novice teacher professional learning such as; supporting novice teachers in understanding of student reasoning, teaching strategies and curriculum knowledge (Angell, Ryder and Scott, 2005), the need for supports outside the school environment (Fresko and Nasser-Abu Alhija, 2015) and novice teacher's limited exposure to classroom experience when reflecting (McGarr and McCormack, 2014).

2.2.6 Novice Teachers and Transitions

Much of the research presented above discusses novice teachers' experiences either as a pre-service teacher or a newly qualified/beginning teacher. Considering novice teachers are defined in this thesis as those that span both of these time periods, literature related to teacher transition was also a relevant area of exploration for this literature review.

Transitions in teacher education were reported in the literature at each level of teacher education (early childhood, primary and second-level). Hopper (1999) reports that novice teachers experience difficulty in separating their experiences of being taught to learning how to teach. This is corroborated in a study of primary science teachers where Mulholland and Wallace (2003) use a "border crossings" theoretical framework to inspect their transition from pre-service to in-service teaching, from non-science to science and from other school subjects to school science. They observed that past experiences and understandings largely influenced their crossing the border from the sub-culture of the university to the sub-culture of the primary school (Mulholland and Wallace, 2003). Pietsch and Williamson (2010) explore beginning primary teachers' changes in knowledge of teaching, contexts of teaching and themselves as teachers. They highlight that developing knowledge of teaching requires more than just 'practice' in a classroom. They also report that employment context was central to development of professional knowledge. Teachers who had their own class that they could monitor over time and reflect and evaluate their own teaching were seen to develop knowledge and skills (Pietsch and Williamson, 2010).

In a study with early childhood teachers, that focussed on transition into the workplace, it was reported that teachers' perceived competence increased at the end of their teacher education and decreased after entering the career (Mischo, 2015). However interesting this finding may seem, Mischo (2015) could not attribute this decrease in perceived competence as related to the work transition as graduates who did not enter the field also experienced it. On the other hand, the study reported that these increased competences of teachers at the end of their graduate degree indicated the effectiveness of their initial teacher education (Mischo, 2015, p.89).

The study of transitions in teacher education, found in the literature, was mostly related to the impact of initial teacher education with their classroom practice

either on school placement or in their first years' teaching. Tynjälä and Heikkinen (2011, p.26) reviewed research related to novice teacher transition and reported similar challenges as graduates from other professions also related to threat of unemployment, feeling of inadequate competences, decreased self-efficacy and increased stress. They understand that teacher attrition, belonging in the work community and learning on the job are all aspects of teaching that novice teachers face in their beginning years of teaching (Tynjala and Heikkinen, 2011). Tynjälä and Heikkinen (2011, p.27) call for further research into novice teachers "practice architectures" (what makes up the educational culture) in order to tailor supports for teachers.

Although transition from pre-service to in-service teacher education seems to be an obvious event in the life of a novice teacher, literature describing the experiences of second-level ***physics teachers*** as they go through this transition (during as opposed to before and after) is sparsely reported. The previous findings offer mostly qualitative findings to inform the exploration of novice teacher education both in pre-service teacher education and in-service teaching environments *in general*. The studies found mostly focused on specific aspects of professional learning, or novice teachers use of tools and strategies considered at a snapshot in time rather than ***holistic explorations*** (using a systematic approach) of teacher transition.

This research thesis aimed to address the gap highlighted in the literature*; novice physics teacher transition from pre-service teacher to newly qualified teacher*, as the teachers engaged in physics teacher professional learning (with a focus on PCK, collaboration and reflective practice). A theoretical framework (transition theory) was selected to examine teachers' experiences of transition holistically and systematically (addressing the lack of methodological approaches in this area), as outlined in the next section.

2.3 THEORETICAL FRAMEWORK

Grant and Osanloo (2016) describe the theoretical framework of a dissertation as the "blueprint" of an inquiry that provides structure to build and support a study. One of the most common issues novice teachers face in the transition from their initial teacher education programme to their early years of teaching is that they are not fully prepared for the complex situations they are faced with when they enter the classroom (Niemi, 2002). The theoretical background for this study was derived from the teachings of transition theory (Schlossberg, 1981) in psychology and provided a lens through which the experiences of novice physics teachers entering the profession could be examined. This section describes the suitability of transition theory to frame the research questions, study design and data analysis (especially in Chapter 5 and 6) focussing on novice physics teacher's transition from university to their first year of teaching.

2.3.1 Transition Theory - Background

In 1981, Nancy K. Schlossberg, a clinical psychologist, proposed a model for analysing human adaptation to transition. She defined transition to be, *"an event or non-event [that] results in a change in assumptions about oneself and the world and thus require[s] a corresponding change in one's behaviours"* (Schlossberg, 1981, p.4). This phenomenon she described was the perception of change by the individual, in other words defined by the person experiencing it. Theoretical perspectives such as the developmental perspective, the contextual perspective, the lifespan perspective, and the transition perspective formed the basis of a transition framework examining the adult experience (Goodman, Schlossberg and Anderson, 2006). The developmental perspective focused on adult development as a sequence of nature through age and stage (moving through stages as a consequence of their age). For example, it examines development based on the resolution of issues (Vaillant, 1995), development based on age (Levinson, 1986) and domain specific development (Belenky *et al.,* 1986). The contextual perspective views adulthood in relation to the context in which it occurs by accounting for the sociological and ecological factors affecting individuals (Hawley, Goodman and Shaieb, 2002; Goodman, Schlossberg and Anderson, 2006). The life-span perspective considers the different forms of adaptation such as: growth, maintenance/resilience and

regulation of loss. This perspective values life events that are specific to the individual (Roberts, Helson and Klohnen, 2002).

Lastly the transition perspective focusses on life events that cause change and require coping with a crisis situation over a period of time and between life stages (Schlossberg, 1981). Transitions can include:

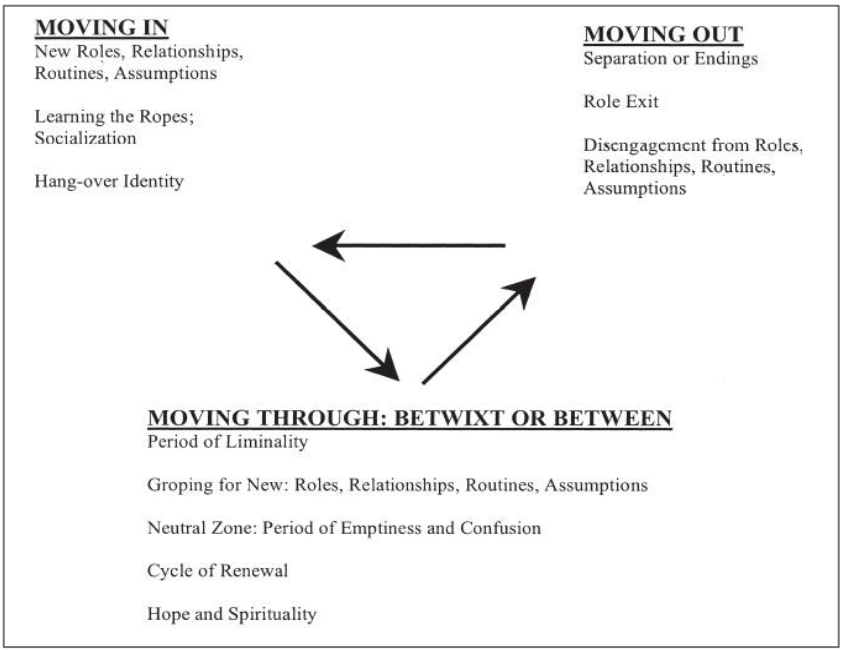
i. obvious life changes (known as anticipated events) such as getting married, graduating, the birth of a child, retirement;
ii. subtle changes (known as unanticipated events) such as a sudden bereavement, being fired, being promoted;
iii. non-events such as not getting married, an expected job promotion that never comes (Schlossberg, 1981, 2011; Goodman, Schlossberg and Anderson, 2006).

The transition framework is based on the premise that i) transitions are continuously happening, ii) the type, context and impact of a transition determine the reaction to the transition and iii) there is no end-point, a transition is a process over time (Goodman, Schlossberg and Anderson, 2006).

2.3.2 The Transition Process

Goodman, Schlossberg and Anderson (2006, p.40) insist that the only way to examine people experiencing a transition is "to study them at several points in

Figure 2.4: Integrative Model of the Transition Process (Taken from Goodman, Schlossberg and Anderson, 2006 p. 50)



time". They suggest three stages for understanding the transition process, moving in or moving out, moving through and moving out or moving in again (Figure 2.4).

Individuals ***moving in*** to a transition share common needs such as becoming familiar with new roles, rules, norms and expectations of the new system (Goodman, Schlossberg and Anderson, 2006). In the context of a work transition specifically, the individual is required to understand the expectations of peers and supervisors and become accustomed to the company/industry norms. This may entail learning new skills and in this new role can result in feeling marginalised. At the same time there is an expectation that the individual will experience joy, at the prospect of a new job. During this stage, the individual needs to feel supported and challenged in balancing work duties and other parts of their lives (Goodman, Schlossberg and Anderson, 2006).

Once the individual has learned the ropes of the new role, they begin to ***move through*** the transition. This period is seen to evoke reflection and re-evaluation of the transition. During the moving through phase of a work transition, a person initially goes through a period of exploration and innovation. This is followed by a period of time during which the person focusses on extending and improving skills. Finally during the moving through phase, the individual must embrace the new and different in order to transform and move to successful fulfilment and reinventing of the future (Goodman, Schlossberg and Anderson, 2006).

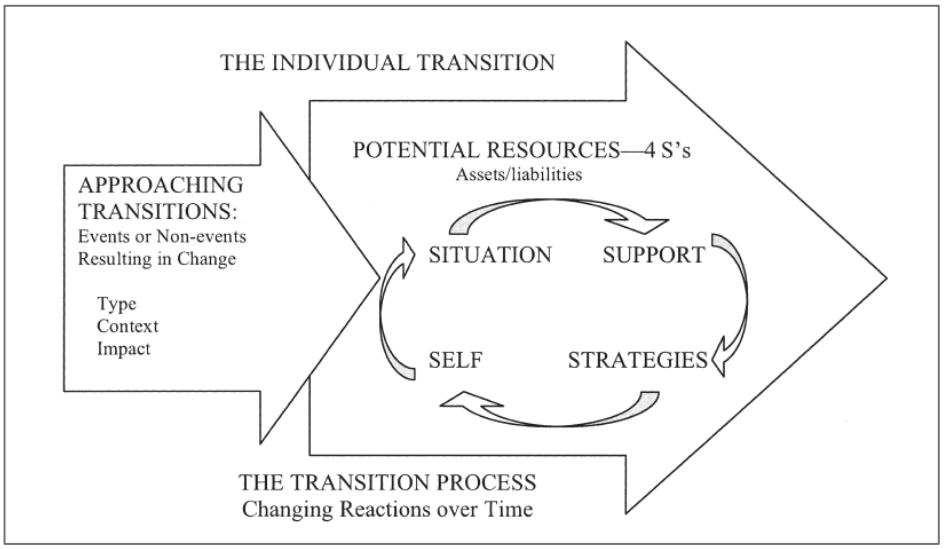
Moving out of a transition can be viewed at the end of a transition period or at the start of a new transition (exiting a transition in order to embrace a new change). Goodman, Schlossberg and Anderson (2006) draw on research from a workshop for people in transition to summarise the shared experiences of individuals moving out of a transition. These experiences included leaving a job, a period of confusion and distress and a new beginning (Goodman, Schlossberg and Anderson, 2006). They report that during this phase the person can display feelings of mourning or disbelief for the job change or loss, to resolution and accepting the reality of the situation (Goodman, Schlossberg and Anderson, 2006).

2.3.3 Transition and Adaptation

Taking stock of the resources an individual needs to cope with the transition is the next step in examining the transition of an individual. The characteristics in this section describe the transition model as the individual is *Approaching Transitions* where the nature of the transition is established, the transition in question is identified and the process locates where the individual is in the transition, see Figure 2.5.

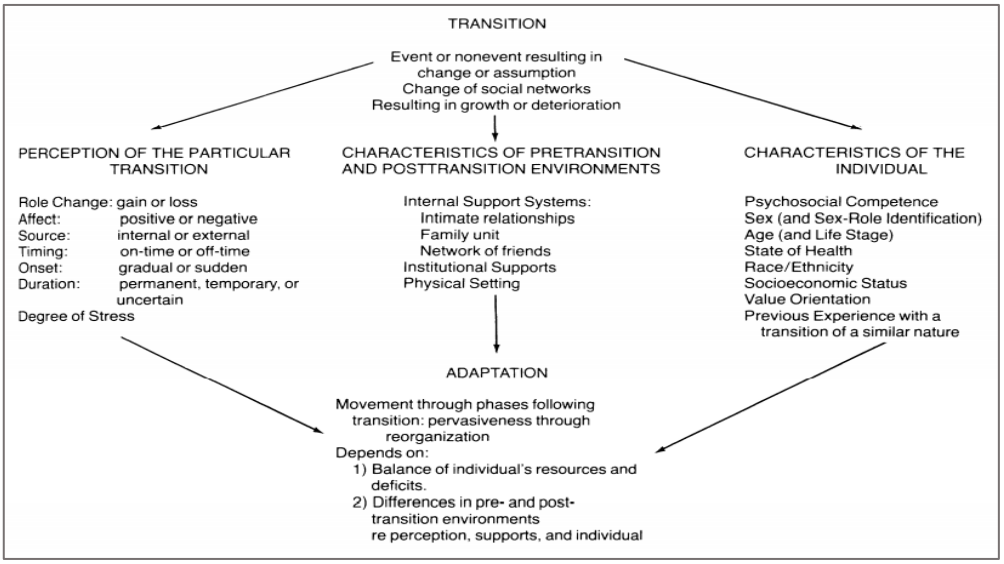
Goodman, Schlossberg and Anderson (2006) provide the 4S system (Situation, Self, Support and Strategies) to identify these resources. The *Situation* the individual is in varies according to what triggered the transition, at what stage in the person's life it happened, if it involves a role change, the length of the transition, any previous experience of this type of transition, the stresses facing the individual and whether they view it as a positive, negative or benign change (Goodman, Schlossberg and Anderson, 2006). The Self refers to the characteristics of the individual as mentioned previously. Similarly, Goodman, Schlossberg and Anderson (2006) describe Support as inclusive of the characteristics of the environments of the individual (specifically the internal support system of intimate relationships, the family unit and the network of friends) that can affect, affirm and aid the transition period. Lastly, Strategies of varying function are implemented by the individual to help cope with the transition and adapt to the change. Most individuals either try to control the situation, control the meaning of the situation or control the stress (Goodman, Schlossberg and Anderson, 2006, p.82).

Figure 2.5: The Individual in Transition (Taken from (Goodman, Schlossberg and Anderson, 2006, p.33)



With transition, comes adaptation to the transition and Schlossberg (1981) defined a dynamic view of adaptation to be, "a process during which an individual moves from being totally preoccupied with the transition to integrating the transition into his or her life" (Schlossberg, 1981, p.7). Adapting to a transition depends on the balance between assets and liabilities within the transition, the environment and the individual (Goodman, Schlossberg and Anderson, 2006) and these aspects form the basis for Schlossberg's model, see Figure 2.6.

Figure 2.6: Schlossberg's Model for Analysing Human Adaptation to Transition (Schlossberg, 1981, p.5)



Interpreting the type of transition, the context of the transition and the impact of the transition on the individuals life is necessary to understand the process of a transition over time (Goodman, Schlossberg and Anderson, 2006). Schlossberg (1981) characterises a transition according to seven parameters. *Role change* is assessed according to whether the individual experiences a role gain (becoming a parent or taking a job) or a role loss (retiring, being widowed) both of which are accompanied by some degree of stress. The positive or negative *affect* of the event is also considered to involve some degree of stress and is one of the characteristics of a transition. The *source* of the transition can involve changes that are a result of a deliberate decision, forced on by other people or circumstances or how much control the individual feels the have on the change. The *timing* of the transition can be on-time or off-time and is most commonly linked with age as a defining variable (Schlossberg, 1981). Whether the transition is gradual (expected due to an inevitable result or deliberate decision) or sudden (unexpected with no time to prepare) can help the individual to cope with the *onset* of the transition. Schlossberg (1981) also highlights that the greatest degree of stress is caused by a transition of uncertain *duration*. Finally, the degree of *stress* is the dependent on the previous characteristics and the impact of this stress can often be softened with interpersonal support systems (Schlossberg, 1981).

Schlossberg (1981) outlines that impact of a transition can be measured by comparing the pre and post transition environments. This entails an examination of interpersonal support systems, institutional supports and the physical setting. Firstly, she maintains that interpersonal support systems such as intimate relationships, the family unit and a network of friends are essential to successful adaptation. Secondly, institutional supports such as religious institutions, political groups or other community support groups can also have an impact on the adaptation to a transition. Thirdly, the broad physical setting such as the climate, location, workplace etc. may contribute to an individual's stress, sense of well-being and general outlook on life (Schlossberg, 1981).

The last aspect to consider within this model is the characteristics of the individual. Psychological competence, sex, age, state of health, race/ethnicity, socio-economic status, value orientation and previous experience with a transition of similar nature characterise the individual experiencing the transition

(Schlossberg, 1981). While most of these indicators are self-explanatory there are two which warrant further understanding (psychological competence and value orientation). Psychological competence refers to one's ego development, optimism, self-efficacy, commitment, values, spirituality and resilience all of which are associated within the individuals self-attitudes, world attitudes and behavioural attitudes (Schlossberg, 1981, p.12). Value orientation is related to priorities given to economic productability, sociability, philosophical or religious codes, helping others or community service (social service), feelings of security or contentment, pleasure or enjoyment and personal growth (Schlossberg, 1981, p.15). Some of the indicators of this characteristic can contribute to high stress, for example, maintaining self-esteem and a sense of personal worth, poor health, high socio-economic status (work/life balance) or a troubling experience with a previous transition. On the other hand, an individual who sets realistic goals, who values their close friendships and is in good health may not experience the same stress in a similar transition period.

2.3.4 Applications of Transition Theory

Schlossberg's transition theory has been applied across a variety of fields in recent years originating in counselling adults (Goodman, Schlossberg and Anderson, 2006) to understanding the journey of a registered nurse (Wall, Fetherston and Browne, 2018), experience of early motherhood (Gbogbo, 2020), transition to supervisory roles in government (Derrick, 2019) and male student athletes (Flowers, Luzynski and Zamani-Gallaher, 2014). Powers (2010) provides a clear application of Schlossberg's transition theory in her study of male dropouts in college. In her study the three phases (moving in, moving through and moving out) provide a conceptual framework that are moderated by the 4S's (situation, support, self and strategies) (Powers, 2010). However, the application of Schlossberg's transition theory to the transition from pre-service to in-service teaching is lacking. Goings, Bristol and Walker (2018) use transition theory with the lens of African American male theory to investigate the experience of a black male refugee pre-service teacher. They report that the participant's various identities were central to understand how he experienced transitions and highlight the need for teacher education programs to support pre-service teachers adapting to working in the school environment (Goings, Walker and Bristol, 2018). Haim and Amdur (2016) apply Schlossberg's theory to

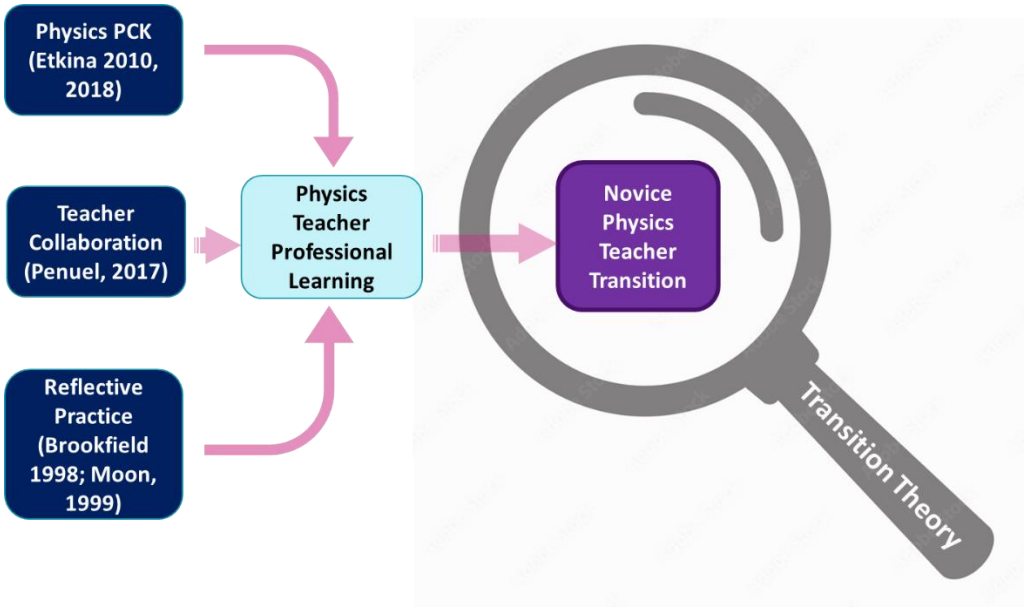
second career teachers in their first year of teaching. They utilize the 4S model to examine teachers experience of their transition into teaching and identify some of the challenges that these teachers encounter (high expectations of themselves from previous career success, adapting to the new environment) (Haim and Amdur, 2016). Goodwin *et al.*, (2019) investigate how the transition of environments and roles vary for second-career and first-career teachers. In this research the transitions examined are that from workplace to school teaching and from university learning to school teaching. Although they postulated that the transitions would differ in terms of retention intentions due to the samples differences in age, stage and work experience, they reported that regardless of the extra work experience [of second-career teachers] all pre-service teachers intentions to stay in the profession drops in their first two years of teaching (Goodwin *et al.*, 2019).

The literature presented here, highlights the sporadic breadth of studies and applications of Schlossberg's theory in novice teacher education. Exploring novice teachers' journey as they approach the transition from pre-service teacher education to in-service teaching would greatly benefit from more studies using this evidence-based perspective of Schlossberg's transition theory.

2.4 CHAPTER CONCLUSIONS

The gap in the literature, presented in this thesis, was identified as*; novice physics teacher transition from pre-service teacher to newly qualified teacher* with a considerable lack of approaches to systematically examine novice physics teacher experiences. Transition theory, as outlined by Schlossberg (1981), was selected as a suitable lens to understand how novice physics teachers experience transition. This theoretical lens was seen (in the application of Transition Theory in other fields of research) as a holistic and systematic approach that could be used to capture the teachers' (in this study) individual context. Meanwhile, teachers also engaged in physics teacher professional learning (with a focus on PCK, collaboration and reflective practice) as part of their journey to becoming a confident and competent physics teacher. This aspect of the research (Physics Teacher Professional Learning) was conceptualised as a contextual input to consider when examining the transition (See Figure 2.8).

Figure 2.7: Conceptualisation of Novice Physics Teacher Transition using Transition Theory in the Context of Professional Learning for Physics Teaching



2.4.1 Research Questions

The following research questions were generated to investigate different aspects of the conceptualisation outlined in Figure 2.8. Firstly, mapping the terrain to investigate teaching Junior Cycle science and trial approaches to support teacher professional learning and collaboration were addressed through the research question:

1. What are science teachers' experiences of engaging in professional learning for physics at Junior Cycle? (Chapter 4)

Research question 2 examined the experiences of novice physics teachers in the context of their transition from being a pre-service teacher to becoming a newly qualified teacher.

2. What are teachers' experiences of becoming a novice physics teacher? (Chapter 5)
    a. What transitions are occurring throughout teachers' experience?

Finally, research question 3 explored how teachers adapted to the transitions (identified in Chapter 5) and how the findings from this study have implications for both practice and policy in teacher education.

3. What adaptations do novice physics teachers experience across transitions? (Chapter 6)

3 CHAPTER: RESEARCH METHODOLOGY

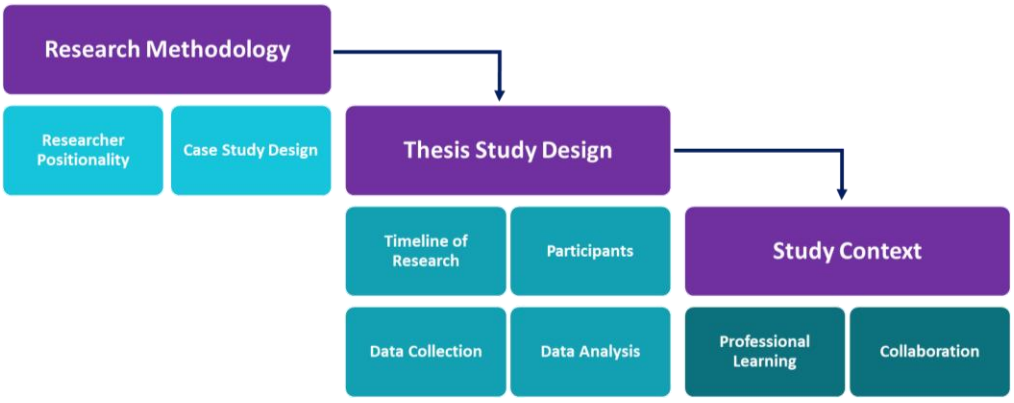
"Good research is not about good methods as much as it is about good thinking."

(Stake, 1995, p. 19)

3.1 INTRODUCTION

This chapter begins with a description of the researcher's positionality within the research (considering epistemological and ontological viewpoints) and reflexivity in making decisions related to the research (See Section 3.2.1). Aspects of bias are also identified in this section. The chosen methodology for this research was case study and an outline of this methodology is described in Section 3.2.9. The thesis study design is described in Section 3.3 and details of the timeline of the research, participants, data collection and analysis are presented. Study context and design consideration such as approaches to professional learning and teachers' collaboration complete the description of the thesis and ethical considerations are also described in this section.

Figure 3.1: Overview of Chapter 3



3.2 RESEARCH METHODOLOGY

In order to select a suitable research methodology, the researcher's positionality within the research needed to be established. The researcher outlined their epistemological and ontological perspectives (mostly interpretivist – constructivist) and described how their bias could have influenced the study. This section then moves on to describe the research methodology (Background, Design, Data Collection, Reporting and Challenges) that was used in this thesis.

3.2.1 Researcher Positionality

Considering the unique and complex issues of individual teachers is a key focus for the researcher when searching for meaning among participant data throughout this thesis. Therefore, the researcher's position (intentions and investment in the study) was an important consideration when interpreting the approach and findings from this research.

Researcher's Note

I am a qualified Maths and Physics teacher currently completing this research as part of a doctoral thesis. As a teacher I was exposed to teaching subjects outside my specialism (namely Chemistry and Geography) outside my qualification (Kindergarten Maths and Science) and in a different country (Bahrain) with very different examination standards (Cambridge International AS and A Level, College Board SAT exams and National Exams). This allowed me in some ways to empathise with the participants involved in the case studies. However, as the researcher it was important to self-reflect and question my relationship with the research context, the participants and the data (Corlett and Mavin, 2018).

The way in which the researcher understands knowledge to be constructed (epistemological beliefs) is an important consideration in any research study (Feldman, 2005; Schraw, 2013). Creswell (2007) states that qualitative research must consider the assumptions, worldview and theoretical lens of the researcher to study meanings related to a social or human problem (p.37). In this study, the researcher positions themselves within the qualitative paradigm of an interpretivist-constructivist perspective. However, aspects of pragmatism related to the functional and methodological approach of the pilot study can also be observed.

Researcher's Note

My experience as a teacher has informed my epistemological beliefs and philosophy of teaching. I have a keen interest in observing and gaining a deep understanding the issues of learners (both as a second level teacher and as a university lecturer) and I adopt a constructivist approach to my teaching methods.

Interpretive researchers are concerned with gaining understanding of an issue in its unique context (Tuli, 2010), understanding subjective meanings of persons and creating a holistic understanding of the different parts of that meaning (Merriam, 1985; Goldkuhl, 2012, p.138). Situated within the constructivist ontology, interpretive researchers believe that knowledge is socially constructed and reality is a human construct (Goldkuhl, 2012). However, the empirical focus on actions and changes, the role of knowledge to be useful for action and the data generation through assessment and intervention that are related to pragmatism are all considerations that are also intertwined throughout this research (see Chapter 4) (Figure 3.2).

Figure 3.2: Goldwuhl's Identification of Pragmatism vs Interpretivism: ideal-typical differentiation (Goldwuhl, 2012, p.142)

	Pragmatism	*Interpretivism*
Ontology	Symbolic realism	Constructivism
Empirical focus	Actions and changes	Beliefs (socially constructed cognition)
Type of knowledge	Constructive knowledge	Understanding
Role of knowledge	Useful for action	Interesting
Type of investigation	Inquiry	Field study
Data generation	Data through assessment and intervention	Data through interpretation
Role of researcher	Engaged in change	Engaged in understanding

Trustworthiness and credibility were necessary criterion for judging the quality of the research studies in this thesis through careful justification of chosen methodologies, processes of data collection and approaches to data analysis (See Section 3.3.6) (Guba and Lincoln, 1994). Aligning with the interpretivist viewpoint, inductive research was conducted which focussed on arguing from the particular to the general (Dieronitou, 2014), and the design of the study was flexible in order to "gain "deep" understanding and valid representation of the participants' viewpoints" (Krauss, 2005, p.764). However, Chapter 6 does focus on applying deductive analytical strategies to consider how theory informs practice and draws on the pragmatist viewpoint of using knowledge for action.

Ontological aspects (the nature of reality) emanated subjective tendencies as methodological considerations were embedded in participants experiences and the meaning created from these experiences were documented through the researchers own perceptions (Tuli, 2010; Goldkuhl, 2012; Schraw, 2013; Merriam and Tisdell, 2016).

Researcher's Note

Across the duration of this research, my own position and roles in education had changed and I had experienced transitions in my own career. Firstly, I changed roles from a second-level teacher to a PhD researcher, to finally being a university lecturer. Considering my values at each time was necessary to remain aware of these subjective and contextual aspects of the study. This was achieved by reading back over researcher notes at the time the data was collected to ensure the different nuances of the situation were respected within the context and time (Holmes, 2020). Secondly, my transition from novice researcher to early career researcher altered my positionality, skillset and experience within the study. Interestingly my epistemological beliefs (a focus on understanding) supported my journey as a researcher in understanding the participants at different points in time. As such I regularly reflected back on the aims and objectives of the study in order to avoid trying to fill the gaps (in the data) according to my own experiences of the field.

3.2.2 Researcher Bias

This section outlines several aspects that may be influenced by the researcher's bias and experiences and discusses how these potential biases were attended to in the design and carrying out of this research.

Good Physics Teaching

From the beginning of this research the term "quality teaching" or "good physics teaching" is used. However, this terminology brings with it a certain amount of bias. The differences in the interpretation of these terms are evident in the diversity of how physics teacher professional development is designed and delivered (See Chapter 2). In this thesis, this bias was attended to by highlighting the key aspects of professional learning (pedagogical content knowledge, teacher collaboration and reflective practice) that contribute to "quality" professional learning (as is reported in the literature discussed in See Chapter 2).

Researcher's Note

My own journey as a researcher has reignited a newfound appreciation of the work of other researchers and the place of theory in practice. This can be seen in the study design, especially the approach to professional learning and teacher collaboration adopted in this research (See Section 3.4.1 and 3.4.2).

Data Collection

Self-reflexivity was an important aspect of the research to declare and make transparent (Burck, 2005). For example, while examining transcripts from interviews, I noticed that as an interviewer there were times when I interjected with a question before the participant had fully responded. Some of this was due to the limitations of online interviews and at other times arose from a tendency to predict the response to a question. As the research progressed, I became more experienced as an interviewer and a researcher. I tried to mitigate any loss of data by providing participants with opportunities to reiterate any aspects they felt that were important or were lost in the interview e.g., "Anything you would like to add?, Any other advice or lessons you learned that you would like to repeat?, Did I understand you correctly when you said…?".

It was important to acknowledge the shift in relationships of power within this research. The researcher relationship with novice teachers changed many times over the course of this research - from their lecturer in their final year of their degree programme to being a researcher and mutualistic partner in the Research Practice Partnership (Discussed in Chapter 5). Mutualism is a key characteristic of RPPs and defined as a situation where "the focus of the work is jointly negotiated and there is shared authority" (Coburn and Penuel, 2016, p.49)

During the Research Practice Partnership meetings, I had to navigate my role as a participant and a researcher in this group. My participation as mutualistic partner required me to learn from the other partners (teachers) and engage in activities during the meetings just as the other partners did (e.g., discover my problems of practice, formulate actions to address these problems etc). As a researchers I was also reflecting on the different components that made up the RPPs (e.g., mutualistic partnerships, content within the meetings, improvements for the next meeting). My role as a researcher was also predominant in the pre and post planning of the meetings as methods of data collection within the RPP and reflections after the RPP were designed and implemented. For these purposes and dual roles, my reflections were documented (See Appendix H) and actions were considered to ensure the integrity of the Research Practice Partnership (RPP) and data collection for the thesis (Penuel and Gallagher, 2017).

Researcher's Note

By keeping a reflective journal, I was able to maintain a reflexive approach and remain open-minded, for example, when participants discussed methods that did not align with my philosophy (Holmes, 2020). This was done by simply writing down questions and critical comments and using them as guides for searching the literature. I found myself re-analysing data towards the end of my study as I interpreted reflections in order to adopt a more rigorous approach and encompass alternative perspectives (Corlett and Mavin, 2018).

My reflections were also influenced by ongoing discussions with my PhD supervisor, who was also a member of the Research Practice Partnership.

Interpreting the Findings

Qualitative research is widely understood in the literature to be a subjective understanding where context matters and data is analysed to either prioritise the interpretations of the participant or the analyst (Braun and Clarke, 2013). When reading the observations and conclusions drawn from this research it is necessary to understand that the interpretations were based on what the researcher thought to be significant. Frequency of themes and a reflective journal were used to mitigate as much bias as possible. However, this is not to be confused with prioritising those themes with a higher frequency (this was not the case) as is stated in the literature thematic analysis is less concerned by the frequency (shallow reporting) of a theme and more about a "coordinated picture" or "explanatory model" (Bazeley, 2009, p.4).

3.2.3 Introduction to Research Methods

Selecting a suitable methodology to address the research questions of this PhD study in a meaningful way was the first consideration in this research study design. Case and Light (2011) reviewed the literature in their quest to identify a suitable methodology for engineering education and their findings were useful in identifying suitable methodologies for the research presented in this thesis (summarised in Table 3.1).

Case study is highlighted as a suitable methodology for exploring interesting or distinct events, participants or activities through in-depth examination (Case and Light, 2011, p.191). The purpose of case study methodology is to contribute to rich and context dependent insights and often the lack of generalisability is put forward as a limitation of this methodology (Flyvbjerg, 2006).

The use of grounded theory is evident in its name, to generate theory from the data (Case and Light, 2011, p. 193). As highlighted by Case and Light (2011), this methodology is an uncommon practice in education research as much of the process of building on education research is to consider theory in practice.

Case and Light (2011) describe ethnography as a methodology that is situated in the life of the participant or event and tries to understand the subject in an environment (p.195). Here, the difficulty lies with interpreting the quality of the data such as overheard conversations as idle pieces of gossip or alternative perspectives (Case and Light, 2011). This type of research is also seen to be open to multiple interpretations and precise details can be difficult to pin down (Walford, 2009, p.275).

Action Research presents itself as a methodology focussed on improving practice within social situations (Case and Light, 2011, p.196). Laudonia *et al.*, (2018) describes the many different types of action research and their role in science education to enhance teachers' professional development, inquire into students' cognition or improving curriculum and pedagogy. Limitations with respect to theory-based guiding principles and more systematic approaches to measure impacts are outlined in the literature on action research (Laudonia *et al.*, 2018).

Table 3.1: Summary of Research Methodologies (Quoted from Case and Light, 2011, p.186 - 202)

Methodology	Description	Uses	Limitations
Case Study	In-depth study or examination of a distinct, single instance of a class of phenomena such as an event, an individual, a group, an activity, or a community	To explore a range of different settings, or identifying unusual cases which allow the researcher to probe particularly problematic situations, or using critical cases which allow for logical deductions of the type	Critiques are concerned with the issue of generalizability of the empirical results attained by case study
Grounded Theory	Theory is generated from the data at hand, rather than already existing theory being used in the analysis as is generally common in education research	To generate new theory	Limited application in education research, where researchers often find it productive to use existing theoretical constructs in their analysis
Ethnography	Participant observation to develop a full understanding of an environment	Closely studying first-hand how people live in particular social situations	Challenges associated with gathering and interpreting data and the quality of data sources
Action Research	Foster change in social practices in the social situations in which they take place "within every day, natural contexts rather than within controlled settings" (Cousin, 2009, p.150)	Strategic improvement of practice	Active engagement of the practitioners can be difficult to recruit
Discourse Analysis	The data that forms the focus for this methodology are actual instances of language in use. The term discourse always refers to communication that is socially situated	To get insights into the beliefs, values, and world views which are held by participants since these are always reflected in the use of discourse	Activities of academic discourse are never neutral and can pose particular difficulties when they clash with other discourses in which the student is engaged
Narrative Analysis	Narrative methodology is focused on investigating the way people experience life.	Narrative methodology focuses on collecting and analysing these stories in order to understand human experience.	"Story" used in this methodology can be misinterpreted and not all prose are narratives.

Souto-Manning (2014) emphasises that discourse cannot be understood apart from the specific contexts in which they arise. Discourse analysis is concerned with participant beliefs, values and world views based on their use of language as it is socially constructed (Case and Light, 2011, p.201). Considerations of the complexity of how language is constructed (power relations) by the participant can often prove challenging in this methodology (Souto-Manning, 2014).

The research method of narrative analysis investigates the power of the "story" to understand the human experience (Case and Light, 2011, p.203; Souto-Manning, 2014). Focusing on building participant identity, this research strategy investigates how the participant situates themselves and draws on different senses of self (Burck, 2005). However, Case and Light (2011), report that

caution is needed in identifying the type of data (sequential data that connect events) that is considered in the analysis.

The research method chosen for this thesis was case study methodology. In alignment with the researchers' epistemological beliefs case study was seen as the most suitable research method to reflect the flexibility of investigating the experiences of teachers and creating a holistic understanding of the findings (Yin, 2009a; Merriam and Tisdell, 2016). Yin's approach to case study was a logical way to design the study, however, Merriam's epistemological beliefs were more akin to that of the researcher and aspects of her constructivist approach are seen in the data analysis and reporting.

3.2.4 Case Study - Background

Case study offers an information-rich approach that is accessible to multiple audiences and investigates perspectives using a narrative to inform action (Simons, 2009; Harland, 2014). When carried out in a systematic way, Simons (2009), highlights that case study examines a phenomenon in "real-life" to understand its complexity. She outlines many strengths of case study research such as: its flexibility in time and method, its ability to explore the process and dynamics of change, its scope in documenting multiple perspectives and contested viewpoints and its potential to engage participants in the research process (Simons, 2009, p.12). Stake (2009) believes that the case study method is one of the most effective ways of adding to understanding. He emphasises that "naturalistic generalisations develop within a person as a product of experience" and can be acquired from reading case study reports about such experiences (Stake, 2009, p.5). What is interesting about reading case studies is the different interpretations that each reader will draw from the research (Harland, 2014). Harland (2014) highlights that for this reason the study can never truly be replicated, but readers can learn from aspects of their narrative.

Ragin (1992) describes cases to be empirical units or theoretical constructs (Ragin and Becker, 1992), however, there is much controversy over the definition of a case study in relation to its place as a data collection strategy or data analysis method (Merriam, 1985; Stake, 1988). Yin (2009), provides us with a technical version of a definition describing case study according to the research process.

> *"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 phenomenon and context are not clearly evident. (Yin, 2009a, p.18).*

This definition is useful in addressing the technical challenges faced with the inclusion of context (Yin, 1993). However, this definition also exhibits restraints as it is positioned within a positivist viewpoint and is supposed to rigid and systematic approaches to design, data collection and analysis, unlike Merriam (1985) and Stake (1988) who assume a more constructivist approach to qualitative case study, and suggest that there is more than one way to represent a case (Yazan, 2015, p.137). Merriam (2009, p.14) defines a case to be "*an in-depth description and analysis of a bounded system*". Considering more loosely a case as a bounded and integrated system, Merriam's definition provides more flexibility to apply case study as a research strategy in this thesis (Yazan, 2015; Merriam and Tisdell, 2016).

3.2.5 Case Study – The Design

The initial stages of case study design, according to Yin, centres around i) the identification of a unit of analysis, ii) whether single or multiple cases will be included and iii) the type of case study the design will adopt (R. K. Yin, 2009a). The unit of analysis (or case) represents a bounded phenomenon within a context and must be clearly defined at the start of the study (Yin, 1993; Gerring, 2004; Baxter and Jack, 2008). Merriam (2009) insists that the case being studied is intrinsically bounded by a finite, time, number of participants, context to qualify as a unit of analysis. Defining a case is reported as one of the most challenging steps in case study research (Creswell, 2007; Yin, 2009b). This difficulty can occur due to practical limitations (availability, quality or relevance) or it is not interesting or "special" enough. Yin (2009) also outlines that should one wish to investigate a more common phenomenon, defining a "compelling" theoretical framework that highlights social processes or outcomes is necessary to contribute to literature. Establishing the boundaries under which your case is applicable is also important in the identification of the unit of analysis (Stake, 2009). This process takes into consideration the time-frame the study is addressing, the context within which it is studied and the participants or events that will be included (Yin, 1993; Thomas, 2011a). Merriam combines Yin and

Stake's approach and presents a detailed step-wise technique which "includes conducting literature review, constructing a theoretical framework, identifying a research problem, crafting and sharpening research questions, and selecting the sample (purposive sampling)" (Yazan, 2015, p.141; Merriam and Tisdell, 2016).

Specifying whether the case study will involve a single case or multiple cases and determining their holistic or embedded nature is the next step in designing a case study. Yin (2009a) identifies five rationale for selecting a single case design: the critical case (testing a theory), the unique case (specific rarity), the representative case (conditions of an everyday experience), the revelatory case (observe a previously inaccessible phenomenon) and the longitudinal case (same case over time). These single case studies can be viewed in retrospect, as a snapshot case at one period in time or a diachronic study showing change over time (Thomas, 2011a). The holistic nature of these cases concerns the global nature of the case whereas choosing an embedded approach suggests that there may be other units of analysis embedded in the design of the overall unit of analysis (Yin, 2009a).

There are three main types of case studies used in research; explanatory or causal, descriptive and exploratory case studies (Yin, 2009a).

- The explanatory case study is most frequently used to explain causal links that may be too difficult to explain using survey or experimental strategies (Yin, 1993; Baxter and Jack, 2008).
- The descriptive case study deals with the scope and depth of the case being described and is often placed within the context in which an event occurs (Yin, 1993; Baxter and Jack, 2008).
- The exploratory case study involves gathering data and carrying out fieldwork prior to defining the research questions or hypothesis and therefore is sometimes seen as the "pilot" study before the "real" study takes place (Yin, 1993). Baxter and Jack (2008) describe its [pilot study] application as the exploration of an event that has no clear single set of outcomes (Baxter and Jack, 2008).

Most case studies include some form of triangulation as part of the methodological strategy and for validation purposes (Flick, 2018). Flick (2018, p.445) outlines the process of triangulation as considering an issue of research

form at least two points or perspectives. Denzin (1978) describes types of triangulation to be the use of multiple methods, multiple data sources (described in this thesis), multiple investigators or multiple theories (as cited in Merriam, 2009, p.215).

Flick (2018) discusses the triangulation process as it may materialise at various stages in the research process: research strategy, data collection and data analysis. Triangulation in the design of the research strategy could include two different strategies such as interviews and observations analysed in different ways, or through a collection of many data types analysed together (as seen in this thesis) (Flick, 2018, p.456).

During data collection Flick (2018) draws on Denzin's between-methods triangulation and within-methods triangulation. Within-methods triangulation (used in this thesis) combines two or more approaches are combined such as interviews, surveys and reflections. Finally, triangulation during data analysis can utilise different analytic strategies to the same data source (Flick, 2018). Ultimately the outcomes of triangulation leads to confirmatory results, complimentary results (leading to a fuller picture of the research issue) or contradictory results (Flick, 2018) that are valid and reliable (Merriam and Merriam, 2009).

A considerable amount of time is required in conducting case study research and researchers acknowledge that sufficient preparatory work be completed beforehand to ensure time is not wasted. Merriam and Stake advocate piloting the research instruments to ensure that time with participants in the study can be spent intently and critically listening rather than clarifying aspects of interview protocols (Merriam and Merriam, 2009). Yin suggests conducting an initial pilot study in order to refine data collection methods and procedures (Yazan, 2015). He highlights that, as much as possible, practical situations such as, availability, quality and relevance of the case study data should be investigated through a pilot study prior to starting your case study (Yin, 2009b, p.3). Creating a stronger link between research questions and availability of evidence are just some of the benefits Yin lists for carrying out a pilot case study (Yin, 2009b).

3.2.6 Case Study – Data Collection

The case-study method lends itself to multiple data collection strategies such as quantitative and/or qualitative data (Yin, 1993). Yin (2009a) believes that using multiple sources of evidence is one of the strengths of case study data collection. Ragin (1994), outlines qualitative, comparative and quantitative research as the common research strategies associated with social research that help to construct representations of social life through systematically collecting evidence. He describes qualitative methods as in-depth, holistic and contextual approaches to relay meaning (Ragin, 1994). Qualitative inquiry lends itself nicely to case study research because of its focus on in-depth contextual explorations of issues (Creswell, 2007). Collecting and analysing qualitative data in case study analysis requires an in depth understanding of the fundamentals of qualitative research. Apart from the obvious differences between qualitative and quantitative research (about meaning [not numbers], subjective understanding where context is important), qualitative research provides opportunity to analyse data that either prioritises the interpretations of the participant (experiential qualitative research) or analyse data related to factors that influence a representation (critical qualitative research) where the analysts interpretations are prioritised (Braun and Clarke, 2013). Braun and Clarke (2013) also highlight that qualitative research is underpinned by ontological (view of the world and our human interactions) and epistemological (the nature of knowledge) assumptions (p.27-28). One of the most important considerations of qualitative research is the selection of a qualitative methodology (See Section 3.3). The framework within which the research is conducted provides a theory of how the research needs to proceed and determines appropriate methods of data collection and analysis (Braun and Clarke, 2013). However, often the process of qualitative research is demanding and requires a commitment to extensive time in the field, engaging in complex and time-consuming data analysis, documenting lengthy reports and participating in procedures that do not always have firm guidelines (Creswell, 2007, p.41).

Comparative research, according to Ragin (1994), studies diversity through comparison of several cases, sometimes in less detail to that of other qualitative methods. Ragin (1994) outlines that studying this diversity means comparing

similarities and differences within a given set of cases aiming to interpret cultural or historical significance or advancing theory.

Quantitative methods address relationships among variables across a large number of cases with less variables to identify broad patterns and predict, test or refine theory (Ragin, 1994). These methods are reported to have well established techniques for gathering and analysing data, are mostly free of subjectivity and can develop explanatory models of cause and effect (Libarkin and Kurdziel, 2002). Carrying out quality quantitative analysis requires the researcher to understand the properties of the data, explore alternatives to your hypothesis, carry out sensitivity analysis, document all work and check for errors (Treiman, 2009). However, Libarkin and Kurdziel (2002) also stress that the formal utilisation of quantitative methods can often cloud the context within which it is being studied and lead to results that are artificially forced into categories.

3.2.7 Sources of Qualitative Data

Sources most commonly used in case studies include (but are not exhaustive), documentation, archival records, interviews, direct observations, participant-observation and physical artefacts (Yin, 2009a). However, the richness of the data collected determines the depth of understanding that can be obtained from qualitative research (Braun and Clarke, 2013). Braun and Clarke (2013), outline that this can be achieved through thoughtful reflection, critical probing questions or text that displays meanings about a topic. In this section we will look at two such data sources, individual interviews and textual data.

Conducting Interviews

Unlike standardised interviews, qualitative interview questions are designed according to the interviewer style and responses of the participant (Braun and Clarke, 2013, p.79). Merriam (2016, p.108) describe the necessity of interviews when "we cannot observe behaviour, feelings, or how people interpret the world around them" or when events in the past cannot be replicated. Braun and Clarke (2013) highlight that a guide for questions is prepared in advance, that is flexible and includes follow-up questions that are mostly open-ended in nature. Here, it is important to note that the interviewer is active in the interview and is involved in constructing meaning with the participant and shaping how the data is produced (Braun and Clarke, 2013). Small samples that are rich and detailed can

be adequate in generating data in qualitative studies, however, sometimes the lack of anonymity and researcher control over the data can be limiting factors in this time consuming data collection method (Braun and Clarke, 2013). Building trust and rapport with the participant is one of the key considerations when conducting qualitative interviews and retrieving rich interactive data (Weller, 2017; Upadhyay and Lipkovich, 2020). In designing an interview guide, Braun and Clarke (2013) also advocate logical sequencing of questions that flow and are clustered by topic, careful consideration of the wording of questions that are gentle and less loaded but address the area of interest, and development of suitable prompts to encourage participants to share information.

Facilitating data collection in a group setting is also recognised by Merriam as an effective data collection tool in qualitative analysis. This incorporates the constructivist viewpoint as data is socially constructed (Merriam and Tisdell, 2016). However, they suggest caution is needed when implementing this type of data collection for topics that may be sensitive in nature (Merriam and Tisdell, 2016). Asking a good question during interviews is an important consideration in the designing of interview protocols and especially being aware of what types of questions to avoid e.g., multiple questions, leading question and Yes/No questions (Merriam and Tisdell, 2016, p.121).

A Move to Online Interviews

In the past year, researchers have sought to continue qualitative research in more dynamic settings created by online platforms, due to the worldwide pandemic (Lobe, Morgan and Hoffman, 2020). Online interviews however, started becoming popular even before this due to their accessibility of recruiting participants and carrying out interviews with participants regardless of their geographical position (Deakin and Wakefield, 2013; Weller, 2017; Saarijärvi and Bratt, 2021). Weller (2017) describes how less confident participants felt more at ease when physically separated from the interviewer as they were less likely to experience embarrassment and risk of exposure in video interviews. The use of online technologies to conduct interviews is also reported to improve diversity and inclusion as participants who previously felt threatened by in-person meetings (due to their race/ethnicity or sexual identity) were more accessible online (Upadhyay and Lipkovich, 2020). Technical issues, confidentiality and suitable environments for video interviews can be issues of

concern in the field of online qualitative research and steps such as sending information and informed consent before meetings and communicating the need for stable internet connections, headphones, video camera etc., are necessary to reduce some of these limitations (Merriam and Tisdell, 2016; Saarijärvi and Bratt, 2021).

Textual Data

Textual data such as qualitative surveys and data in which participants record their experiences can be another useful data source in qualitative research. Merriam and Tisdell (2016), discuss mining data from documents and artefacts from the research setting that are a natural part of the setting and do not intrude on how the researcher interacts with the participant (p,162). Much of the preparation with qualitative surveys is in the designing of open-ended questions that align with ther research question, drafting and piloting the survey and reviewing and revising questions before a final version is advertised to recruit participants (Terry and Braun, 2017, p.31-33). Recognition of the time, effort and skills that participants require to answer qualitative surveys are considered as limitations of this type of data source but can be easily managed with clear guidelines that outline these expectations (Terry and Braun, 2017). There are many other forms of textual data that can also be used to examine human experience. Lindsey and Rathbone (2021) analysed textual data that already existed and was routinely collected (namely meeting minutes, incident reports and WhatsApp messages) to provide insight into social and clinical pharmacy practice. They highlight that identifying, accessing and extracting these data becomes the process of data collection with naturally occurring records such as these (Lindsey and Rathbone, 2021). Lindsey and Rathbone (2021) emphasize the broad opportunities for gaining deeper insights into human experience and complement quantitative findings, give first-hand accounts from participants, identify relationships between characters in the records and provide contextual perspectives related to a specific time and place.

3.2.8 Case Study – Reporting

Reporting a case study requires consideration of the target audiences (Merriam and Tisdell, 2016). By orientating the case study report to an audiences' needs, decisions about the format of the report such as, single or multiple narratives, question-and-answer format or cross-case analysis, can be clarified (Yin, 2009a). Yin (2009a) recommends composing the case early in the analytic process. Drafting a literature review, bibliography and methodological sections before data collection and analysis complements the ongoing practice of the compositional process (Yin, 2009a). Yin (2009a) highlights that case study reports as part of larger mixed-method studies can either i) encompass the other methods (incorporate the findings from the other data into the case) or ii) be encompassed by the larger study (case study is complete and separate to findings from other data). This second scenario [case encompassed by the larger study] may be chosen for the following reasons: to triangulate data, to illustrate findings from a survey or quantitative analysis or to compliment findings using another method (Yin, 2009a). The compositional structures of a case study can be used with either case study format [above] but must be bounded by the purpose of the case study (Explanatory, Descriptive or Exploratory) (Yin, 2009a).

Yin (2009a) describes six of these structures to be:

- linear-analytic structure: issue/problem > review of literature > methods > findings > conclusions (used in all three types of case study),
- comparative structure: repeats the case study several times (used in all types of case study),
- chronological structure: present evidence in chronological order (used in all types of case study),
- theory-building structure: each chapter/section reveals a new aspect of theoretical argument (used in explanatory and exploratory case study),
- suspense structure: inverted linear-analytic structure (used only in explanatory case studies),
- un-sequenced structures: separate chapters with no order of importance (used in descriptive case studies only) (p.176-178).

Finally, an exemplary case study goes beyond methodological procedures and requires a significant case (unusual or important), is complete (explicit attention

to the boundaries, collection of relevant literature, completed within constraints), considers alternative perspectives (challenge the assumptions of the case), displays sufficient evidence (relevant evidence for independent judgement) and composed in an engaging manner (the reader experiences the case) (Yin, 2009a).

3.2.9 Case Study - Challenges

The notion of generalised knowledge is a matter for contention and one which is widely debated as a shortcoming of case study research (Flyvbjerg, 2006). Thomas (2011) asks us to consider that generalisable knowledge should not be privileged over exemplary knowledge (that which can be produced from case-study research). He argues that for research to be worth something meaningful within the social sciences, we need to move past generalisations and consider that cases can provide explanatory propositions and discover patterns emerging from experience (referred to as special generalisations) (Thomas, 2011b). Flyvbjerg (2006) highlights this misunderstanding about generalising from a single case to contribute to scientific development. He outlines, similar to Thomas, that formal generalisation is overvalued and the "force of example" is underestimated (Flyvbjerg, 2006). However, Merriam and Tisdell (2016) outline measures that can be taken to ensure the trustworthiness and credibility of qualitative research hence, lending to its transferability to other contexts (See Table 3.4).

3.3 THESIS STUDY DESIGN

This thesis focusses on the experiences of teachers to address the overarching question of: *How can the quality of physics teacher education in Ireland be improved?* The studies presented in this thesis examine the experiences of out-of-field physics teachers teaching physics as part of the Junior Cycle Science Curriculum in Ireland (Chapter 4 – Pilot Study) and novice physics teachers transitioning and adapting to their transition from pre-service teacher to newly qualified teacher (Chapter 5 – Case Study A and Chapter 6 – Case Study B). Out-of-field teaching is described in this thesis using the definition: *"Teachers assigned by school administrators to teach subjects which do not match their training or education"* (Ingersoll, 2002, p.5).

Each of the three studies presented in this research adopted a qualitative research design. The importance of the qualitative paradigm to generate new meaning from participant data, complimented the researcher's interpretive epistemology through its careful foundations in data collection and analysis of this thesis (Krauss, 2005). The units of analysis (cases) varied and were defined for each of the studies. Triangulation of multiple data sources was implemented both in the research strategy and data collection phases (further detail within Chapter 4,5 & 6) (Merriam and Merriam, 2009; Flick, 2018). The data collected for the thesis was qualitative in nature (focus groups, interviews, reflective journals and qualitative surveys). This qualitative data helped to inform in-depth contextual explorations of issues outlined by the research questions (Creswell, 2007).

Reflexive thematic analysis was chosen as the most suitable analytical strategy because of its independence of requirements for data collection, theoretical positions and epistemological or ontological frameworks for this multi-study design (Braun and Clarke, 2013). This analytical strategy was not assumed to be atheoretical but instead to be used within a set of epistemological beliefs described by the researcher. This flexibility allowed the researcher to investigate each study (Pilot Case Study, Case Study A and Case Study B) according to the specific theoretical propositions and epistemological and ontological considerations of each study.

3.3.1 Timeline of Research

The research reported on in this thesis was carried out over a four year period with the pilot study spanning the first two years (2017-2019) and Case Study A and Case Study B (2019-2021) conducted in the last two years (See Figure 3.3). For each of the three studies, data collection began naturally at the start of the second level school year (start of September) and was completed at the end of the school year (end of May). Most of the study design and data analysis occurred during the summer months (June-August), although these aspects were also ongoing throughout the research. The findings from each case study informed the design of the next.

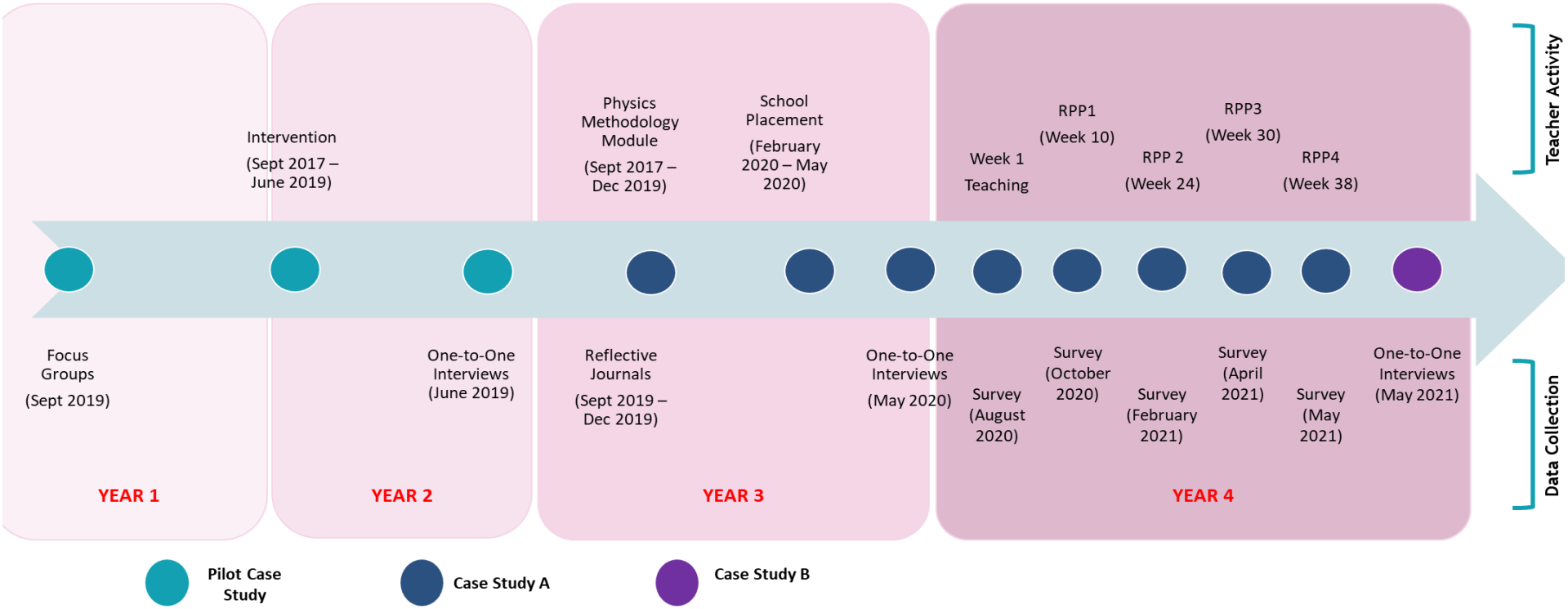
The pilot study (Chapter 4) investigated ***science teachers' experiences*** of engaging in professional learning for physics at Junior Cycle level. This study involved pre-intervention focus groups with in-service science teachers (see Section 3.3.2 for info on Participants) in September 2017. These teachers then participated in a two-year intervention until June 2019 and at this point a small cohort of the teachers participated in post-intervention interviews (one-to-one) to reflect on their experiences. The use of pilot case studies (not to be confused with a pre-test which is a formal trial that is followed strictly) has been promoted as a useful first step to investigate complicated cases e.g., in order to encounter relevant data collection issues or because it is convenient and accessible with large supply of data and sources (Yin, 2009a). This type of case was formative in nature and aided the development of questions, conceptual insights and research design considerations (Yin, 2009a). Yin (2009a) outlines that the scope of the pilot case is often much broader with less focus on specifics that are conducive to the "real" case studies. As a result, the focus of pilot study cases is on the lessons learned in terms of research design and field procedures in order to map the terrain of teaching Junior Cycle science and trial approaches to support teacher professional learning and collaboration (Yin, 2009a, p.94)

Case Study A (Chapter 5) examined ***teachers' experiences*** of becoming a novice physics teacher and the associated transition that were occurring during this period. The study involved six novice physics teachers and began in September 2019. At this time, the novice teachers were in their final year of a four-year concurrent BSc in Science Education. During the first semester the teachers participated in a twelve-week Physics Methodologies module (See Table 3.10

for further details). During this module the teachers experienced an intervention similar to the approach implemented in the pilot study (See Table 3.5 for comparisons). In addition, the teachers completed weekly reflective journals during this time which were collected for this study. In the second semester, the novice teachers completed their final School-based placement (14 weeks) as part of their university degree. After this school placement, teachers were interviewed to explore their experiences of teaching. After graduating from their degree, the novice teachers began their first year of teaching as a newly qualified teachers in September 2020. During this time, they also participated in regular RPP meetings with two science education researchers (See Section 3.4.2 for details). At the start of each RPP meeting, teachers were asked to complete a survey and this data was used to capture teachers' experiences throughout their first year of teaching as a newly qualified teacher. This data was used to identify the transitions they were experiencing as novice physics teachers.

Case Study B focussed on the experiences of the same novice teachers, using a separate data set collected at the end of the two years of the study. This case study was concerned with ***teachers' adaptation*** to transitions experienced as a novice physics teacher and therefore "adaptation" was defined the unit of analysis. Here, the six teachers participated in one-to-one interviews that were designed using transition theory as the theoretical framework and implemented with each of the teachers from their different perspectives and contextual settings.

Figure 3.3: Overview of Research Timeline



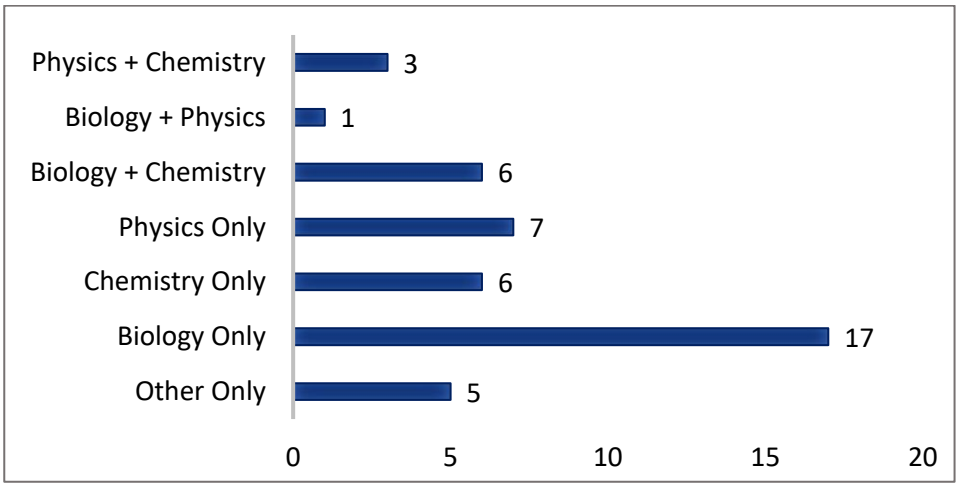
3.3.2 Participants

An outline of the participants involved in each of the case studies (Pilot Study – Chapter 4, Case Study A – Chapter 5 and Case Study B – Chapter 6) are outlined in this section.

Pilot Study Participants

Fifty-one in-service science teachers from seven second level schools participated in this study. The science teachers were all teaching the Junior Cycle science curriculum at second level in Ireland. Teachers ranged in experience from less than one-year teaching experience to twenty plus years. Each teacher worked within their school science department which typically had only one teacher qualified to teach physics and the majority of other teachers qualified as chemistry or biology specialists. Forty-five teachers (34 female, 9 male and 2 prefer not to say) from the sample volunteered information on the subjects they were recognised by the Teaching Council to teach. Often teachers were qualified in one or more of the science subjects at upper second level (Physics, Chemistry, Biology) as is evidenced in Figure 3.4. Ten of the teachers were qualified to teach two science subjects. Five of the teachers, teaching Junior Cycle science, were not qualified to teach any science subject and held qualification in subjects such as Home Economics, Maths, English, Applied Maths and Business. Only eleven teachers from the seven schools were qualified to teach physics.

Figure 3.4: Pilot Study Teachers Subject Qualifications



Case Study A & B Participants

The participants included in Case Study A and Case Study B were six novice physics teachers in the final year of their pre-service physics education programme. The sample was purposefully sought (Merriam and Tisdell, 2016) to address the research question, however the sample was also convenient to the researcher who taught a final year Physics Methodologies module to the participants as part of their BSc in Science Education (See Table 3.9 for details). All of the novice physics teachers (originally seven) in this year group were invited to participate in the study, however, one teacher decided not to take up a role as an in-service teacher and withdrew from the study. All data pertinent to this teacher was omitted from the study. Demographic data related to the individual participants were excluded in the reporting of this thesis in order to maintain teachers' anonymity due to the small sample size.

3.3.3 Data Collection

The data collection methods used in this study included focus groups, one-to-one interviews, reflective journals and open-question surveys (See Table 3.2).

Table 3.2: Summary of Data Collection Methods used

Data Collection	Pilot Study	Case Study A	Case Study B
Focus Groups	✔		
One-to-one Interviews	✔	✔	✔
Reflective Journals		✔	
Surveys		✔	

Focus Groups

Merriam and Tisdell (2016) describes the benefit of collecting data in a group context in order to capture data as it is socially constructed (See Section 3.2.7 above for more details on focus groups). Seven focus groups were carried out at the beginning of the pilot study with fifty-one science teachers from different schools. The sizes of the groups varied depending on the size of the school's science department (typically 5-11 teachers). During these focus groups teachers were prompted to talk about their planning, resources for teaching, difficulties teaching any science topics and the reflective practice of teachers or students.

The focus groups varied in length from 30-40mins depending on the group size (See Appendix A for protocol).

One-to-one Interviews

Flexible qualitative interview questions were designed according to the interviewer style and adapted during the interview to suit the responses of the participant as advised by Braun and Clarke (2013) (See Section 3.2.7 for more details on qualitative interviews).

- *Pilot Study*

One-to-one interviews were carried out with 10 science teachers two months after they had completed the intervention (See Figure 3.3). The interviews were approximately 60 minutes in duration. The interview protocol was designed and conducted by an external evaluator for the purpose of the wider research project and to maintain an objective perspective and so that teachers did not feel pressured to answer in a specific way due to their personal relationship with the researchers (who were involved in the design and facilitation of the intervention). The interviews (see Appendix B) probed teachers overall experience of teaching Junior Cycle physics after their participation in the intervention. Teachers were asked to comment on their expectations of the intervention, anything they learned from their involvement in the intervention, report on any changes to their practice, report on any changes to the science department or overall school culture, general advice or feedback about the intervention.

- *Case Study A*

Semi-structured interviews were conducted as part of data collection for Case A. Six novice physics teachers participated in a 50-minute interview at the end of their final teaching placement in university (see Figure 3.3). There were 9 questions in total and the interview (Appendix C) probed, teachers' experiences of school placement, supports available to pre-service teachers during their school placement, opportunities for collaboration with other teachers, barriers to teaching physics, difficult physics concepts (as teacher and as learner), general advice for future teachers and any concerns they may have starting a new job.

Case Study B

One-to-one semi-structured interviews were used as the main data collection method in Case Study B. Online interviews were conducted with the six novice physics teachers at the end of their first year of teaching. The interviews were approximately 60 minutes long and took place over the online platform Zoom due to the restriction imposed during the Covid-19 pandemic. The interviews were conducted, in May 2021, at a time that the researcher felt a transition had occurred for the participant and the questions were designed to ensure that the participant identified this transition before being probed it further. Schlossberg's theory highlights that an event can have different meanings for different individuals (Schlossberg and Goodman, 2005, p.36). The questions were designed to avoid the assumption that the researcher had decided when a transition for the teacher was happening. The interviews took place in the context of the participant's role as a teacher and to some extent this may have influenced their response to the obvious university-job transition. The researcher tried to mitigate this bias by including questions related to contextualising the transition in the form of another similar experience in their life.

This interview protocol (0) had two very distinct sections. Questions in Part I of the interview were designed to address teachers' adaptation transitions. Questions for the interview protocol were adopted from Powers (2010) and Allen (2008) and focussed specifically on identifying the resources teachers drew on during their transitions related to situation [Q1], self [Q2, Q3], support [Q4] and strategies [Q4, Q5] (Schlossberg, 1981; Allen, 2009; Powers, 2010). The questions were broadly used to identify the transition of the participant and understand their interpretation of the situation [Q1], support [Q4] and at the time of the transition.

Demographics are reported to be important in reporting cases (reference Braun & Clarke), however, this cohort started out as university students and to request demographical information at that point would have been of ethical concern. The researcher instead tried to extract this information from the perspective of the participant and allowed them the opportunity to disclose any aspects of their identity that they felt might have added to/taken away from their experience of the transition [Q6].

Part II of the interview focussed on similar questions to the interview that took place after the final teaching placement and explored teachers' experiences of their first year of teaching [Q1], their experiences of collaborations [Q2], reflections on their pre-service teaching [Q3], challenges or barriers teaching physics [Q4] and teachers understanding of the teaching profession [5] (0). Questions 6-9 were included to allow teachers to comment on any other experiences that they had learned from or general advice based on their experiences. This part of the interview was used to encourage teachers to reflect back on their experiences throughout the two years of their journey that the study spanned.

Reflective Journals

Merriam and Tisdell (2016) emphasises the usefulness of textual data that does not intervene with the participant as they document their experiences (See Section 3.2.7). Novice teachers engaged deeply in reflective practice as part of Physics Methodologies module over 12 weeks in the first semester of their final year (See Table 3.9 for course details). Textual data in the form of 60 reflective journals were collected at the end of each weekly lecture that ranged from approximately 500-2000 words. Further details of how teachers were encouraged to write their reflections are detailed in Table 3.11.

Surveys

The six novice teachers were invited to complete qualitative surveys in the first week of teaching and at the start of each Research Practice Partnership thereafter for approximately 15 minutes. The qualitative surveys consisted of four open-ended questions that aligned with the research question and were completed online in Google Forms (See Appendix E). The qualitative question probed teachers on what challenges have they faced [up to now], what they were excited for [in the year ahead], concerns they may have [in the year ahead] and resolutions they will try and make [before the next meeting]. Thirty-five qualitative surveys were collected in total. The implementation of this data tool was accompanied by clear guidelines and expectations to mitigate the limitations outlined by Terry and Braun (2017).

3.3.4 Case Study – Analytic Strategy

Yin (2009a) emphasizes the importance of identifying a suitable analytic strategy in the analysis of a case study. Using theoretical propositions (basing the objectives and design of the study on propositions that will be reflected in the research questions, literature review and hypothesis), case description (a descriptive framework for organising the study), using both qualitative and quantitative data or exploring rival explanations (if outcomes are a result of an alternative intervention to the one being studied) are examples of general analytic strategies that can be used in case study analysis in order to develop internal and external validity (Yin, 2009a, p.130-134).

Analytic techniques that can be applied to these strategies vary from pattern-matching, explanation building, time-series analysis, logic models and cross-case synthesis (Yin, 2009a). Yin (2009a) describes pattern matching as a comparison between observed experimental patterns with predicted patterns and is mostly used in explanatory case studies. In business and management studies, Sinkovics (2018) also shows how different levels of pattern matching (full pattern matching, flexible pattern matching and partial pattern matching) can be applied to an explanatory case, exploratory case or concept mapping of theoretical realms and the investigator's mental models. Carrying out pattern matching as a form of analysis is contributes to to rigorous and structured research processes that undertake systematic planning and detailed documentation (Sinkovics, 2018). Explanation building builds on the technique of pattern-matching and uses a series of iterations to build an explanation: initial theoretical statement, comparing findings against this statement, revising the statement, comparing other details of the case, comparing to more cases, repeating the process (Yin, 2009a, p.143).

The analytic technique of time-series analysis involves asking "how" and "why" questions about the connection of events over time (Yin, 2009a). Campbell and Ross (1968) are cited frequently for their use of "interrupted time-series design" in "The 1955 crackdown on speeding" in Connecticut. In their comparison of data before and after a new law [to reduce speed limit] had been enforced, they proposed a predicted time-series pattern (that the new law reduced fatalities) against the proposition that no effect had occurred and examined which best matched the empirical data (Campbell and Ross, 1968). Yin (2009a) stresses that

identifying a specific factor to be tracked over time, with specific time intervals and particular relationships to be investigated are all features of time-series analysis that must be considered before collecting the data.

Logic models are used to specify a complicated chain of events over a long period of time (Yin, 2009a). McLaughlin and Jordan (2004) describe a logic model as a model that predicts how a program will solve identified problems under particular conditions. They identify resources (inputs required to support the program), activities (actions needed to produce outcomes), outputs, customers (the users or receivers of the program) and outcomes (changes or benefits of the program) as the basic features of a logic model (McLaughlin and Jordan, 2004).

Finally, cross-case synthesis is used for multiple cases only and can apply quantitative, meta-analysis or word tables for synthesising data and developing arguments supported by the data (Yin, 2009a). These methods are usually applied to multiple-case studies whose numbers of cases are very large. However, with smaller samples of multiple-case studies, comparisons of explanations as a whole can be analysed against each other (Yin, 1981). Miles and Huberman (1984) describe another process of carrying out cross-case analysis as data reduction (aggregating and organising data according to some set of rules), data display (making sense of large data sets through displays such as matrix or graphic form) and conclusion drawing (Huberman and Miles, 1983).

Thematic Analysis

Merriam and Tisdell (2016) provide a step-by-step process of analysis which includes: category (theme) construction (involves familiarisation, open coding, axial/analytical coding,), sorting categories and data, naming the categories. Braun and Clarke (2020) offer an overview of where thematic analysis sits with other pattern based approaches and outline its use to novice qualitative researchers and when the research questions are not focussed so much on language as in discourse analysis (Braun and Clarke, 2020). Thematic analysis (TA) provides a more comprehensive method for qualitative data analysis that is independent of requirements for data collection, theoretical positions and epistemological or ontological frameworks (Braun and Clarke, 2013). For this reason, it is recommended to apply the thematic analysis approach within an existing theoretical framework (Braun and Clarke, 2013). Recognised for its

flexibility, thematic analysis is an approach to 'identify themes and patterns of meaning across a dataset in relation to a research question' (Braun and Clarke, 2006, 2013, p.175). Thematic analysis, used as an umbrella term for many approaches, is thought of in terms of three areas: coding reliability (structured and focussed on reliability and accuracy, 'small q TA'), reflexive TA (organic and results from deep engagement, 'Big Q TA'), and codebook TA (combined structured procedures with qualitative philosophy) and vary mostly in their approach to coding (Clarke and Braun, 2018). These approaches can be applied inductively (generating analysis from the data – bottom up), theoretically (guiding analysis using existing theory), experientially (focussing on the participants perspective) or using constructionist thematic analysis (focussing on how topics are constructed) (Braun and Clarke, 2013; Braun *et al.,* 2018, p.175).

Reflexive TA requires a process that is loosely summarised as: i) transcription, ii) familiarization, iii) coding, iv) searching for themes, v) reviewing themes and vi) defining and naming themes (Braun *et al.*, 2018, p.10). More specifically Braun and Clarke (2021) highlight the reflective nature of reflexive thematic analysis as the researcher is immersed in the data and engages in "reading, reflecting, questioning, imagining, wondering, writing, retreating, returning" (p.332). Transcription offers a valuable experience in terms of familiarization with the data and 'informs early stages of analysis' by developing a thorough understanding of the data (Braun and Clarke, 2006, p.88). Once the data has been transcribed the researcher must approach the data from an analytical perspective and immerse themselves in the data to recognise connections and nuances that may manifest (Braun *et al.,* 2018). Generating codes involves the systematic and thorough engagement with the data to organise into meaningful patterns (Braun *et al.,* 2018). Bazeley (2009) outlines that caution is required to avoid tunnelled interpretation of the data. Discussing small segments of the data with a colleague can help to add fresh perspective to your interpretations (Bazeley, 2009).

Constructing themes from codes is the next step of the TA process that involves clustering codes according to analogous meanings to generate themes or promotion of substantial codes to themes (Braun *et al.,* 2018). Braun *et al.,* (2018) describe a theme as "a pattern of shared meaning, organized around a core concept or idea, a central organizing concept" (p.3). Moving beyond 'garden path analysis' (analysis that lacks meaning and coherence) can be

achieved using strategies such as: describe-compare-relate (outlining context, compare differences in characteristics and boundaries, relating to themes in the literature), using divergent views (negative cases or outliers), returning to the literature and using displays (matrix displays, flow charts and models, typologies) from the data (Bazeley, 2009).

Braun *et al.*, (2018) suggest that themes need to be revised by clearly defining their boundaries and central concepts and comparing the themes to the whole dataset. Bazeley (2009) emphasizes that data must be "challenged, extended, supported and linked" to capture the value of the theme. Consideration of whether the themes actually "emerge" as opposed to a priori categories (created from the literature) and viewed with emphases on specific nuances or contexts can be one of the shortcomings of researcher's approach to reviewing themes (Bazeley, 2009). The naming of themes provides a meaningful summary without having to provide considerable explanation to the reader (Bazeley, 2009). Bazeley (2009) highlights the problem of reporting themes without expressing how broadly they span the sample, its links to other themes, those who express the theme differently and those who do not express the theme at all. Clarke and Braun (2018) emphasize the importance of a central organising concept to conceptualise a theme and describe the core ideas that underpins and unites observations (p.108).

Some of the challenges associated with reflexive thematic analysis are the incorrect assumptions that researchers hold with this analytical strategy such as that assumption that thematic analysis is only an analytical approach, that is atheoretical or is only descriptive (Braun and Clarke, 2021b). Therefore, Braun and Clarke (2021, p.345-346) suggest declaring epistemological and ontological viewpoints and following a detailed evaluation tool in the use of thematic analysis.

3.3.5 Thesis Data Analysis

Reflexive thematic analysis was the analytical strategy implemented for the studies presented in this thesis due to its flexibility in nature. Braun *et al.,* (2018) highlight that the specific approaches of thematic analysis (coding reliability, reflexive thematic analysis and codebook thematic analysis) that can be applied inductively, theoretically, experientially or using constructionist thematic analysis. The following sections outline how thematic analysis was applied for each of the data collection points.

Focus Groups

Audio recordings from each of the focus groups were listened to by the researcher in order to become familiar with the data set. All focus groups' data was analysed as a collective group of science teachers rather than as part of separate science departments in order to investigate general experiences of science teachers (see Research Questions 2.4.1). Digital recordings were then inputted directly into NVivo and their audio transcripts were coded using inductive thematic analysis as outlined by Braun & Clarke (2018) in section 3.3.4. Snippets of the audio transcripts were initially coded openly in an inductive (bottom-up) approach and were grounded in the participant's views. Patterns were then identified in the codes to generate more general categories (see example in Appendix F), which were then clustered around a centralising concept defined by key themes.

One-to-one Interviews

- *Pilot Study & Case Study A*

Interview data from the pilot study and case study A was analysed inductively as in the focus groups and collectively (teachers as one group). However, for one-to-one interviews, all audio transcripts were first transcribed and then uploaded to NVivo 12 where they were re-read for familiarisation. Braun and Clarke's (2018, p.10) method of reflexive thematic analysis were then applied throughout: i) manual transcription, ii) familiarization (including member checking to capture context for colloquial terms) , iii) coding (systematic engagement), iv) searching for themes (at the intersection of data), v) reviewing themes (around a centralising concept) and vi) defining and naming themes (See Appendix F).

- *Case Study B*

Interview data from Case Study B was analysed differently from the other interviews as a deductive approach was adopted. This approach was chosen because the researcher's ideas related to theories (as opposed to being generated from the data) and therefore potential codes were tagged within the dataset (using the theoretical framework) (Braun *et al.,* 2018). Teachers' data was analysed individually as the findings were to be reported as individual embedded units within the case (adaptation See Chapter 6).

Initially (inductively), data from each teacher was transcribed and re-read for familiarisation and a first round of open coding was applied to each data set. All of the codes were then organised (deductively) into predetermined categories related to the different factors affecting adaptation (Perception of the transition, Characteristics of the Individual and Characteristics of the Environment) (See Table 3.3). Schlossberg's (1981) resources for transition (Situation, Self, Supports, Strategies) were then used to report the findings in a meaningful way (See Appendix G). Cross-case analysis was applied to the findings from each teachers' data in order to establish similarities or differences between participants. Member checking was applied to the findings of this research in order to maintain reliability.

Table 3.3: Model for Analysing Human Adaptation to Transition

Resources for Transition	**Situation**	**Self**	**Support**
Factors Affecting Adaptation to the Transition	Perception of the Transition - Role Change - Affect - Timing - Onset - Duration - Degree of Stress	Characteristics of the individual - Psychological Competence - Sex/Gender Identification - Age - State of Health - Race/Ethnicity - Socioeconomic Status - Value Orientation - Previous Experience	Characteristics of the Environment - Internal Supports - Institutional Supports - Physical Setting
Resource for Transition	**Strategies**		
Factors Affecting Adaptation	- Control the Situation - Control the Meaning of the Situation - Control the Stress		

Reflective Journals & Surveys

- *Case Study A & Case Study B*

All textual data from reflective journals and surveys were inputted into nVivo 12 for analysis and followed the same approach to reflexive thematic analysis as with the interview data in the pilot study and Case Study A (See Section above 3.3.5). Iterative cycles of thematic analysis were carried out on the surveys described (above) throughout the research process in order to inform the next RPP meeting (See Chapter 5 for more detail). Here the researcher's reflective and thoughtful engagement with the data was recorded in a reflective diary (See Appendix H) and checked regularly during the analytic process in order to reflect the intersection of the researcher's theoretical assumptions, resources and skills (Braun *et al.*, 2018).

Researcher's Note

There were many ways to approach the analysis of data and reporting of findings in this research however, in order to represent the cohort in a meaningful way and answer the research questions posed two separate case studies were chosen as the preferred approach. It was felt that reporting the findings in this way yielded the most interesting findings that contributed to the literature and avoided repetition of findings.

Case Study A (Chapter 5) was reported as an entire cohort as teachers were already interacting as a group in their undergraduate degree and as part of the Research Practice Partnerships. Initial analysis indicated that there would be little difference in the findings between participants. Exploration of more complex and individual real-life situations may have been at the expense of investigating the bigger picture and understanding the transition as a whole (rather than an individual's transition).

Case Study B (Chapter 6) was presented as a cross case analysis of individual embedded cases. Here, the researcher felt that there were lessons to be learned from the individual participants (see Special cases – Chapter 7) and their cross case analysis captured the different nuances that present in teachers experiences as well as being able to track the root of some teachers' challenges and successes.

3.3.6 Validity and Reliability

Yin (1993) highlights that construct validity, internal validity, external validity and reliability ensure sound case study design. Construct validity concerns itself with accurately operationalising instruments and measures. Using multiple sources of evidence, having a chain of evidence and inviting participants to review the case study report are tactics that can be implemented to achieve construct validity (Yin, 2009a). Internal validity can be ensured in the selection of the unit of analysis, data collection and analysis and is mostly applied in explanatory case studies as it extends to making inferences (Yin, 2009a). Yin (2009a) also suggests that analytical tactics such as pattern matching, explanation building, addressing rival explanations and using logic models can help in achieving internal validity. External validity deals with the connection of theoretical perspectives in order to make generalisations which proves to be a barrier in case study research (Yin, 1993). Here, it is important that the focus is on analytic generalisation (generalise a particular set of results into theory, Yin, (2009a, p.43)) and as such replication logic (testing a theory by replicating findings in another case) can be used to achieve this (Yin, 2009a).

Reliability is often achieved through application of protocols that formalise the development of a case (Yin, 1993). Yin (2009a) outlines the case study protocol to include: i) an overview of the case study project (objectives, issues relevant readings), ii) field procedures (access, sources of data etc), iii) case study questions (specific questions, sources of information) and iv) a guide for the case study report (outline, format, use, bibliography etc) (p.81). This protocol ensures that the researcher employs targeted studies and anticipates problems before initiating the case study (Yin, 2009a). Reliability can also be achieved through the use of a database as it allows the researcher to track and organise data (Yin, 1993; Baxter and Jack, 2008; Yin, 2009a). Creating the database requires collection of the data and the report of the investigator in order for other researchers to review the evidence directly and increase reliability (Yin, 2009a).

Although helpful in organising data and measuring its validity and reliability, within the interpretivist and pragmatist epistemology, such guidelines as Yin's are constraints in understanding the data to have multiple interpretations (Yazan, 2015). Stake suggests four strategies to help validate qualitative research: "data source triangulation, investigator triangulation, theory triangulation, and

methodological triangulation" (Yazan, 2015, p.146). Merriam suggests six strategies to enhance internal validity, three techniques to ensure reliability and three approaches to enhance external validity (Summarised in Table 3.4) (Merriam and Tisdell, 2016, p.259). Ethical considerations of the qualitative research also contributes to the credibility of the researcher and their rigorous thinking towards the study (Merriam and Tisdell, 2016).

Table 3.4: Sharan Merriam's Criteria for Determining Quality of a Case Study (Adapted from Yazan (2015, p.150))

Internal Validity	External Validity	Reliability
Triangulation Member checks Long-term observation Peer examination Participatory research Disclosure of researcher bias	Use of thick description Typicality or modal categories Multi-site designs	Explanation of investigator's position with regards to the study Triangulation Use of an audit trail.

Validity and reliability were considered in the design of research presented of this thesis and measures were taken to ensure sound research design. Construct validity was achieved in each of the case studies by collecting multiple sources of evidence (triangulation) and inviting participants to review the case study data and report. Triangulation of the case (***teacher experience***) in Case Study A occurred both in the research design (including all sorts of data that were part of the research study) and data collection (using two or more sources combined into one method e.g., reflective journals, interviews, RPP surveys) (Flick, 2018). In Case Study B, triangulation of the case (***adaptation***) occurred in the research design (6 different perspectives [teachers from different school contexts] were selected), data collection (interview protocol was designed using theoretical framework) and analysis (deductive analysis using theoretical framework and cross-case analysis to compare similarities and differences between participants) (Flick, 2018). Pattern matching, explanation building, member checking, participatory research and disclosure of the researcher bias were used in the analysis stage to address internal validity (Yin, 2009a; Merriam and Tisdell, 2016). External validity was achieved through use of *thick description* (Merriam and Tisdell, 2016).

To maintain reliability Case study A and B were presented according to Yin's case study protocol:

i) an overview of the case study project (objectives, issues, relevant readings),
ii) field procedures (access, sources of data etc),
iii) case study questions (specific questions, sources of information) and
iv) a guide for the case study report (outline, format, use, bibliography etc) (Yin, 2009a, p.81).

An explanation of the researcher's positionality was also disclosed at the beginning of each of the case studies to maintain reliability (See 3.2.1) (Merriam and Tisdell, 2016).

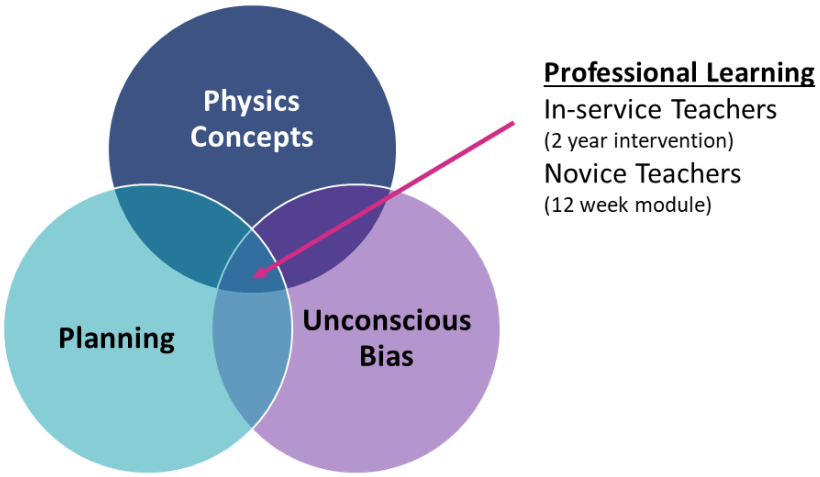
3.4 STUDY CONTEXT

The data collected as part of this research thesis was done within the context of teacher's participation in professional learning. This pilot study was part of a wider project, Improving Gender Balance in Ireland (IGBI), that was concerned with increasing the number of girls studying physics through a holistic approach involving the whole school. The design principles IGBI were based the UK-based Drayson Project. The Drayson Project worked directly with girls, science departments, and senior leadership in schools, with the goals of building confidence, supporting inclusive teaching, and involving the whole school. The number of girls taking AS-level physics in Drayson schools more than trebled over 2 years, soaring from 16 to 52 students, from the Improving Gender Balance report (Institute of Physics, 2016) although significant and conclusive results on this project had not been published on this project until after the pilot study (reported in Chapter 4) was conducted (See further details of project at Institute of Physics, 2017; Plaister and Thomson, 2020). The Improving Gender Balance in Ireland (IGBI) project was then established to trial a similar intervention in Irish secondary schools. The design principles focused on i) enhancing these science teachers' pedagogical content knowledge for teaching physics, ii) providing teachers and students with access to information on a wide variety of career opportunities and future pathways and iii) highlighting the influence of stereotypes and unconscious biases on students' engagement in subjects.

The research aspect of the IGBI project took the form of a pilot study (presented in this thesis) and explored Junior Cycle in-service science teachers' (n=51) experiences of participating in an intervention for teacher professional learning. Approaches to professional learning such as: PCK, collaboration and reflective practice. This study was used to map the terrain in order to examine physics teaching as part of Junior Cycle science and trial approaches to support teacher professional learning and collaboration.

These principles (enhancing physics teaching, awareness of unconscious bias and careers) were translated into three professional learning workshops (Physics Concepts, Planning, Unconscious Bias) that were then also implemented as professional learning opportunities for novice physics teachers (See Figure 3.5). The following sections describe how the principles were integrated into the workshop design.

Figure 3.5: Aspects of Teacher Professional Learning during Data Collection



3.4.1 Approach to Professional Learning

In-service teachers in the pilot study were involved in a two year intervention where they attended seven physics school-based workshops with other teachers in their science department, 1 planning workshop and one-two unconscious bias workshops (See Table 3.5). These teachers participated in the unconscious bias workshops at the start of the year with their whole school (as part of the wider project see Section 4.2 for details). The science teachers then completed each of the physics workshops consecutively. At the end of the second year, teachers engaged in the planning workshops with colleagues from their schools' science department.

The workshop design was refined after this two-year period and delivered within a Physics Methodologies module over 12 weeks with the novice teachers in Case Study A (See Table 3.10for details). Here the novice teachers participated in 6 physics workshops (the continuous based assessment (CBA) workshop spanned elements of all the other workshops), 2 planning workshops (as the Pilot study identified more time was needed to complete meaningful planning – See findings Chapter 4) and 1 Unconscious Bias workshop.

Table 3.5: Outline of Workshop Facilitation Across Case Studies

Workshop Type	Pilot Study (2years)	Case Study A (12 weeks)
Physics Concepts	7 workshops (90mins each)	6 workshops (90mins each)
Planning	1 workshop (60mins each)	2 workshops (120mins each)
Unconscious Bias	1-2 workshops (45mins each)	1 workshop (45mins each)

Physics workshops

The teachers in both the Pilot Study and Case Study A participated in physics workshops (See Table 3.6). Based on a needs analysis and discussions with teachers from the pilot study, seven inquiry-based workshops (Bevins & Price, 2016) were developed based on the three design principles.

The first design principle was focused on enhancing these science teachers' pedagogical content knowledge for teaching physics (Etkina, 2010). Etkina's outline of "Tasks of Teaching" in her assessment tool for measuring teachers' content knowledge for teaching physics, were embedded in science teacher professional learning workshops (Etkina *et al.,* 2018).

The second design principal was focused on providing teachers and students with access to information on a wide variety of career opportunities and future pathways in physics based on findings within the literature that suggest that many students toy with the idea "is science for me?" (Archer, Dewitt and Osborne, 2015).

The third design principle highlighted the influence of stereotypes and unconscious biases on students' engagement in subjects. Hazari reports that secondary physics teachers can positively impact on physics identity development among their students (Hazari *et al.,* 2010). Mujtaba and Reiss also report that extrinsic factors such as material gain motivation (measures the belief that getting a qualification in physics would be useful) in physics was the most important indicator of intention to participate in Physics after the age of 16 years (Mujtaba and Reiss, 2013).

The science education team (researcher and supervisor) designed workshops that focussed on specific topics in physics (Light, Energy, Motion, Earth & Space, Electricity, Forces and Classroom Based Assessments) with target concepts and aspects of inclusive practices embedded in order to address each of the design principles (See Table 3.6).

Table 3.6: Overview of Physics workshops

Workshop	Topics	Target concepts	Inclusive practices
1. Light	Light signals and fibre optics	- Defining and describing the properties of light - Differentiating between absorbing, scattering, reflecting and transparent materials	Common student and teacher difficulties
	Lenses and telescopes	- Investigating reflection of light - Explaining how optical fibres guide light - Describe how lenses focus light - Understand the physical concept of "focal point" - Identifying real and virtual images - Building two types of telescopes - Calculating the magnification of a telescope	Careers involving light
2. Energy	Energy and sustainability Heat transfer	- Principle of conservation of energy - Energy changes - Energy efficiency/dissipation - Conduction and convection – heat as a form of energy - Measure energy inputs/outputs - Calculate efficiency - Sustainability issues - Ethics surrounding consumption of electricity - The effects of global warming	Industries in the Energy and Sustainability sector Relevance of Specific vs Generic Praise for Students
3. Motion	Introduction to concept of speed	- Planning investigations - Developing hypotheses - Working collaboratively - Identifying variables - Forming Conclusions	Connecting concepts in Maths and Science
	Relationship between distance, time and speed	- Forming coherent arguments - Graphical representation of data - Interpretation of scientific data	

Workshop (*cont.*)	Topics	Target concepts	Inclusive practices
4. Electricity	Series circuits	- Making and breaking a circuit - Identifying conductors and insulators - Using a Multimeter - Identifying components of a circuit - Investigating current in a series circuit - Investigating voltage in a series circuit - Designing, testing and building a device that transforms energy - Investigating current in a parallel circuit	Discuss career opportunities within the field of electricity Reduce negative language use when approaching the topic e.g. too difficult
	Parallel circuits	- Investigating voltage in a parallel circuit	
5. Earth & Space	The science of rockets	- Identifying Forces – Newtons 3rd Law - Exploring factors affecting rate of reaction	Gender biased careers related to space travel
	Travelling through space	- Describing the water cycle - Examining photosynthesis in space - Planning Investigations - Identifying variables - Testing hypotheses - Investigate motion of a falling meteorite - Define gravitational force of attraction - Discuss artificial and natural satellites - Investigate the phases of the moon	Language used when teaching about gravity Multiple representations of moon phases for differentiated learners
6. Forces	Resultant forces	- Investigating forces in a given direction - Providing evidence of Newton's 3rd law	Making mistakes is good Stereotype awareness: physics is too hard because it's too 'mathsy' and the maths is hard
	Moments of a force	- Finding the value of friction - Planning investigations - Finding the weight of an object using moments of a force	
7. Classroom Based Assessments	What do Junior Cycle CBA's look like?	- Outlining the features of quality of CBA's - Examining exemplar CBAs - Considering the role of assessment in the classroom	Objectively assessing student work Self-reflection on current practice

Planning Workshops

As part of the pilot case study and Case Study A, teachers and researchers collaborated in a planning workshop (See Table 3.7) centered around teaching physics. The workshops focussed on the Ambitious Science Teacher (AST) framework outlining pedagogical approaches for engaging science through supporting intellectual engagement and promoting attention to equity (Windschitl *et al.,* 2012). This framework supports teacher's professional learning using four key practices: i) planning for engagement with important science ideas, ii) eliciting students' ideas, iii) supporting on-going changes in thinking and iv) pressing for evidence-based explanations. The AST protocols for the first practice (planning for engagement with important science ideas), were adapted from dimensions of planning (Windschitl *et al.,* 2012). These dimensions of planning used were: causal explanation, essential question, scientific concepts, lesson activities, links to curriculum and how the learning is assessed. Etkina *et al.,* (2018) outline specific "Tasks of Teaching" in their assessment tool for measuring teachers' content knowledge for teaching physics and these were also embedded in the planning workshops (See Table 3.7) (Etkina *et al.,* 2018). The final aspect of the planning workshops were inclusive practices that focussed on fostering physics identity through raising awareness of unconscious biases and gender stereotyping (Hazari *et al.,* 2010) and promoting STEM careers (National Council for Curriculum and Assessment, 2002).

Table 3.7: Overview of Components included in Planning Workshops

	Dimensions of Planning	Description	Tasks of Teaching (ToT)
Ambitious Science Teaching	Causal Explanation	What's happening (description)? Why is it happening (explanation)? Detailed (researched) description of the phenomenon	I: Anticipating student thinking V: Using examples, models, representations, and arguments to support students' scientific understanding
	Essential Question(s)	Record all questions relating to a phenomenon Identify essential / investigable questions Turn questions into investigative questions	IV: Engagement in a science learning community
	Scientific concepts	Identify a range of physics/science concepts – related to causal explanation Student conceptual difficulties	II: Designing, selecting, and sequencing learning experiences
	Lesson activities	Design experiments to support student learning Sequence activities/experiments to construct Consider effective instructional strategies	VI: Construct, test, and apply concepts II: Designing, selecting, and sequencing learning experiences III: Monitoring, interpreting, and acting on student thinking I: Anticipating student thinking
	Links to curriculum (cross strand)	Identify learning outcomes on curriculum (in any of the strands) Create links across the strands of curriculum	Specific Learning Outcomes (Student Targets - ST)
	How is the learning assessed	Outline how the learning will be assessed Develop/adapt rubrics/questions etc/	III: Monitoring, interpreting, and acting on student thinking I: Anticipating student thinking
Inclusive Practices	Career/Societal Awareness	Suggest similar phenomenon in everyday life that can be explained using this phenomenon Identify careers in which this information could be helpful Research/name someone you know who works in this area	Identifying careers/links to society and role models
	Unconscious Bias Awareness	Creating awareness of stereotypes that surround different career types Being aware of how one's own perceptions might influence the teaching process Identifying any gendered language that may be connected to the topic (difficult, "mathsy" etc.)	Creating awareness of unconscious bias

The third workshops that both in-service science teachers and novice teachers participated in focussed on creating awareness of the effects of unconscious bias on teaching and learning (in general). The key objectives of these workshops were: to support teachers to critically reflect on their own gender biases; engage in professional learning about unconscious bias and gender stereotypes; identify biases or stereotype threats that may exist in their subject; design strategies to tackle biases in the learning environment; collect evidence of learning and reflect on the effect of their actions on classroom practice.

Guskey's approach to teacher professional learning was adopted for these workshops (see Table 3.8) and articulated over five steps:

i) Student learning outcomes – consideration of students' subject choice at upper second level underpinned the motivation for professional learning,
ii) New practices to be implemented – suitable resources were selected and implemented to create an awareness of unconscious biases and gender stereotyping backed up by research,
iii) Needed organizational support – principal buy-in was necessary to foster a whole school effort create an inclusive learning community,
iv) Educator knowledge and skills – reflection of teacher's own assumptions around gender differences and knowledge of careers was necessary to start the conversation of the changes needed to be made to classroom practice,
v) Optimal professional learning activities – creating a space where teachers can collaborate and take suitable actions to combat the issues they have highlighted, in the context of their subject department, was expected to reach a common goal for student learning (Guskey, 2014).

Table 3.8: Outline of Design Principles of Unconscious Bias Workshops

Guskey's Planning Backward Approach (Guskey, 2014)		Unconscious Bias Workshop Design
i.	**Students learning outcomes**	Identify one's own unconscious biases Demonstrate how unconscious bias can impact subject choice/ attitude to learning Assess how one's own unconscious biases can affect others (student, teachers, peers, family) Design an action plan to reduce harmful unconscious biases and promote inclusion and diversity
ii.	**New practices to be implemented**	Subject audit of resources and practices Subject action plan to promote inclusion and diversity Teacher reflective practice on awareness of unconscious biases and the impact on subject choice decisions and attitude to learning
iii.	**Needed organisational support**	Communication channels between unconscious bias lead, school management and all teaching staff Scheduling freedom for whole school workshops Space to facilitate workshops for whole staff Regular feedback loops with teachers and school management
iv.	**Educator knowledge and skills**	Understand the contextual differences between school types Experience as a learner in unconscious bias workshops Training in the delivery of unconscious bias workshops Background knowledge on unconscious bias in the brain, impact of unconscious bias in educational related settings, strategies to promote inclusion and diversity Researcher skills to collect evidence (quantitative and qualitative) of impact and report back to schools and relevant stakeholders
v.	**Optimal professional learning activities**	Bi-annual teacher unconscious bias workshops Optional student unconscious bias workshops Annual school showcase and sharing of subject findings

Further Context for Case Study A & B

The professional learning workshops outlined above (physics concepts, planning and unconscious bias), were carried out with novice teachers during their Physics Methodologies module in the first semester of their final year of a BSc in Science Education and an outline is shown in Table 3.9.

In this programme, students can choose to complete two from three pathways leading to qualification to teach Physics, Chemistry or Mathematics at Leaving Certificate level in Ireland. All six of the novice teachers participating in this study had chosen pathways to qualify as physics and mathematics teachers and completed methodology modules for both physics and mathematics in semester one of their final year. During the second semester of final year, the teachers complete a 14-week school-based placement and gain experience teaching physics and mathematics at junior and senior cycle.

Table 3.9: Overview of structure of BSc in Science Education

Subjects (s)	Year 1	Year 2	Year 3	Year 4
School Placement	Microteaching (5 ECTS)	Microteaching and School placement (10 ECTS))	School placement (10 ECTS))	School Placement (30 ECTS)
Biology	Biology (10 ECTS)			
Mathematics	Mathematics content modules (60 ECTS)			
Physics	Physics Content modules (including laboratories) (62.5 ECTS)			
Chemistry	Chemistry Content modules (including laboratories) (62.5 ECTS)			
Foundation & Professional Studies	Education content modules (35 ECTS)			
		Methodologies for Junior Cycle science and mathematics (10 ECTS)	STEM Projects (7.5 ECTS)	Methodologies for Physics/Chemistry/ mathematics (10 ECTS)

The Physics Methodologies module was delivered over three hours per week for 12 weeks. The physics workshops (See Table 3.6) were facilitated over 7 weeks, during their 2-hour lab session (See Table 3.10). Components of assessment (Workshop 7) were integrated into each of these workshops rather than having only one workshop dedicated to Classroom Based Assessments.

Table 3.10: Outline of Physics Methodologies Module

Week	Lab (2hrs)	Tutorial (1hr)
Week 1	Planning and designing a six-week physics-themed programme for students	Group Work
Week 2	Refinement and peer feed-back on programme	Group Work
Week 3	Workshop 4 - Electricity Integrating Literature – How Children Learn Reflective Practice - The role of reflection in teaching and learning	Leaving Certificate Electricity experiments
Week 4	Workshop 5 – Earth & Space	Leaving Certificate Motion experiments (Gravity)
Week 5	Workshop 1 - Light Reflective Practice – Reflecting on my Reflections	Leaving Certificate Light experiments
Week 6	Presentation of TY module	
Week 7	Reflective Practice – Assessing Reflective Diaries IBL – what is it and what does it look like for the student and the teacher? Planning Workshop - Planning a sequence of lessons	Leaving Certificate Energy experiments
Week 8	Workshop 2 – Energy Reflective Practice – Writing Critically	Assessment Support
Week 9	Workshop 3 - Motion Fostering a professional learning community - PLC Building Activities	Leaving Certificate Motion experiments
Week 10	Workshop 6 - Forces Unconscious Bias	Leaving Certificate Mechanics experiments
Week 11	Planning Workshop - Planning a sequence of lessons	Assessment Support
Week 12	Presentation of Sequence of Lessons	

There were two main additions to the physics workshops carried out with the novice teachers. The first was that the workshops focussed on the physics concepts both at Junior Cycle and Leaving Certificate level. Each lab was also accompanied by an hour long tutorial where teachers had the opportunity to carry out some of the Leaving Certificate mandatory experiments related to the physics concepts addressed in the workshops.

The second addition was that reflective practice was a key component of the module design (See Table 3.11). Teachers were introduced to: the role of reflection in teaching and learning (Moon, 2004), reflecting on their reflections and assessing their reflections (Binks *et al.*, 2009) and writing critically (Larrivee, 2000). Teachers completed reflective journal entries in the first two weeks based on their prior knowledge of reflective writing throughout their pre-service education. In week 3 participants were introduced to Moon's reflective writing framework (Moon, 2004). Participants identified examples of descriptive writing, descriptive reflection and critical reflection and discussed similarities and differences that their own reflections exhibited. In week 4, 5 and 6 participants engaged in whole class feedback on each other's reflective journal entries. Week 7 provided participants with an opportunity to look back on their reflective writing, consult literature and summarise the key points. Participants took part in whole class discussion and feedback on reflective writing in Weeks 8 and 10.

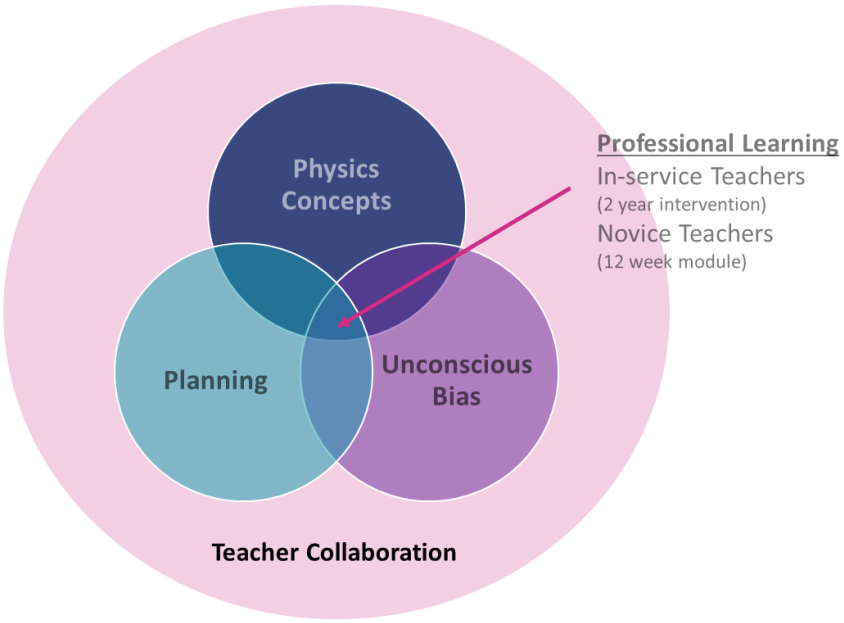
Table 3.11: Reflective Practice Components in Physics Methodologies Module

Module	Outline
The role of reflection in teaching and learning	Gather prior knowledge on reflective practice: 18 purposes (Moon, 1999) View sample lesson stories (reflective practice – students discuss the different components of lesson stories) (Binks et.al 2009) [The presentation: Moon 2004] Critique different reflective journals and feedback to the class
Reflecting on my Reflections	Discuss one reflective diary from week 3 – consider what promises you will make to improve reflective writing in next entries. [Think about: What is the main event? What is the motivating dilemma, conflict or central problem of the story? What is the turning point? Was the ending positive or negative? What would you like for the audience to learn? What else would be useful to reflect on and why?] (Binks et.al 2009) Compare lesson plan from week 3 and lesson plans from "light 1" [Think about: What aspects of lesson plans are useful? What changes would I make? Is there any evidence of addressing stereotypes or unconscious bias]
Assessing Reflective Diaries	Discuss different types of sample reflective entries. Students will add feedback comments to diary entries from previous weeks. [Think about: What is the main event? What is the motivating dilemma, conflict or central problem of the story? What is the turning point? Was the ending positive or negative? What would you like for the audience to learn? What else would be useful to reflect on and why?] (Binks et.al 2009)
Writing Critically	Analyse two weeks journal entries and summarize into 10 and 5 main points. [Discuss what are the main teaching points from this entries? What was the main focus? What can I infer from my reflections? Any future implications to practice?]

3.4.2 Approach to Teacher Collaboration

Enhancing teacher collaboration was another important aspect that was highlighted in the pilot study and was embedded in the approach adopted for Case Study A and Case Study B (See Figure 3.6). In-service science teachers from the pilot study participated in groups during the school-based workshops and discussed the time that was needed to collaborate with colleagues in designing engaging lessons.

Figure 3.6: Model Teacher Professional Learning and Collaboration



Novice teachers mostly participated in groups in their Physics Methodologies module, however, there was some interaction with literature and collaboration with peers prompted by professional learning community building activities introduced in the module design (See Table 3.12) (School Reform Initiative, 2017).

Table 3.12: Outline of Teacher Collaboration Model

Element of Teacher Collaboration	In-service Teachers (2017-2019)	Novice Physics Teachers (2019-2021)
Physics Methodologies Module	-	Group Work (Some PLC building)
School Placement	-	Collaboration with colleagues in school only
In-Service Teaching	Group Work	Research Practice Partnerships

During school placement novice physics teachers reported losing contact with their peers from university and feeling disconnected from their pre-service teacher training as they described the difficulty moving from theory to practice (See Findings Chapter 5 and Chapter 6). At this time teachers depended mostly on their cooperating teacher (teachers whose classes they were teaching).

Research Practice Partnerships (RPPs) were formed as part of Case Study A and Case Study B study design. The purpose of RPPs was to reconnect novice teachers with their peers (of similar subject discipline) and link theory to practice by building on key findings in the literature to address the novice teachers' problems of practice. The RPP meetings took place four times during the novice teachers first year of teaching (See Table 3.13).

Six novice physics teachers and two science education researchers (Researcher and Supervisor) joined the RPP voluntarily and the first meeting focussed on negotiating norms and setting expectations for the year ahead (Penuel and Gallagher, 2017). It was important that all members shared their common goals in order to have equal buy in from each partner and build a mutualistic relationship (discussed in Section 2.2.3).

The processes incorporated into the RPP meetings were similar to the functions of CoPs, identify problems of practice, discuss and expand these problems into new possibilities, express reservations and concerns and share artifacts of classroom practice (Little, 2003, p.938). Data collection was embedded naturally into the RPP meetings (surveys) and were analysed iteratively to inform the agenda for the next meeting. For example, teachers discussed problems of practice related to assessment and differentiation which were included in the following meetings (RPP2 and RPP3). The researchers reflected after each RPP and made changes based on their observations of the meeting such as removing hierarchal power dimensions (lecturer vs learner) by including teacher contribution during the workshops (sharing of useful resources or strategies) (See Appendix H). Group exit tickets and round table discussions also allowed all partners to have their say and direct the conversations to issues that they wanted to prioritise during the meetings.

Table 3.13: Outline of Research Practice Partnership Meeting Agendas (Case A)

RPP1 (October 2020)	**RPP2 (February 2021)**	**RPP3 (April 2021)**	**RPP4 (May 2021)**
Welcome	Catch Up Chat	Informal Chat	Informal Chat
Negotiating norms	Survey - What are your Problems of Practice	Survey - What are your Problems of Practice	Survey - What are your Problems of Practice
Survey – What are your Problems of Practice	Share useful tool/strategy/resource they have used	Sharing of Assessment strategies	Formulating a research question
Sharing findings & relevant research	Share findings from COVID study	Linking Literature to Practice (Differentiation)	Analysing classroom data
Formulating Research Questions	Share findings from first RPP meeting	Looking at the Leaving Certificate in depth	Reviewing the literature
Designing an action plan + collecting evidence	Group working document (Action plan for analysing practice)	Round Table discussion	Interpreting the data
Physics Resources	Group exit ticket	Group exit ticket	Reporting your findings
Round-Up			Round Table discussion

3.5 ETHICAL CONSIDERATIONS

Merriam and Tisdell (2016) outline that considering the ethical implications of a research study adds to the credibility of the research. This study sought ethical approval for working with both groups of teachers (in-service and novice).

3.5.1 Pilot Study

Ethical approval was granted for the pilot study (DCUREC/2017/190) to conduct the study with science teachers from seven second-level schools in the wider Dublin area from October 2017 – September 2019. An amendment/extension request form was then submitted to extend the study until December 2019.

Data Collection

Participating teachers were professional adults talking about their professional activities in their professional capacity and as such they are not vulnerable. Confidentiality is an important issue during data collection (Kaiser, 2012). The teachers' identity and other personal information were not revealed, published or used in further studies. Teachers were assigned an ID number once their data was saved and all names or identifiable data was deleted (it was necessary to keep teachers' names for this study). The principal investigator and collaborators listed on this ethics application only had access to the data. Audio of interviews will be reviewed only by the researcher(s). These were destroyed after completion of the research. All teachers were reminded of their right to withdraw from the study and that their data would be removed from the study.

Data Storage

All electronic media was stored securely in a password protected computer or hard drive.

All participants were made aware that the data collected in this study would be used to generate reports which would be sent to their school. One hard copy of the report would be mailed to the school for their records. A digital PDF would also be sent to the school should teachers/students/parents or other participating stakeholders wish to obtain a copy. Data was stored on an encrypted hard drive and disposed of by the principal investigator five years after the completion of this research.

Potential Risk

As is the case with any qualitative research study with a small sample size, there was a small risk that the teachers may be identifiable by data extracts given in reports and final thesis but the steps mentioned previously were taken to minimize this risk. In the unlikely event that any participants experienced distress when completing focus groups or interviews about their educational experiences the participant would have been removed from the research. The incident would have been reviewed by the researchers to identify if the research methods needed to be modified. The project would have been postponed until the event was reviewed. The action taken would be determined by the nature of the incident.

3.5.2 Case Study A & Case Study B

Ethical approval was sought and granted for Case Study A and Case Study B (same participants) initially from September 2019 to December 2019 when novice teachers were participating in their Physics Methodologies module as part of their BSC in Science Education (DCUREC/2019_134). Furter approval was sought for the novice teachers from May 2020 to September 2021 to investigate their experiences at the end of school placement and in their first year of teaching (DCUREC2020/093).

Data Collection

Novice teachers were adult students talking about their professional practice and therefore considered low risk. Individual interviews with pre-service science teachers may be considered moderate risk but because the teachers are professionals this was also a low risk data collection. Teacher reflections and surveys focussed on professional activities and as such this were also considered low risk. The teachers in this study were assigned unique ID codes and any reference to their personal information was removed. The results of data analysis were anonymised prior to dissemination. Audio of interviews will be reviewed only by the researcher(s) and destroyed after completion of the research.

Data Storage

Interview recordings were downloaded to a folder on Google Drive immediately after they were conducted and recordings on the device used for interviews were then be deleted. Identifiers of groups were kept separately by the PIs in a password protected folder on their personal DCU computer (encrypted). All survey responses were also stored in a designated password protected folder on Google Drive (DCU account). All identifiers (such as names) were deleted from the data before saving them to the folder. A record of these identifiers was maintained by the PIs and kept separately by the PIs in a password protected folder on personal DCU PC (encrypted).

Potential Risk

It is possible that participants may be identified by their responses given in reports of this study. Demographics are reported to be important in reporting cases however, this cohort started out as university students and to request demographical information at that point would have been of ethical concern. In order to protect the participants' anonymity, the research will refrain from using quotes that may be identifiable and all participants will be invited to member check their data should they wish any aspect to be removed before dissemination. The voluntary nature of the research was made clear to participants who are all adults and they were informed that they can withdraw at any time without penalty. In the unlikely event that a participant would suffer as a result of being identified in the study, the offending article/quote/extract would be removed, and the participant was reminded of their right to withdraw from the study. In this instance all of their data was removed from the study.

There was one case in this study in which a participant ceased communication (mid-study) with the researcher and their data was removed and deleted from the study.

4 CHAPTER: PILOT CASE STUDY

"Naturalistic generalisations develop within a person as a product of experience"

(Stake, 2009, p.5).

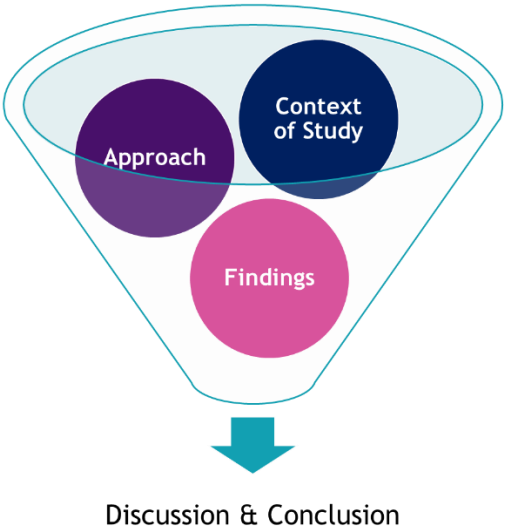
4.1 INTRODUCTION

This chapter presents a pilot case study of in-service teachers from seven second-level schools in the wider Dublin area. This pilot case-study involving 51 science teachers was carried out to explore teachers' experiences of teaching science at Junior Cycle (See Section 3.3.2 for details on participants) and was guided by the research question:

1. What are science teachers' experiences of engaging in professional learning for physics at Junior Cycle?

Firstly, an overview of the context for the pilot study is described in Section 4.1 (See Figure 4.1). An outline of the approach taken for the pilot study presented in this chapter in Section 4.3 and relevant details pertaining to the methodology used is discussed in Chapter 3. The findings of the pilot study are described in Section 4.4 and 4.5 and a mapping of themes is discussed towards the end of the study (See Section 4.6).

Figure 4.1: Outline of Chapter 4



4.2 PILOT STUDY CONTEXT

The pilot study was part of a two-year research project that involved the participation of whole school staff including science teachers. The design principles of the project were informed by the Drayson Schools Project in the UK that worked directly with girls, science departments, and senior leadership in schools, with the goals of building teacher confidence, supporting inclusive teaching, and involving the whole school (Institute of Physics, 2016).

The total teaching staff in this wider project comprised of 405 teachers and a total student population of 5,149 students (3,078 girls and 2,071 boys). Agreed criteria were used by the project team to select schools as representative of the wider cohort of Irish second level schools. These criteria included school-type (single-sex or co-educational [co-ed]), location (rural or urban) and socioeconomic background (delivering equality of opportunity in schools - DEIS). From this, seven schools were selected from the greater Dublin area, two single-sex and five co-ed, two of which were rural and five urban schools, and two designated disadvantaged schools.

The wider research project (Improving Gender Balance in Ireland) focussed on two cohorts i) all staff and ii) science teachers. All staff (including management, teaching staff and support staff) engaged in annual (and in some cases biannual) unconscious bias workshops based on the second and third design principles (See Table 3.8). All staff (including science teachers) from each of the schools were invited to participate in annual school-based unconscious bias workshops at the beginning of the school term. The participating teachers were facilitated by the researcher to collaborate in small groups of 4/5 to form a professional learning community (PLC) based on the subject department they belonged to (Dana and Yendol-Hoppey, 2015). Teachers presented action plans as part of their subject departments to address some of the inequities within their disciplines. Findings from the wider research project discuss how teachers have addressed gender issues and adopted strategies in the teaching and learning of their subjects have been reported at (McLoughlin, O'Neill and Fagan, 2020). The specific findings will not be discussed as part of this case study as they did not use rigorous research methodology.

The findings reported in this thesis focusses on participating science teachers only and details of all-staff activities (unconscious bias workshops) are only described to give context of the overall project. This pilot study was used to map the terrain in order to investigate teaching Junior Cycle science and trial approaches to support teacher professional learning and collaboration addressed through the first research question: *What are science teachers' experiences of engaging in professional learning for physics at Junior Cycle?* Focus groups and one-to-one interviews were conducted pre and post intervention to achieve this.

Researcher's Note

At the start of this study the researcher did not have a previous relationship with the teachers and was mostly an objective individual during the pre-intervention focus groups.

The researcher then formed close working relationships with the teachers of each science department as they were involved in the coordination and facilitation of the unconscious bias workshops and some of the physics workshops. Due to the changing dynamic of relationship, an external party carried out the post-intervention interviews so that teachers would feel comfortable giving an honest account of their experiences of the professional learning.

4.3 STUDY APPROACH

As outlined by Yin (2009a), pilot studies serve a purpose to inform and support the development of questions, conceptual insights and research design considerations. This study focused less on specifics and more on the outcomes and lessons learned from broad objectives and as such focusses less on methodological rigour as in Case A and Case B and also reported by Yin (2009). The objective of this pilot study was to investigate suitable design principles for physics workshops with in-service science teachers that novice teachers could also engage in, as part of their pre-service education in the following studies (Chapter 5 & 6). Therefore, the study design presented as part of this study aligns with a pragmatist perspective. The findings do not presume to be representative of all science teachers and the case design is loosely applied under the limitations of a pilot study.

The design principles of the Improving Gender Balance in Ireland project (enhancing physics teaching, awareness of unconscious bias and careers) were incorporated and trialled through seven physics workshops (Light, Energy, Motion, Earth & Space, Electricity, Forces and Classroom Based Assessments) and a planning workshop (See Chapter 3).

Science teachers in this study participated in one-two whole school unconscious bias workshops, seven physics concepts workshops and one-two planning workshops (at the end of the study) over a two year period as part of a professional learning intervention. An outline of each workshop type can be found in Chapter 3. The pilot study presented in this chapter investigates science teachers' experience of teaching Junior Cycle science as a collective unit of analysis.

4.3.1 Data Collection & Analysis

Data collected for the pilot study included focus groups at the beginning of the pilot study with science teachers from each of the seven participating schools (see Figure 3.3). Teachers were prompted to discuss planning, resources for teaching, difficulties teaching any particular science topics and the reflective practice of teachers or students. The data was coded by school e.g., teachers from School A were coded as Focus Group 1 etc. Data collected from these focus groups were thematically analysed as detailed in Chapter 3. Finally, one-to-one

interviews were conducted with ten of the teachers from the cohort. Teachers discussed their experiences of the pilot study with direction from semi-structured questions (See Appendix B). Data collected from teacher interviews were also thematically analysed as detailed in Chapter 3.

4.4 FINDINGS FROM FOCUS GROUPS

This section details the findings from focus groups carried out at the beginning of the pilot study (October 2017) before any of the workshops were conducted. The findings from focus group interviews highlighted four key themes, ordered according to the most frequently mentioned by teachers. These themes were formed by combining categories to represent a common idea that included all seven schools in the sample. The themes identified were summarised in the Table 4.1 below. Here, the number of codes attributed to each theme was mostly quoted as an indication of the themes that dominated teachers' discussions,

Table 4.1: Summary of Themes from Focus Groups

Themes	Categories	#Codes
1. The introduction of a new curriculum causes teachers to interrogate it [the curriculum] at each stage of implementation: design, implementation and assessment	• Tension between the "old" and the "new" • Classroom practice must change • The mismatch between planning and assessment	*93 codes*
2. Teacher collaboration happens in both a formal and informal capacity	• Formal collaboration • Time as a constraint to planning • Opportunities for informal collaboration	*55 codes*
3. Lesson planning evolves from department planning to individual teachers' approach to classroom practice	• Designing lesson plans individually • Teacher implementation of plans	*52 codes*
4. Teachers learn from their experiences by reflecting on practice	• Self-reflection as a form of professional learning • Assessing student understanding as a form of reflection	*47 codes*

Some of the themes had common aspects and could have been further condensed using domain summaries e.g. "planning", however, careful consideration was taken to maintain the integrity of the themes so that they reflected the nuanced nature of the teachers' comments when naming the themes (Braun and Clarke, 2013).

1. The introduction of a new curriculum causes teachers to interrogate it [the curriculum] at each stage of implementation: design, implementation and assessment

The new Junior Cycle curriculum was rolled out nationally in 2015 in Ireland and at the time the focus group took place (2017), teachers were only two years into its implementation and high stakes exams had not yet been administered (Dept. of Education and Skills, 2015). Unsurprisingly, this theme dominated teacher discussion as they described their approach to designing plans, implementing plans in their classroom practice and assessing students in line with the new specification.

Tension between the "old" and the "new"

It was very evident from teacher comments that there was a tension between teachers trying to identify "concepts" according to the learning outcomes of the new curriculum versus identifying "topics" from the old curriculum. This tension seemed to stem from teachers' practice of using the textbooks to structure their planning. In some cases, teachers reported trying to map the learning outcomes on to the chapters in the book. In other cases, teachers began by first identifying topics to teach in blocks and then match them onto the learning outcomes from the curriculum. "*We base the topics of the chapters in the books and then we looked at the learning outcomes from the syllabus that would be relevant to those topics" – Focus Group 1*

This mapping approach was evident in all seven focus groups and as teachers discussed this approach they acknowledged that they needed to change their approach and focus on overarching concepts across the different strands of the curriculum (Earth & Space, Physical, Chemical and Biological) and linked with the Nature of Science strand in the curriculum. "*…we try to do little bits of each…and try and link it back to the Nature of Science I suppose..*" *– Focus Group 1*

Teachers were cognisant of the fact that with a new curriculum came a new perspective on teaching and learning. With this in mind teachers acknowledged that their approach to planning also had to change. *"*

> *You can no longer look at these things [topics] in isolation as we would have done before and say there is the chapter in energy, it's done*

now…I'm only learning how to look at the different way of planning" – Focus Group 3

Within this sub-theme of tension between the old and the new curriculum, teachers highlighted some of the issues they were encountering in the design stage of their planning such as the depth of treatment of a concept, balancing teaching content and enhancing skills and interpretation of the specification. Teachers expressed their concern in judging where a concepts ends and how deep to go into the concept with students. Some teachers felt that they were sacrificing content when they focussed on enhancing students' skills through the Nature of Science strand. Teachers' interpretation of the learning outcomes was also an issue and they were unsure if their understanding was similar to other teachers. Finally, one focus group summed up their position with the new curriculum as being out of sync as a department due to the change in routine that they were used of with the old curriculum. *"..we were excellent and in sync [planning for teaching the curriculum] for a long number of years…but honestly first year now seems to be a bit all over the place" – Focus Group 4*

Classroom practice must change

Teachers also discussed the impact of the new curriculum on classroom practice. The new curriculum came with an introduction of a new strand called Earth & Space. Teachers discussed how this was a new concept for them and therefore found it difficult to determine how much detail to focus on within the learning outcomes. They highlighted students' eagerness to ask questions around the content in this strand and found it challenging to balance students' inquisitiveness around the concepts, with achieving the planned learning outcomes.

"..when I was talking about the Space they just, you get so side-tracked. So, you have this plan to hit these learning outcomes and then you end up on a completely different tangent. You're trying to pull them [the students] back then because they are just so intrigued by everything…" – Focus Group 1

Teachers highlighted that enhancing students' skills such as designing and carrying out experiments through inquiry was a big part of their approach to their

classroom practice when implementing the new curriculum. However, teachers emphasised that inquiry may present itself in different ways in different classes and there must be consideration for achieving the learning outcomes as well as enhancing inquiry skills. One focus group suggested that each class could contain an aspect of inquiry rather than completing a full inquiry cycle that may take up too much class time.

> *"..it's just the curriculum is too big. I don't think you can do it [inquiry cycle] every week in every class. Every class can have an element of inquiry in it where they [the students] are asking questions and how would you look at it.." – Focus Group 5*

The mismatch between planning and assessment

Assessment of the new curriculum was an area that teachers felt most unprepared for when integrating the new curriculum. Firstly, teachers encountered difficulty planning class assessments and assessing the Junior Cycle skills within class when there was no indication of how students would be assessed in the high-stakes summative exams for the Junior Cycle. Teachers felt that their in-class assessments should be a reflection of and prepare students for the final assessment (Junior Cycle exam) at the end of their three years of science.

> *"The problem is the end game is not there yet. Yano, like its ok to say, cover enough content and the next thing you get an exam. And like bottom line is they are going to do an exam.." – Focus Group 4*

Teachers outlined challenges in assessing the lessons they had planned. Often they found that there was also a tension between assessing content and assessing skills as was mentioned previously in the design phase of planning. This can be seen in a teachers comment where they note that although the class went well and students were engaged in the learning, it did not translate when they completed the assessment task. Interestingly, teachers were trying to compare an improvement in skills to student achievement in class tests.

> *"..mine are getting good at designing experiments and they are much better…at carrying out an experiment. But then when it came to their Christmas tests and written work, it didn't translate." – Focus Group 5*

Overall teachers felt that although students showed increased interest in the learning, trying to assess what the students did learn was more challenging.

2. Teacher collaboration happens in a formal and informal capacity

Teachers discussed working together during subject department meetings. This typically occurred once or twice a year and more frequently and informally over conversations on the corridor or staff room, in this theme.

Formal collaboration

Department meetings were dedicated times for teachers to collaborate and plan formally for the year ahead. In most schools these meetings were held at the start of the school year and focussed on consolidating a scheme of work for junior cycle science as teachers described getting together to decide on the work for the year ahead. Selecting and deciding on what content or topics were to be taught for each year group was the extent to which teachers collaborated together. In some schools, teachers delegated topics to plan in smaller groups or individually and then would feed back to the larger department. This would often be assigned by the subjects or year groups that teachers taught. *"We would kind of split up. Say, three people did first year, three people did second year, three people did third year and then feed back to the group kind of" – Focus Group 1*

Teachers also collaborated on collecting resources for the Junior Cycle within the department meetings. Resources (such as PowerPoints or lesson plans) were typically shared on an online platform where teachers would leave a comment of what worked well. In some schools, department meetings were used to discuss the planning of Junior Cycle investigations. The department meetings were also a place for teachers to discuss broken equipment or lessons that did or did not work well. *"The only thing that might come up is an experiment that didn't work, that three or four of us have done. Or a piece of equipment that's not working….and who broke it." – Focus Group 7*

Time as a constraint to planning

Department meetings varied in frequency throughout the year from school to school, with some schools meeting once a term and others twice a year. In some cases, teachers described the difficulty they had organising department meetings due to the limitation of finding common free hours between teachers within the larger science departments. However, smaller departments also reported having difficulty to find time to facilitate in-depth planning. Often the agenda in department meetings was consumed discussing upcoming science events or

other issues unless time was assigned specifically to creating plans. The consensus among teachers in all of the focus groups was that there was insufficient formal time dedicated to planning and for that reason the evidence of meaningful collaboration was lacking with little reference to in-depth interrogation of teaching approaches, assessment or inspection of current plans and resources. *"..there just wouldn't be enough time to actually plan it out [detailed lesson planning] unless we were going to meet every evening as a core group of teachers…you need a lot more time." – Focus Group 4*

Opportunities for informal collaboration

Teachers reported that informal collaboration happened a lot more frequently than department meetings. Teachers described having informal "chats" about what went well (or did not go well) with colleagues on the corridor, in the staff room and between shared classrooms. The informal collaboration also served as a form of reflection for teachers to think back and compare strategies with their colleagues. Teachers reported informally collaborating mostly with teachers that shared the same classes with them. Here, they discussed day to day issues with classes, lessons that worked well or didn't work at all and pacing to see if they are up to date for end of term assessments. *"We would informally, kind of ask…but very informally, as to what we'd do day-to-day. We would make sure that we have touched base at exam time, so at Christmas and Summer" – Focus Group 6*

3. Lesson planning evolves from department planning to individual teachers' approach to classroom practice

This theme focussed on two main ideas: teachers' individual approach to planning and teachers' process of implementing their plans in their classroom practice.

Designing lesson plans individually

Once a broad scheme of work was established at the department level, teachers mostly reported planning their own individual lessons. The majority of teachers preferred to plan their own lessons and resources. In some cases, shared PowerPoints were used by all teachers, however they were prepared with flexibility to allow for each teacher to adapt it to suit their teaching style. Teachers highlighted that they planned to teach the same topic as the other teachers but preferred to have the autonomy to approach it in different ways. One teacher summarised this nicely by saying that creating a lesson plan is as individual as the teacher teaching it.

> *"…[the way teachers teach measurement] it's as individual as we are …The end product is the same but how we approach it is very different. Even how I go about it now, as I did three years ago is different, yano." – Focus Group 7*

At the individual teacher planning stage, teachers reported that they focussed more on the learning outcomes and how they were related to their lesson plans. Again, it was evident that teachers were approaching their planning at an individual level very differently as a result of the new Junior Cycle curriculum.

> *"Well, I know this year, I'm looking at my planning totally different, my own individual planning. So like say energy….I certainly won't be looking at that chapter like I used to be looking at it" – Focus Group 3*

This comment (above), like many others under this theme suggested that teacher planning was an iterative process which occurred both in the initial idea generation phase quite close to implementation, as well as after the lesson had taken place. This can be seen when Focus Group 5 explained that they were using a trial and error approach with two of the same class groups; one who had science class at the start of the week informed changes to be made to the class who had science at the end of the week:

"It often goes wrong with us for one class and then fine with the other. That's what happens, we have one class early in the week and it's kind of not so good, it's kind of our trial and then by the end of the week it's alright.." – Focus Group 5

The resources that teachers utilised in teachers' individual planning varied from school to school. In some schools the textbook was the starting point for designing lessons and in other schools, students were not likely to bring their textbooks to school and therefore teachers relied on worksheets and supplementary classroom materials. Teachers also found that they were evaluating the applicability of textbooks halfway through the year and supplementing them with other resources as they felt they were insufficient at addressing the learning outcomes in the new curriculum. All of the focus groups indicated that PowerPoints were their most utilised planning documents and most of their lesson revolved around this. Other resources mentioned by teachers in their planning included online resources, workbooks, lab-books and for one school, knowledge gained form a professional development course on the Leaving Certificate (senior cycle planning). *"A few of us met and we ran through, because Teacher A is on the Biology science trial and Teacher B is on the Physics science trial for Leaving Cert, so we tried to bring it back to Junior Cycle…" – Focus Group 4*

Teacher implementation of plans

Teachers discussed a broad range of teaching strategies that were used to implement lesson plans. These included, relating content to every-day experiences and future jobs and careers, carrying out research projects, using a hook or experimental investigation to teach content and encouraging students to generate information through class discussion and prior knowledge. Teaching by inquiry was a predominant feature of teacher discussions as they described problem based approaches and open inquiry to elicit student understanding.

"I started with how to make a cup of tea to get them to write out instructions. And then I would make the tea…just looking at that, that they're not using any measurements so that they're not just saying add milk.." – Focus Group 6

Accessibility of resources varied from school to school and this impacted the implementation of teachers' plans. Availability of lab spaces to carry out investigations with students was a constraint for teachers as they reported utilising lab space for double classes and doing "theory" in the classroom. Teachers also discussed organising lessons so that equipment could be rotated between teachers. This issue was most evident in schools with large departments that did not have enough equipment for eight science classes simultaneously or disadvantaged schools who did not have the resources in the first place. *"I'm timetabled opposite Teacher C, if he is doing an experiment this week I will do it the next week" – Focus Group 7*

4. Teachers learn from their experiences by reflecting on practice

This theme mostly focussed on teachers' professional learning within their own classroom practice. Teachers' reflective practice and assessment of student understanding were key discussion points within this theme.

Self-reflection as a form of professional learning

An interesting finding within this theme was the observation of teachers reflecting on their practice as they were asked to describe "*how do you reflect on your practice*?". Teachers not only described the nature of their reflection (informal) but began describing situations in their classroom practice where they felt a certain strategy worked or didn't work. Here, it was seen that teachers' spontaneous and subconscious reaction when being probed about reflection, was to reflect!

Teachers' discussion in this theme was dominated by planning as they reported that often regardless of the precision in planning, plans do not always materialise how they expect. They attributed plans failing during implementation, to factors such as teachers' confidence teaching new concepts in the Junior Cycle curriculum, teachers trialling new teaching approaches that have not yet been perfected, assessing student understanding as part of the new curriculum, balancing priorities such as, enhancing student skills and incorporating content into the lesson and teachers not having the time to try experiments for themselves before using them in the classroom.

> *"It was a combination of different powders that were all white, so they had to try and identify that with things like for cooking and….yeah, it was*

terrible. It was really, really bad, because I hadn't really tried it before. I do feel like you have to practice the experiments before." – Focus Group 5

Teachers from five of the focus groups commented on their own professional learning through a form of self-reflection. Here, teachers showed evidence of engaging with some investigation of their own practice and collecting evidence to support the investigation. This was in the form of practising experiments, applying new inquiry teaching strategies that allowed students to generate knowledge or implementing new assessment strategies and measuring the change in students understanding. *"We did a little rubric [for Junior Cycle science, based off Leaving Certificate exam], and we marked them doing practical exams…we designed it and we just ran it." – Focus Group 4*

Assessing student understanding as a form of reflection

Other ways that teachers reported reflecting on their practice was through their students. They discussed monitoring student progression and understanding in a class. They explained that if they noticed that a student was struggling they had to pause and reflect on how they could change or refine their plan to address these gaps. Often teachers were able to assess if a new strategy is working by monitoring students' level of engagement, body language or enjoyment in the subject. Many teachers reported that they would document changes to lessons or ideas that went well or didn't work in their journals as a means of reflection, either from their own classroom experience or from conversations with colleagues.

"I write it down, in my notes, definitely I have to say, I think it's so important. Something that so didn't work that you thought was going to work, or something that you would do different the next time. And even through informal conversations you hear things and go, oh my god, I need to write that down now and remember it the next time." – Focus Group 3

4.4.1 Summary of Themes

These themes reflect the challenges and issues in teaching Junior Cycle science identified by the teachers in focus group interviews before an intervention took place. Unsurprisingly, the introduction of a new curriculum specification in its second year of implementation was an issue of great concern to teachers. Teachers now had to unpack learning outcomes into learning intentions, group these learning outcomes into teaching units, ensure that each unit was interdisciplinary (include aspects of the nature of science, physical world, chemical world, biological world and earth and space) and select appropriate resources to meet the learning outcomes. Teachers were unsure of what teaching approaches were now appropriate (to teach the new curriculum) and how to implement more investigative approaches. Teachers reported time for collaborative planning, time for implementing new teaching approaches and time to refine plans as constraints for teachers to engage in professional development. The individual teacher planning and implementation highlighted the issues with accessibility to resources and lab spaces. Teachers also expressed lack of confidence in their teaching of certain new concepts from the specification (e.g., Earth & Space) and assessing of student understanding and skills. However, teachers still had an interest in progressing their practice, by engaging in cycles of investigation on their own classroom practice and learning from new experiences.

4.5 FINDINGS FROM ONE-TO-ONE INTERVIEWS

One-to-one interviews were carried out with ten of the teachers at the end of the study (June 2019) after teachers had participated in the intervention (seven physics workshops, one-two planning workshops, one unconscious bias workshop) detailed in Chapter 3. The findings from these interviews highlighted five key themes identified below (Table 4.2) as:

Table 4.2: Summary of Themes from One-to-one Interviews

Themes	Categories	#Codes
1. Teachers report a positive influence on classroom practice as a result of focussed the intervention	• Access to resources • Increase in confidence • Student-centered teaching approaches • Effect on student attitudes and skills • Collaboration and planning	*221 codes*
2. Teachers mostly recognised unconscious bias to be an important factor to consider in their planning	• Understanding of unconscious bias • Career Awareness • More needed to make an impact	*135 codes*
3. Teachers identified factors to consider for effective facilitation of workshops	• Motivation for buy-in • Communication of project objectives	*119 codes*
4. Teachers enjoyed the facilitators, approach and content of the physics workshops	• Focus of workshops • Approach taken by facilitators	*103 codes*
5. Teachers describe their lack of confidence teaching physics in the past and presently	• Non-physics teachers' lack of confidence • Supports needed for teaching physics	*66 codes*

The last theme generated in this sample had a low number of codes, however, it was justified as themes because of its unique reference to the specific needs of the teacher.

1. Teachers report a positive influence on classroom practice as a result of the intervention

Teachers discussed many aspects related to the impact of the intervention on classroom practices such as access to resources, teacher confidence and content knowledge, student centered teaching approaches, effect on student skills and collaboration and planning.

Access to resources

Most evidently, nine of the teachers mentioned that access to resources supported the implementation of ideas from the workshops into classroom practice. These resources included kit boxes related to the concepts addressed in the workshops, information on careers and ideas for extracurricular events such as subject open days, resources (equipment and lesson ideas) that could be used in other subjects e.g., SPHE (Social, Personal and Health Education). Teachers highlighted that often when they engage in professional development workshops, although they find the ideas and concepts good, without having the resources available and ready to use they are less likely to implement them into their practice once the session ends.

> *"if they're trying to teach you something … show you something that you should then teach your students, but you don't have the equipment, you know, you're very unlikely to go with them and do it. But the fact that they're actually supplying you with the equipment and, um, everything that you need to go then and teach this is a real positive." – Teacher 10*

Some of the teachers did, however, highlight that the resources needed to be adapted to cater for all learner types. They felt that in some cases the resources were better suited to the higher ability students in the class. Teachers did acknowledge that their use of the resources may also have been a reflection on this observation and with further practice, this issue may be resolved.

> *"I find that even when I did try some of the initiatives that [the facilitator] had given us, it was still lost on some of the weaker students... But I'm not sure that that's a reflection on what [the facilitator] was trying to show us. I think it's actually more reflection on, on my questioning.." – Teacher 9*

Increase in confidence

Teachers also reported that their confidence in teaching physics had improved as a result of their participation in the physics workshops. This was reported both from the point of view of having more confidence to teach by inquiry and filling the gaps in their content knowledge. Teachers' confidence was expressed through their positive attitude to physics, their adoption of new teaching approaches and enthusiasm teaching a subject outside of their specialism. Initially teachers reported being apprehensive in their approach to teaching some concepts in physics such as, electricity, forces and space. However, after the workshops they highlighted that they felt supported by the facilitators and also had an opportunity to familiarise themselves with some of this new content. Many of the teachers also felt reassured when some of the content in workshops reaffirmed their existing knowledge or approach to teaching a concept.

> *"..when you're specifically trying to hit certain criteria and outcomes on the syllabus you're going, oh yeah, we're doing this and we're doing that. So, you know, it was kind of reaffirming to know that, yeah, you were doing all of those things.." – Teacher 8*

Student-centered teaching approaches

Embedding a student-centered approach within classroom practice was emphasised by all teachers as a change they adopted throughout their involvement in the physics workshops. This included orientating their teaching approaches to include more practical elements to engage students in the learning, encouraging student understanding through investigative approaches, considering the teaching approaches that suit different learners in the class and highlighting student misconceptions to advance their knowledge of physics concepts. *"..I suppose leaving the students to try and figure things out more so than I would have before, like that's the way my teaching is trying to go." – Teacher 3*

Teachers understood student-centered learning to mean giving students the freedom to figure things out by themselves while the teacher acted as the facilitator to scaffold their learning. Some of the teachers explained the approach they took in teaching particular concepts, all of which focussed on an investigation and effective teacher questioning. Strategies that teachers described implementing to enhance student-centered learning included:

stationed activities using jigsaw approach; predict-observe-explain; open and guided inquiry; and investigating student misconceptions. *"So, in that respect it was student led discussions and student led sort of inquiry and then we kind of teased some of those ideas out and kind of, um, you know, explain to some of them where their misconceptions were.." – Teacher 8*

Effect on student attitudes and skills

Teachers also discussed, in detail, the effect that their upskilling in their physics teaching has had on their students' attitude towards science in general. They reported that students were enjoying using more up to date equipment, that students were more engaged and motivated to learn in the classroom and that students more aware of the stereotypes that exist around physics that may impact their perception of the subject. *"I, they are not very enthusiastic now that I'm doing it through notes, but definitely last year they were way more enthusiastic and they enjoyed coming to science class.." – Teacher 9*

Although teachers reported that it was difficult to measure change in student skills, participation in regional science competitions and an increase in physics based projects was an indication that their new approaches to teaching physics were having the desired effect.

Collaboration and planning

An increase of collaboration between teachers was also reported within this theme. Teachers noted that there were more conversations being held with each other regarding their teaching approaches, planning and resources that they were implementing into their classes. Planning practices were now being embedded into department meetings and teachers were also prioritising planning time as a department. Teachers discussed various ways that their planning had changed, they now discussed a more organised approach to delegating the designing of plans sharing them with each other, in other cases teachers had begun planning units of work together as a department. Overall, it was evident that teachers valued the time that they had during the workshop to converse about classroom practice. *"it has shown us as well how to do it...so she's giving us practical examples of how we can actually collaborate together and form a unit of work together…Yeah, I think it is something that we will continue definitely.." – Teacher 10*

In addition to the facilitation of planning within the department, there was a significant focus on teachers changing their approach to planning. For example, teachers discussed creating plans that incorporated all of the strands on the curriculum and included resources they received from the workshops. Teachers felt that the trial and error of implementing plans they created during the workshops, along with the facilitators support, helped them to refine their approach and begin to organise their yearly units of learning.

> *"Bringing all the physical world and the chemical world and the biological world and science and whatever altogether.…definitely I'd say the involvement with um [the facilitator] hugely helped that. I'm not sure whether we would have come to that conclusion ourselves without some direction." – Teacher 8*

Teachers highlighted the need to embed structures to facilitate meaningful planning with colleagues in the department. They emphasised that time to plan as a department (for Junior Cycle) at regular intervals throughout the school year, during school time, would greatly support the generation of creative lessons and facilitate natural professional dialogue among colleagues within different subject specialisms. Teachers also stressed that having agendas set for these collaborations is essential as often there are other issues that take priority during department meetings; *"And then when we do get together we're just talking about CBAs or we're talking about different exams. There's always something else that needs to be done." – Teacher 1*

Finally, teachers felt it would be beneficial to embed practices that measure the impact of new teaching strategies, content or ideas and allow teachers to reflect on these changes for their own professional learning and classroom practice. Overall, this theme presented evidence to highlight the need for physics based workshops and opportunities for professional learning and showed that teachers valued the support that these workshops presented.

2. Teachers mostly recognised unconscious bias to be an important factor to consider in their planning

This theme presented findings related to the second strand of the intervention, creating an awareness of unconscious bias. Teachers mostly found this strand to be informative and shed light on some issues they may have not considered

before within their classroom practice. However, some teachers did not recognise the value of creating an awareness of unconscious bias throughout the school and their views presented gaps in the intervention approach that will be discussed further in this theme.

Understanding of unconscious bias

Teachers exhibited a broad understanding of what unconscious bias was and the effects of biases on classroom practices. They felt that they now understood what biases they had as teachers and the biases their students might have taking their subjects (such as biology is an easy LC subject or physics is too mathsy). Teachers discussed the different factors that affect both genders in their experience but also acknowledged the wider issue of inclusivity and diversity. One teacher especially outlined that being equal does not translate to equal outcomes for all and emphasised the need to provide equitable opportunities to all students.

> *"I do think that by providing equal opportunities, that does not mean that you are actually in the end going to get equal outcomes, if you know what I mean….As an educator, all I have to do is ensure that the education that I provide to the males and the females sitting in front of me gives them equal opportunity." – Teacher 7*

Teachers described how the whole school workshops was a space for them to reflect on their practice and consider issues of gender imbalance and ways to overcome harmful unconscious biases. Teachers also showed evidence of consulting the research on aspects of gender equality following the whole school workshop. In one school the whole school took part in a poster presentation within each subject department to highlight the actions teachers were taking to promote inclusivity and diversity. Teachers found this to be an insightful experience and enjoyed hearing what their colleagues were doing to address the issue of gender imbalance within other subjects.

> "*I found it really interesting and it was so interesting to see what other departments in our school are doing and how they're tackling or how they're looking at the challenge [of gender imbalance]." – Teacher 6*

Teachers gave examples of how their awareness of unconscious bias was reflected in their classroom practice. Some of the strategies teachers had

embedded into their practice included promoting role models, considering the language they used and assessing that the resources they use are inclusive. Teachers also discussed their heightened awareness around issues such as appropriate use of pronouns for students, students with extra needs (e.g., young teenage mothers/fathers) and the different supports that students may require in their classroom. *"I think me myself I've been changed a little bit, definitely, a little bit more open… And one girl actually has a young baby in the school. I'm very conscious of that." – Teacher 5*

Career Awareness

Within this theme teachers also discussed how their knowledge of careers and their students' knowledge of careers had broadened. Teachers also described choosing role models of equal genders and representing minorities in particular. Teachers reported that their students were also now more aware of the different types of jobs and career paths that were available to them as a result of embedding career awareness into their classroom practice. However, teachers also admitted focussing too much on the content aspect of their subjects that other issues related to unconscious bias and career awareness were forgotten about, *"..i'll try and do anyway, in the lesson, sometimes you might get caught up in the content more than the actual you know, applications, or employment, or career prospects that students could take." – Teacher 5*

More needed to make an impact

Apart from reporting the positive impact of the workshops on teachers, they identified areas of improvement to enhance the awareness of unconscious bias within science and across the whole school. Teachers felt that there was a low whole staff buy-in due to the fact that there was only one or two unconscious bias workshops. On the contrary they felt that because the science teachers had more exposure to the facilitators and key messages of the intervention they had a greater buy-in and understanding of the issues, *"we've had a lot of dealings with [the facilitator] and had a lot more exposure to it.." – Teacher 6.* They suggested having more frequent workshops within smaller departments to have greater impact. Teachers highlighted the need to point out the wider issues of inclusivity and diversity to all staff. Science teachers also felt that a greater focus on gender within the physics workshops with a clear outline of steps to take to enhance students' experience of the subject would be beneficial.

Within this theme there were also teachers that did not recognise the significance of the unconscious bias strand. Some science teachers felt that they got more out of the physics workshops than they did from the unconscious bias aspect and did not see the link to gender within these workshops. As a result, these teachers did not grasp the bigger picture of the intervention and were focussed on physics content only, *"it's nice to be reminded, about our biases, but I would, it wouldn't be top priority, gender bias would not be top priority on my list of things to do.." – Teacher 7.* Other teachers outlined that the willingness of staff to engage with this strand of the intervention depended on each individual teacher and their openness to taking on new ideas.

3. Teachers identified factors to consider for effective facilitation of workshops

This theme was mostly generated from the feedback of coordinating teachers (teachers who were the main contact point within each school, n=4) as they described initiating the intervention within the school and organisation of workshops. All teachers interviewed contributed to discussion around the intervention's objectives and their view of the best way to organise and facilitate workshops from a science teachers' perspective.

Motivation for buy-in

Schools were recruited to take part in the intervention and it was generally the principal or coordinating teachers who made the decision to get involved. Teachers reported that motivation to get involved varied between schools from low numbers of girls studying physics, to low numbers of physics teachers or getting access to resources. The coordinating teacher was solely responsible for communicating between the researchers of the intervention, management, science teachers and all staff. Four of the teachers interviewed were coordinating teachers and they discussed that it would have been helpful to have more science teachers and representatives from each of the subject departments involved initially in the decision making stages to get buy-in from all staff and accommodate for changing personnel within the department, "*I think having a contact person in smaller groups. So, if you're going to roll it out, then asking me like it needs to be driven on by the head of the department, in each subject department." – Teacher 1*

Many of the teachers could see the value in the physics workshops after they attended them and this helped in their overall buy in. Teachers described the good overall attendance at workshops, the willingness of teachers to give up their free time and the suggestions from teachers to roll out the workshops as a national professional learning opportunity for all teachers as evidence for department buy in, "*well not everybody was able to do it, that's fine, but I mean people were, I suppose they accommodated as many as they could and it was up to the people [teachers] themselves and, so yeah I think for the most part it worked pretty well." – Teacher 3* Some of the teachers suggested changing the format of the workshops so that they could attend a few workshops in an all-day course. Teachers felt that condensing the workshops into fewer days over a shorter period may be a more flexible approach and relieve some of the pressure of attending after school workshops, *"..maybe trying to do as many as you can in one session rather than spreading it out over say ten.." – Teacher 11*. Teachers also felt that they would have liked even more topics covered in the physics workshops.

Communication of project objectives

Within this theme, teachers highlight the need to communicate clearly the objectives of the intervention with all participating teachers and throughout the intervention to get buy-in from all involved. All of the teachers interviewed felt that they did not fully understand the different moving parts of the intervention until the end of the initiative and some were not aware that it was a whole school intervention. Some teachers expected that the workshops would be offered in each of the science subjects, others would have liked an opportunity to choose what physics workshops they would attend. Overall teachers felt that there was a lack of communication about the purpose of the workshops and this led to tension when facilitating the workshops, *"I think that they need to really, um, be very clear themselves [project coordinators] as to what they're doing and why they're doing it and communicate that with the people that are taking part in it.." – Teacher 10.*

Linked to the communication of the objectives of the intervention were teachers' expectations of the commitment needed to participate in the intervention. This aspect of the theme highlights that the communication teachers are discussing, may be related to internal communication between management and teachers.

Management's true commitment to the initiative was reflected in the facilitation of workshops. Although principals in each of the schools "supported" the intervention there was only one school that facilitated physics workshops within school time. Often this decision was due to teachers having breaks in their timetables at different times, teachers being involved in more than one department or lack of personnel to cover teachers' classes (as these costs were offered by the coordinating team to be covered). However, these issues were rarely shared with the teachers and as a result some teachers felt that two hours outside of school time was a lot to commit to, *"They weren't very impressed because a lot of the workshops were after, well, all the workshops were after school, all the science departments ones." – Teacher 2*

4. Teachers expressed their enjoyment of participating in physics professional learning

This theme showed evidence of teachers' enjoyment of different aspects of the intervention including the content, approach and facilitators.

Focus of workshops

Teachers described how they found the focus on ideas for physics teachers very helpful especially for out-of-field physics teachers. They discussed the benefits of being able to experiment with equipment that they had in their schools and were unfamiliar with, equipment that they have not seen before and practical examples of home equipment that could be used in the science classroom. Teachers found the physics workshops to be of high quality and that the practical activities that were embedded provided them with new methodologies, ideas and resources to teach physics concepts.

> *"I think the practical workshops were fantastic. Um we did ones on water and speed and um, uh, electricity…So the actual practical ideas and putting them into context so I'd say those practical activities were brilliant, they'd be very worthwhile." – Teacher 8*

Approach taken by facilitators

Teachers broadly understood the workshops to adopt student centered approaches to teaching physics. This student-centered and inquiry approach (see description of physics workshops – Chapter 3 for further detail) teachers felt supported the introduction to the new curriculum which teachers found useful

for new ideas and to ask for advice on their own practices. Some teachers acknowledged that the approach taken in the physics workshops was very different to how teachers themselves were taught and therefore the resources had to be made accessible to teachers as well as students. Teachers appreciated that the workshops were not static or prescribed and that the facilitators changed, amended and adapted the workshop approach depending on the teachers' needs. For example, teachers suggested changing the approach from allowing teachers to try out different activities and ideas during the workshops to actually treating them as the learner so that they could learn from the student perspective,

> *"..the first few days sort of presented um they presented a station so we did the activities of the stations on that first day….And then I know as a group, we were sort of saying, you know, maybe it would be more helpful for us to actually be taught how to teach the topic... they did start to treat us more like the students and actually taught us the way it should be taught.." – Teacher 7*

Teachers also described the workshops as an encouraging environment for teachers to learn. They discussed the usefulness of learning how to form hypotheses, challenging student misconceptions, learning questioning styles to facilitate inquiry based learning and promoting conceptual understanding in the classroom. Teachers also felt comfortable sharing questions and ideas with colleagues, learning from their own mistakes and getting the time to become familiar with some to the content that was new to them, *"I suppose it's also a platform to air your views and for them to be heard and for other people even when they're answering questions, that you're learning by what they're saying.." – Teacher 3*

Teachers appreciated the expertise the facilitators brought to the workshops. They discussed the value of having different facilitators giving different perspectives, who were supportive [empathetic to them as teachers] and approachable. Teachers also highlighted that they liked that some of the facilitators were teachers themselves who had similar experiences and expectations as the participating teachers, *"I think it's good if you have people that are currently teaching as well if that's possible." – Teacher 5*

Overall, the teachers outlined the high quality of the workshops and the positive impact this had on their own professional learning. Teachers found the physics workshops to be informative and enjoyable which led to their overall positive attitude towards teaching the concepts addressed during the intervention.

5. Teachers describe their lack of confidence teaching physics in the past and presently

This last theme presented evidence to show that teachers were not confident teaching physics. This theme highlights the persistence of teachers' lack of self-confidence when teaching physics at Junior Cycle. Teachers discussed their apprehension about their content knowledge, insufficient physics qualification and difficulty adapting new teaching approaches within this theme. They also highlighted some areas that would benefit non-physics teachers to enhance their professional learning experience in physics.

Non-physics teachers' lack of confidence

Teachers openly expressed their lack of confidence teaching physics. Particularly among the non-physics teachers, there were concerns about certain concepts that they found difficult or daunting to learn themselves. These teachers felt like they would like to understand the concepts better so that they would be confident enough teaching them, "*like we're really not comfortable. So that's the only thing like it really kind of has to be dumbed down as much as possible..*" – *Teacher 9.* Teachers attributed their lack of confidence to their inexperience in teaching the subject and their lack of qualification.

Some of the teachers outlined the difficulty they had prior to the physics workshops with keeping up with the physics content. They felt that they would not be able to complete the Junior Cycle physics course in time. Teachers also discussed the safety concerns they had due to their unfamiliarity with the equipment. They outlined topics such as electricity and as a result felt they could not consult with colleagues as most teachers in the department also had these content knowledge gaps,

> *"I asked around I was like you know I'm looking for something to do Ohms law and the teachers they either didn't do it, or they showed a little video of it but they didn't practically do it because people are not too*

sure about it, when they're doing it practically they're not sure about it.." – Teacher 3

Often teachers felt that the teaching approaches they used to teach physics reflected their lack of content knowledge in the subject. Teachers discussed adopting a chalk and talk approach when they were unsure of the content. In some cases, teachers avoided asking students questions that they did not know the answer to themselves, *"...and try not to have the students asking too many questions because they often wouldn't have known the answers." – Teacher 2* Teachers also reported reverting to more traditional approaches such as "note taking" when they were under pressure to complete the curriculum. Some of the teachers also felt that the new approach of inquiry based learning did not match the high stakes exams and that this exam focus reinforced traditional teaching approaches. It was highlighted that teachers tried to mimic the approach to teaching that the facilitators presented without trying to embed their learning into their own practices, *"...I suppose I could, I mean she gave us loads of different ideas and it was more to be honest with you copying what she did" – Teacher 9.*

Supports needed for teaching physics

Teachers were very forthcoming in the supports they felt they needed to overcome the lack of confidence teaching physics that still persisted within their departments. Time was the single most discussed resource that teachers emphasised to aid in their professional learning. This included time to become familiar with course content, to review material before workshops so that richer discussion could be facilitated, time to plan creatively and discuss aspects of their planning with colleagues. Teachers outlined the benefit of being able to bounce questions off facilitators and learn from their own mistakes was a helpful learning experience to come out of the workshops and could be further reinforced in the design principles, *"...once I have it worked out then I'd love to be able go to the experts and say look at how, am I teaching this concept..." – Teacher 7*

4.5.1 Summary of Themes

The five themes outlined above after teacher participation in an intervention (See outline of workshops in Chapter 3) reflects the impact of the intervention specifically on classroom practice. Teachers felt that there was a positive change to their classroom practice and that their experience of the workshops highlighted what worked well and would benefit from sustained support in the school. Teachers exhibited a heightened awareness of unconscious bias and most saw the value of incorporating aspects of career awareness and measures to reduce harmful biases into their practice. The facilitation of workshops presented many challenges and teachers used these challenges to highlight changes and improvements to the intervention. Overall, teachers had a positive experience of the workshops and mostly referred to the physics workshops in their acknowledgment of high quality content, facilitators and approaches. However, there was evidence to suggest that teachers still experienced a lack of confidence in their teaching of physics and further opportunities for professional learning was needed.

4.6 DISCUSSION

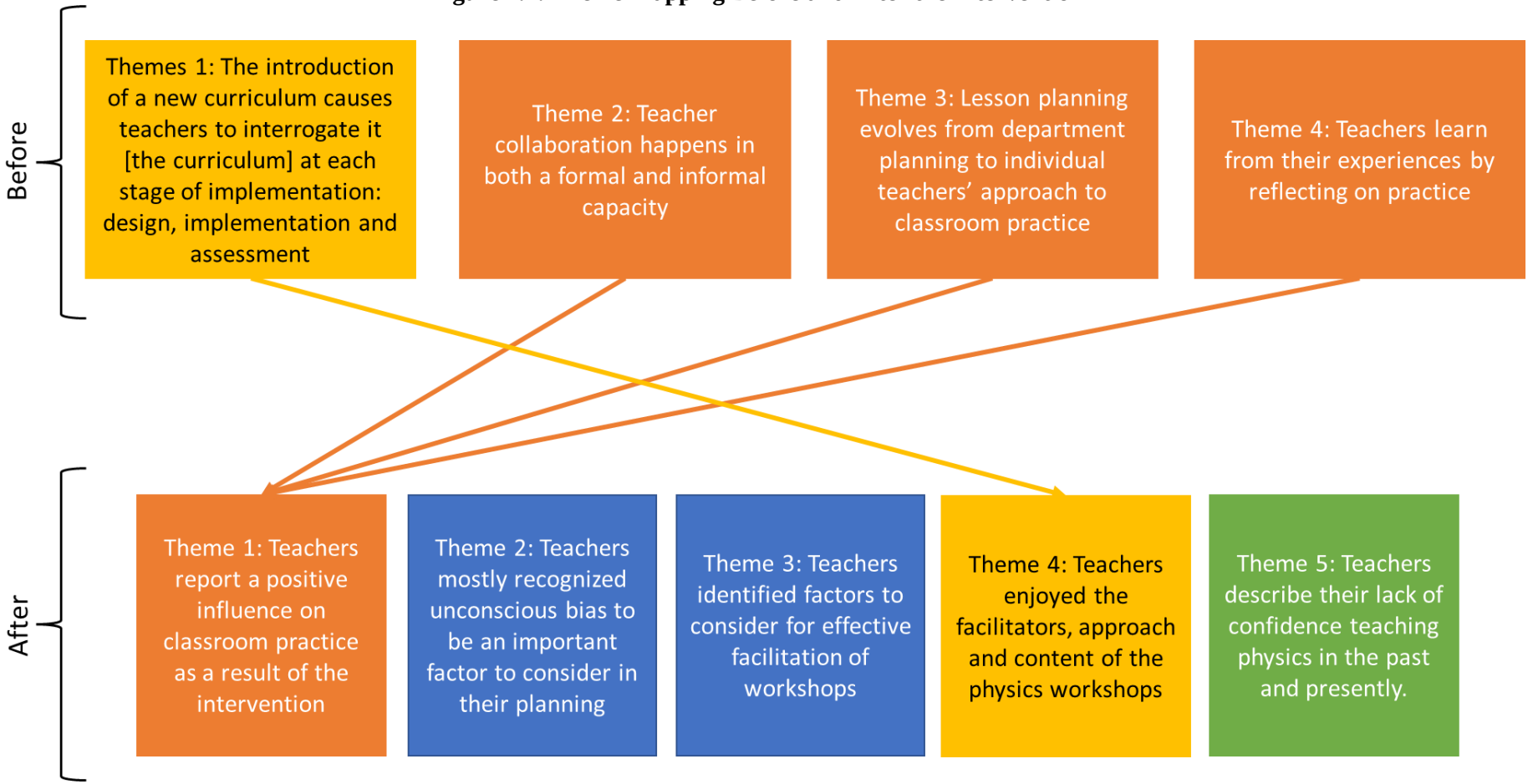
This study examines the experiences of in-service science teachers in order to address the first research question:

1. What are science teachers' experiences of engaging in professional learning for physics at Junior Cycle?

The themes outlined before intervention findings highlighted issues related to collaboration between teachers within the science department, embedding meaningful planning opportunities for teachers, trial and error of new teaching strategies and challenges associated with the introduction of a new curriculum (See Table 4.1).

Themes from after the intervention were mapped onto the initial themes to understand how the intervention may have influenced teachers' experiences (See Figure 4.2). In Figure 4.2, the yellow colour for Theme 1 (before) and Theme 4 (after) indicates a parallel between how the workshops aligned with the approach of the new curriculum and how the intervention was complimentary to this curriculum change. The orange colour for Theme 2,3,4 (before) and Theme 1 (after) highlights how collaboration, formal planning and reflection (highlighted by teachers) embedded in the intervention design resulted in a positive influence on classroom practice. The blue themes (2 & 3) emerged from the design principles of the intervention that focussed on unconscious bias and career awareness. Finally, Theme 5 (green) was a new theme that highlighted teachers' persistent lack of confidence teaching physics.

Figure 4.2: Theme Mapping Before and After the Intervention



4.6.1 Observation 1

Teachers felt supported by the intervention as it addressed the concerns raised at the beginning of the study (facilitating collaboration, supporting planning and reflection on practice). Theme 1, post-intervention, outlined how teachers felt the intervention influenced their classroom practice as the workshops addressed the issues that they reported in the pre-intervention focus groups, e.g., linking topics within the new curriculum, specific aspects of physics they found difficult etc. These findings suggest that creating opportunities for teacher professional learning that include space for planning and reflecting is important for influencing classroom practice as is replicated in the literature (Tichenor and Tichenor, 2019). Similar to findings from Tichenor and Tichenor (2019), this study outlines the tensions between teaching towards high-stakes exams, the introduction of a new curriculum (and teachers preconceived ideas about it, such as being too broad) and lack of time for planning to be in competition with opportunities for teachers to design and implement plans effectively.

There were also positive outcomes related to the affective domain as teachers expressed their enjoyment of the physics workshops, in particular, due to the experienced and varied facilitators, the approach to teaching (aligned with the new curriculum) and content (physics) in Theme 4 (post-intervention). The study highlighted the need for designing teacher professional learning experiences that focus on effective collaborative planning where teachers have similar goals based on real problems of practice (Penuel & Gallagher, 2017).

However, teachers also reported that appropriate infrastructure is needed to facilitate time and space for teachers to design, plan, implement, and refine new teaching approaches (Theme 3 post-intervention). They emphasised that time to plan as a department (for Junior Cycle) at regular intervals throughout the school year, during school time, would greatly support the generation of creative lessons and facilitate natural professional dialogue among colleagues. This idea is not a new one, as the importance of teacher planning to review available resources, meet curriculum objectives and consider student aptitudes is highlighted as one of the most crucial aspects of teaching in literature (Yinger, 1979). Although teachers had a dedicated workshop for planning, this was not sufficient time to embed ideas and some teachers suggested that this came too late in the intervention. Studies suggest that teachers experience specific learning during

the planning process of inter-disciplinary units and need sufficient time to support this learning as is the case, in this study, with the new Junior Cycle curriculum (Petroelje Stolle and Frambaugh-Kritzer, 2014).

4.6.2 Observation 2

Unconscious bias and career awareness did not present as a theme before the intervention (as most teachers did not know about the issues related to these aspects of the intervention). However, after the intervention teachers exhibited a broader understanding of issues related to awareness of unconscious bias and career awareness. Teachers described how the whole school workshops was a space for them to reflect on their practice and consider issues of gender imbalance and ways to overcome harmful unconscious biases. They now felt that their increased awareness of issues of inclusivity was something that they needed to consider in their planning (Theme 2 – post-intervention). Dee and Gerhenson (2017, p.13) suggest implementing interventions to address unconscious bias (UB) in the classroom such as, focussed school policies and practices that are specific to UB, student-facing interventions to reduce the harm of UB and teacher-facing interventions that can directly impact classroom practice (as also reported by teachers in this study). They emphasise that teacher-facing interventions should be prioritised due to their capability to improve classroom environments to be more inclusive and have longer lasting effect than student-facing interventions with higher turnover from year to year (Dee and Gershenson, 2017).

The findings presented relating to unconscious bias and career awareness are still incomplete and require more in-depth study and interrogation. Teachers felt that there was a low whole staff buy in due to the fact that there was only one or two unconscious bias workshops. These findings suggest that creating an awareness of the need for inclusive practices across the whole school is necessary to sustain a change in attitude towards inclusive practices as teachers identify that more is needed to impact change. This type of study could build on the teachings of Banks & Banks (2019), who identify empowering school culture and examining the culture and organisation of the school to promote gender, racial and social-class equity (Banks and Banks, 2019). This would have clear implications for policy and practice in second-level schools and for the preparation of pre-service teachers and in-service teachers.

4.6.3 Observation 3

Theme 5 (post- intervention) outlined teachers' persistent lack of confidence teaching physics. Although teachers embraced the ideas from physics workshops and felt empowered to try some of the new approaches in their own classroom practice, their physics content knowledge emerged as a stumbling block for their future engagement with teaching physics. This barrier was evident through an absence of teacher discussion around specific physics concepts as they spoke in general about their pedagogical approaches of teaching physics rather than particular concepts that they found difficulty with. This finding was in agreement with studies that report teachers' unwillingness to commit to putting their own ideas forward outside of the information in textbooks due to lack of confidence (Sánchez and Valcárcel, 1999).

Another consideration of this particular finding is the nature and purpose of the *unit of analysis* in this study: teacher experience. Teacher's specific physics PCK was not probed for in the data collection and as such a change in teacher PCK cannot be definitively determined. However, teachers' expression of lack of confidence teaching physics may be linked to their knowledge and proficiency in teaching it. Teacher's confidence in teaching is greatly influenced by their qualifications (Lekhu, 2013) and conceptual understanding (Menon and Sadler, 2016). Theme 5 highlights the need for sustained engagement with out-of-field teachers to address their professional learning needs. Out-of-field teachers "don't know what they don't know" when it comes to sufficient content knowledge in all of the disciplines related to STEM and find it difficult to provide quality education and deep learning opportunities for students, as studies show (Kenny, Hobbs and Whannell, 2020, p.1487).

4.7 CHAPTER SUMMARY

This chapter highlights lessons learned from a pilot intervention for physics teacher professional learning. Initially teachers were focussed on the granular aspects of teaching science related to the introduction of a new curriculum, collaboration, planning and reflecting. After the intervention teachers considered broader issues related to the teaching and learning of science such as diversity and inclusion. Observations related to the professional development that supports teachers in their planning, facilitation of effective teacher collaboration, embedding unconscious bias more frequently in professional learning for teachers and content knowledge for teaching physics for out-of-field teachers were the main outcomes of this pilot study. These outcomes informed the design of professional learning for Case Study A and were incorporated into the recommendations for the IGBI project (McLoughlin, O'Neill and Fagan, 2020).

5 CHAPTER: CASE STUDY A

"How can we understand and help adults as they face the inevitable but non-predictable transitions of life?

(Schlossberg, 1981, p.3)

5.1 INTRODUCTION

This chapter reports on the experiences of six **novice** physics teachers throughout their final year of pre-service teacher education into their first year of teaching (Case A).

> **Researcher's Note**
>
> Here, the term "novice" refers to teachers in their final year of a pre-service teacher education programme through to the end of their first year of in-service teaching. At times when teachers were still completing their BSc in Science Education, the term pre-service teachers (PSTs) was used to label this cohort. Similarly in their first year of teaching, the term newly qualified teachers (NQTs) were used to distinguish this cohort from their colleagues who are identified as in-service teachers (ISTs).

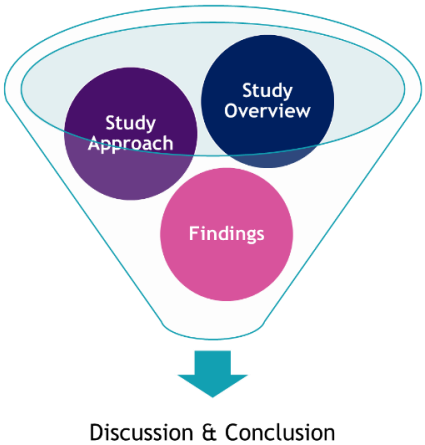
This study aims understand how the experiences of novice teachers change over time and to identify the transitions (moving in, moving through or moving out) experienced by these teachers during a two-year period. The research questions that guided the design and analysis of this study were:

2. What are teachers' experiences of becoming a novice physics teacher?

a. What transitions are occurring throughout teachers' experience?

An overview of the study's case, approach, context and data collection and analysis are first presented (See Section 5.2 and Figure 5.1). Findings from the study are then presented including a mapping of themes to summarise teacher journey throughout their two years (Section 0). The findings are then discussed within Schlossberg's transition theory in Section 5.6.

Figure 5.1: Outline of Chapter 5



5.2 CASE STUDY A – OVERVIEW

This section provides context for the findings presented in Case Study A. In this section the case is defined and key learnings from the Pilot Study are outlined. An overview of the approach adopted in this study for data collection and analysis is presented in Section 5.3.

5.2.1 "The Case"

The case investigated in this study was teachers' ***experience*** throughout pre-service teacher education to in-service teaching. The experience was bounded by time (start of final year of degree programme until the end of the first year of in-service teaching) and context (novice physics teachers in the Irish education system). The participants of this study were six novice physics teachers and they were selected as embedded units of analysis to investigate their experience and to identify the process of transition (moving in, moving through, moving out) that novice teachers encounter during this phase of their career.

5.2.2 Key Learnings from the Pilot Study

Key learnings from the pilot study conducted with in-service science teachers (Chapter 4) were used to inform the design of Case Study A. The first observation from the pilot study indicated that workshops included in the intervention supported teacher collaboration, planning and reflection on practice and teachers enjoyed participating in them. Changes were made to the workshops for use in the Physics Methodologies module with the novice teachers, such as, allowing more time for planning and encouraging teachers to think about planning earlier in the process (See Table 3.10). The activities from the assessment workshop were split up and incorporated into all of the other workshops as the novice teachers had less experience of assessing students.

The second observation suggested that teacher's exposure to issues related to unconscious bias and careers were influenced by the workshops but more needed to be done to address this issue. Therefore, this study incorporated a workshop to increase awareness of these issues with pre-service teachers.

The third observation from the pilot study indicated that in-service teachers had persistent problems of practice around their confidence in teaching physics. The novice teachers in this Case Study A were asked what topics/areas they felt least

confident teaching at the beginning of the year and because of this each tutorial session focussed on facilitating novice teachers to practice carrying out the Leaving Certificate mandatory experiments (See outline of module Table 3.10). The pilot study also highlighted a fear among out-of-field physics teachers when teaching physics and therefore this study focussed on addressing this issue with novice teachers from the start of their final year of pre-service teacher education and during their first year as newly qualified teachers. Research Practice Partnerships (RPPs) were established at the start of the novices' first year of teaching and aimed to support teachers in addressing problems of practice that arose during the year. The RPP design was informed by the previous pilot study and work with teachers during their pre-service education. These changes included i) opportunities for formal collaboration between teachers (Pilot Study themes), ii) opportunities for collaborations between teachers and researchers (Pilot Study themes & Physics Methodologies themes). Further details of the design of the RPPs can be found in Chapter 3.

Researcher Note

In this study, the researcher had many different roles at different points during the data collection. Firstly, the researcher was the lecturer facilitating the Physics Methodologies module. Power dynamics were mitigated in this instance through documenting researcher reflections. The aims of the research were communicated with participants who understood that participation in the research was separate from and would not impact on their module grades.

During the teachers' school placement, the researcher was not involved with the teachers and interviewed the participants as an objective party that was simply interested in their experience of school placement (as was communicated with the teachers). Teachers were invited at the end of this interview to continue to collaborate with the researcher as a colleague.

Finally, during the RPP meetings, the researcher worked to maintain a mutualistic relationship with the teachers devoid of hierarchal structures. This type of relationship was fostered through regular communication of the joint goals of the researchers and teachers, negotiating norms within the group and maintaining researcher reflections that probed the relationship types during the meetings.

5.3 STUDY APPROACH

This study was carried out with six novice physics teachers over a two-year period (September 2019 to May 2021). In Semester One 2019/20, the teachers participated in two-hour workshops (face to face) for each of the twelve weeks. The workshops had been developed for the pilot study with in-service teachers and were adapted by the researcher to be used in the Physics Methodologies module facilitated by the researcher (See Chapter 3 for details). The purpose of these workshops was to enhance teachers' confidence and competence for teaching physics at Junior Cycle and support the teacher in designing units of learning that could be used to teach Senior Cycle Physics. Teachers were required to reflect on their experiences each week (reflective journals) and document their own learning (See reflection protocol in Table 3.11).

In Semester Two, the teachers participated in school-based placement as part of their degree programme, which involved the teachers teaching 14 classes per week for a 14 week period. Teachers were supported by two university tutors and placed under the supervision of a cooperating teacher in each school (See Table 3.9 for course structure). The researcher met with the novice teachers after their school placement to discuss their experiences and invite them to continue their participation in this study after they graduated from the University (See Interview Protocol in Appendix C).

In September 2020, at the start of their first-year teaching as NQTs, the teachers formed a Research Practice Partnership (RPP) with two science education researchers (researcher and supervisor). During the 2020/21 school year, four RPP meetings were held and data collected during these meetings informed the agenda for the next meeting (See Meeting Agendas in Table 3.13). All meetings were carried out online, because of the COVID 19 pandemic (See Section 3.2.6 for strengths and limitations of online data collection). The meetings followed Penuel's RPP model (Penuel and Gallagher, 2017) and the research design and data collection aligned with Merriam's case study approach (Merriam and Tisdell, 2016).

5.3.1 Data Collection & Analysis

Data collection was guided by the researcher's epistemological beliefs (interpretivist -constructivism, See Section 3.2.1) literature review (RPPS, See Section 2.2) and research questions (See Section 2.4.1). Data collection tools were carefully selected to fulfil the dual purpose of informing teachers professional learning and the research study. For example, during the Physics methodologies module, teachers completed reflective journals as part of the module assessment and these were then used as data to inform the RPP surveys. RPP meetings were designed to support teacher professional learning. Surveys were conducted during the meetings and the findings from the qualitative and quantitative surveys were shared and discussed with teachers to identify areas that could be addressed in the next meeting.

Researcher's Note

Researcher reflections were also used to inform the agenda of the RPP meetings and ensure that mutualism was maintained (See Appendix H).

Data from all teachers was analysed collectively to represent the cohort of novice teachers, as the analysis of individual teacher data showed strong commonality in their responses. Iterative cycles of thematic analysis were carried out on each set of data collected during RPP meetings (as described in Chapter 3). The findings from this analysis were reported chronologically to represent the cohort of novice teachers' journey over time. Themes from each of the data sets were then mapped onto the theoretical framework used in this research to establish the transition process (See Chapter 3) experienced by the cohort.

The themes were condensed into subject domains for ease of comparison between the data sets and mapping onto the theoretical framework. Indicators from the theoretical framework were used to establish the teachers' transition process and attention was paid to any singular deviations from the themes that might indicate a different point in the transition process.

5.3.2 COVID 19

The emerging Covid-19 pandemic had a significant impact on the context and findings from this study during this period (September 2019 to May 2021). Teachers were moving between online and face-to-face teaching approaches, implementing social distancing guidelines and relaxing guidelines depending on school policy. Table 5.1 below summarises the restrictions in place at each data collection point during year one 2019/20 and year two 2020/2021.

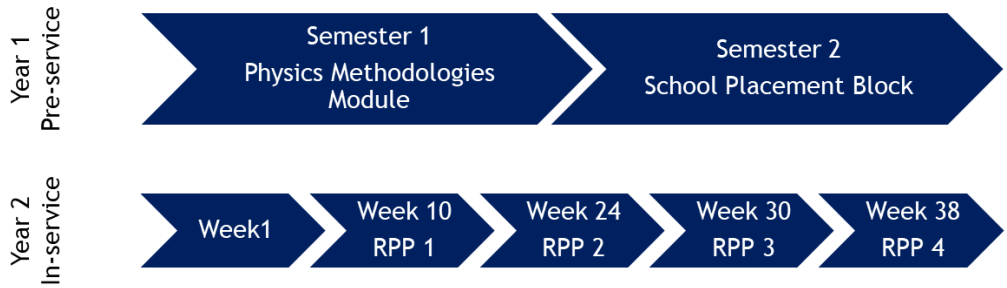
Table 5.1:Overview of Lockdowns and Restrictions during COVID 19 pandemic in 2019-2021

Data Collection Point	COVID-19 Restrictions in Ireland
Year One – Semester 1	No COVID
Year One – Semester 2	March 12th: School Closures until end of school year – online teaching
Year Two – Week 1	August 23rd: Face-to-face teaching, face coverings, social distancing, no group work, limited use of lab equipment
Year Two – Week 10	October: Face-to-face teaching, face coverings, social distancing, no group work, limited use of lab equipment
Year Two – Week 24	January – February 15th: School Closed – online teaching
Year Two – Week 30	April 12th: Face-to-face teaching, face coverings, social distancing, no group work, limited use of lab equipment
Year Two – Week 38	May: Face-to-face teaching, face coverings, social distancing, no group work, limited use of lab equipment

5.4 CASE STUDY A FINDINGS

Findings from this case are reported in chronological order at specific milestones along the research journey (Figure 5.2).

Figure 5.2: Outline of Data Collection Points



5.4.1 Year One - Semester 1

Teachers completed a weekly reflection after every lecture (workshop) as part of their Physics Methodologies module. The reflections were thematically analysed (See Chapter 3 for detail) and six themes were generated from the data. Within each theme, categories described the main ideas documented by teachers (See Table 5.2). More detailed description of themes can be found in Appendix I.

Table 5.2: Summary of Themes and Categories from Teacher Reflective Journals

Theme	Category	Theme	
1. Teachers described how they would plan and implement ideas ***(257 codes)***	• Teachers discuss teaching strategies that they think will be effective • Teachers discuss effective classroom management strategies • Teachers suggest adaptations to suit their classroom practice • Teachers identified aspects of assessment throughout the module and how they related to classroom practice	**4. Teachers outlined specific learning gained from the module** ***(91 codes)***	• Teachers evaluate their own performance during workshops in group activities and presentations • Teachers discuss the thinking behind teaching ideas • Teachers describe the importance of real life applications • Teachers discuss implementing career awareness into their classroom practice • Teachers discuss their interest in exploring the impact of unconscious bias on students
2. Teachers critically analysed teaching approaches ***(142 codes)***	• Teachers critique the lecturer's approach to teaching • Teachers discuss aspects of the workshops they would have reservations adopting • Teachers describe inquiry based learning as a teaching approach • Teachers discuss the implications of implementing groupwork	**5. Teachers mentioned the supports in place to develop their learning** ***(79 codes)***	• Teachers reflect on the impact of past school experiences • Teachers draw on past teaching experiences to inform their decisions • Teachers describe the support they drew on from mentors
3. Teachers described instances where they lacked the overall pedagogical content knowledge for a task ***(136 codes)***	• Teachers identify areas of their content knowledge they would like to improve on for their own learning • Teachers describe areas that they found difficult in the module • Teachers discuss their confidence teaching certain topics • Teachers discuss their lack of experience teaching	**6. Teachers discussed student learning in their reflections of teaching** ***(64 codes)***	• Teachers' experience as the learner gives a student perspective to the teaching approaches • Teachers consider the needs of different students in their class • Teachers discuss necessary skills to pass on to students • Teachers identify the student and teacher role in learning • Teachers consider the way in which students learn to inform their teaching

1. Teachers described how they would plan and implement ideas

Teachers described how they would prepare themselves for teaching classes in the future as they were still completing their pre-service education. They identified several teaching approaches that were adopted during their weekly workshops that they felt would be effective to incorporate into their classroom practice. Classroom management consumed a large proportion of teacher discussion. They considered how class length, seating plans and available resources were all factors that had the potential to support or cause classroom management issues. In most cases when teachers described effective teaching strategies, they also suggested adaptations that they would implement to suit their own classroom practice. Adaptations included time for student feedback, adding prompts for students, or giving clear instructions. The teachers also identified aspects of assessment throughout the module and how they could be implemented in the classroom such as, increasing the weighting of continuous assessment, using pause time to assess student understanding during a class and including higher order questions. In some cases, teachers spoke about how their own experience of continuous assessment of the module was helpful for them to experience as learners. Teachers discussed the time and space needed to consider implementing inquiry based learning and linking to the curriculum in their planning.

> *"I feel that you really have to plan and prepare when and how you are going to introduce these simple examples to your lessons and if they will really benefit the students learning."* - *Teacher 3*

2. Teachers critically analysed teaching approaches

Within the second theme, teachers critical thinking skills were very evident as they critiqued the lecturer's approach to teaching topics in physics and discussed aspects of the workshops they would have reservations using in their own classroom practice such as starting an activity without outlining the expected outcomes or teaching using an anchoring idea. In most cases the reservations that teachers had to adopting workshop ideas, were a result of their lack of experience of teaching. They specifically spoke about inquiry based learning and group work and how these strategies might look if they were to adopt these approaches (teacher as the facilitator of learning, multiple ways of solving a problem, allowing students autonomy of their learning). It was evident, from this

theme, that teachers had mostly experienced inquiry based learning as students an dthey had not been exposed to planning for IBL as teachers.They described how they felt when they participated in IBL activities and identified their concerns carrying out some of the tasks as the learner (not knowing the outcome, not knowing the answer to questions asked).These experiences made teachers feel that they would not be equipped to useIBL strategies in the classroom,

> *"The discussion on IBL did help clarify a little about what students should be doing during this type of lesson, however I'm still struggling to see how to set up an IBL lesson and how to execute it in a class." – Teacher 2*

3. Teachers described instances where they lacked the overall pedagogical content knowledge for a task

The third theme reflected teachers' motivation to improve their pedagogical content knowledge. Teachers discussed their concerns around learning the content within the Leaving Cert Physics curriculum and the work they needed to put in to ensure they were prepared to teach it. The biggest area teachers felt they could improve on practicing the mandatory experiments themselves. Most of the teachers reported that they had not carried out these experiments since their own school education and were surprised that they had forgotten so much of the detail in them. Teachers acknowledged that they lacked confidence teaching a topic and identified gaps in their content knowledge that may contribute to this such as, using moments of a force to calculate mass of a meter stick and misconceptions associated with light. Overall teachers felt that they needed more experience to feel competent as a physics teacher in using different types of teaching approaches (mostly IBL and using rubrics to guide learning). Teachers were also still unsure of the depth of knowledge that they needed as teachers. They described trying to decipher whether information was relevant (or not) and being surprised by the amount of background knowledge a teacher might need to teach a topic effectively. *"This made me wonder if it was me who should be able to understand the relevance of the information or if the information was not relevant." – Teacher 6*

4. Teachers outlined specific learning gained from the module

Teachers' experience of the learning gained from their weekly workshops in the module was reflected in the fourth theme. Communication and collaboration in group activities was often discussed by teachers. Teachers attributed good communication and understanding of how group members worked to ensure effective collaboration. Teachers also evaluated their own performance in presentations and in situations where they had to teach their peers. Often teachers discussed the thinking behind activities or motivation for choosing particular activities e.g., cross curricular relevance, reiterating science concepts (overlapping learning outcomes), promoting communication of scientific ideas. Teachers did not simply describe the activities, they analysed their use in the classroom, specific changes that could be made to adapt the practices and also tried to explain the approach the lecturer took in introducing them. Teachers recognised the importance of promoting physics as a subject due to the low uptake of the subject at Leaving Certificate level. They highlighted that the importance of embedding real life applications in lesson planning, creating awareness of careers and jobs in the field and drawing attention to how unconscious biases affect our decision making when it comes to choosing subjects. To do this, they suggested strategies such as creating cross-curricular links with Physics, promoting physics careers, directing students to informative and engaging websites, using specific praise in the physics classroom (enhance student self-efficacy in physics), measuring their own biases as teachers.

> *"I am very intrigued by unconscious bias. I would like to learn more about the topic in the future….I was happy to see the lesson reflection-tally sheet as I was confused at how this unconscious bias could be measured…The 'language' element was something I didn't fully understand and hope to explore more in depth in the future." – Teacher 6*

5. Teachers mentioned the supports in place to develop their own learning

In theme five, teachers discussed ways in which their own learning was supported throughout the semester. Learning from their peers was a strong focus of teachers' reflective journals. Teachers discussed their learning from working with peers, engaging in peer assessment tasks and general group discussions during lectures. Teachers' own learning experience of when they were in school was used to connect concepts within the workshops. Teachers found it helpful to synthesize their past experiences as learners into the experiences of their prospective students. For example, one teacher described their lack of interest in doing homework in school and how they might create more meaningful homework exercises. Teachers also regularly drew on previous teaching experience to support their learning. These experiences identified challenges teachers encountered in previous school placements (students energy levels in particular classes at particular times of the day) and also highlighted approaches that worked well for them (keeping a routine so that students had expectations for the class). Support from lecturers and other mentors was also discussed in this theme. Overall teachers reported seeking advice from their lecturer or cooperating teacher about issues such as troublesome students, looking for clarity on subject content or accessing resources for topics they found difficult to teach. There were some instances where teachers felt uncomfortable asking for help or receiving constructive criticism, however this teacher describes an instance when a lecturer noticed errors in one of the module resources (even their mentors make mistakes) it took the pressure off them to create perfect resources,

> *"This was refreshing because [the facilitator] could even point out small flaws in the worksheets…so it made me feel a little better about the criticism I get….I feel like a big part of it [feeling overwhelmed] was that I constantly was trying to avoid that criticism or constantly expecting it." – Teacher 5*

6. Teachers discussed student learning in their reflections of teaching

Student learning was the central focus of this theme as teachers described how their experience as a learner gave them a student perspective on some of the teaching approaches. Teachers explained how their experiences from the workshops helped them realise how students may feel being introduced to a new approach to learning, difficult topic or confusing instructions from the teacher. Teachers frequently discussed the needs of their students and took into consideration the way that students learn to inform their teaching. Using appropriate resources for students with special learning needs, differentiating resources for mixed-ability classes, and being sensitive to students that may be affected by subject content due to personal experience, were all aspects that teachers discussed in their reflections. Teachers also identified the student role in learning and the necessary skills that students need for their learning. Teachers discussed balancing the teacher and student role so that students were active in their learning and took control of the exploration resulting in deeper engagement with the concepts. Teachers discussed how they explored promoting students' individual participation in a group, how to enhance student autonomy of learning and how to encourage students to "think like a scientist". Teachers also highlighted the diversity of learning approaches among their students and the multitude of ways in which a student may complete a task.

> "*At the end of the class we looked at how other people think and who works well with each other. The class was very divided, and it shows how everyone is different and this would also affect group work." – Teacher 4*

Summary of Themes

These themes, presented in Table 5.2, reflect teachers' experiences throughout the first semester of their final year of pre-service teaching. Teachers were largely focussed on planning and implementing new ideas into the classroom practice for their next school placement. Teachers identified their main source of learning was their own reflections and analysis of teaching approaches they had experienced as a learner during the workshops in the Physics Methodologies module. There was also evidence to suggest that teachers lacked pedagogical content knowledge leading to their lack of confidence teaching that concept in the classroom. However, the teachers observed the learning they had gained from workshops had provided them with skills needed to evaluate their own learning and enable them to work independently on improving their pedagogical content knowledge while they gained teaching experience. Teachers highlighted the supports that they felt had enhanced their learning, which included peers, lecturers and prior teaching and learning experiences. Teachers considered how students learn, their specific needs and the student role in learning which were all influenced by their own experience as a learner during the module.

5.4.2 Year One - Semester 2

Teachers were interviewed at the end of Semester Two when they had just completed their 14 weeks school placement block. After their fourth week of school placement, the whole country entered a nationwide lockdown (due to the Covid-19 pandemic) and all teachers across all schools in Ireland had to move to online remote teaching approaches. The interviews with the teachers were thematically analysed and four themes were generated below and within each theme, categories described the main ideas discussed by teachers (See Table 5.3).

Table 5.3: Summary of Themes and Categories from Year One – Semester 2

Theme	Category
1. Teachers describe the impact of support on their professional learning ***(183 codes)***	• Teachers describe how they were supported through working with other teachers • Teachers describe impact of school culture on support • Teachers describe the relevance of pre-service education to their school placement experience • Teachers discuss their evolution as a teacher (from student to teacher)
2. Teachers describe how their pedagogical content knowledge impacted their school placement experience ***(159 codes)***	• Teachers discuss their experiences of planning and implementing new teaching approaches • Teachers discuss their experience of assessing student learning • Teachers identify teaching moments where they lacked content knowledge • Teachers identify some of the barriers to science e.g., access to resources
3. Teachers highlighted that classroom management was the focus of their planning for teaching and learning ***(69 codes)***	• Teachers describe the impact COVID had on classroom management • Teachers suggested strategies that they tried to manage behaviour issues • Teachers describe the variety of issues that presented as a result of lack of classroom management
4. Teachers discussed the student and teacher role in the classroom ***(44 codes)***	• Teachers described student and teacher role in learning • Teachers identified factors that affected student motivation in the class • Teachers acknowledged that their expectations of students did not match student outcomes

1. Teachers describe the impact of support on their professional learning

The first theme in this data set reflected different aspects of support that teachers drew on for their own learning such as: cooperating teachers, other novice teachers, peers, students and their pre-service teacher education. It was interesting here that although each teacher had two assigned tutors from the university (tutors were assigned to support PSTs while on school placement but also had the role of assessing their performance), they did not see this as a support that they utilised. There was little evidence in this theme to suggest that teachers leaned on their peers for support and this gap in the data suggests that teachers were either trying to problem solve by themselves or use supports within their individual school context. Teachers experienced varying degrees of support from their cooperating teachers (this was the teacher whose classes the PST had been assigned and was teaching) depending on the school they attended. In most cases, teachers described a very supportive environment where the cooperating teacher would regularly check in and discuss their planning and teaching approaches. However, the teachers also felt under pressure to conform to traditional teaching approaches in order to cover the curriculum or sequence specific activities according to the book as regularly instructed by the cooperating teacher. It was evident in this theme that teachers were beginning to notice the different aspects that make up the school culture as they found themselves familiarising themselves with the school. Teachers found that there was little induction for them to integrate into the school as they began their placement in the middle of the school year and were not involved in staff meetings. Teachers also noted that senior management (who accepted them on placement) and their cooperating teachers had not communicated in relation to their (the PSTs) arrival and in some cases did not have things such as keys for classrooms or specific classes assigned to the teachers which they found unsettling. *"There was no preparation or anything before the observation…Not with me but with their own deputy that they hadn't talked to them sooner before that. So, I kind of stood there saying "well I'm here now". – Teacher 1*

Within this first theme it was also evident that teachers were still growing as professionals as they discussed their experiences both from a learner and a teacher perspective (realising teachers have different styles of teaching or thinking of questions students will ask when planning lessons). Teachers described how they were making conscious efforts to reflect on their practice to

take note of their learning. Teachers felt that their pre-service education was somewhat theoretical knowledge when they went on placement and they needed further support on the practicalities of implementing strategies. Some teachers reported new learning experiences such as teaching new subjects, teaching in a disadvantaged school and teaching high achieving students. Other teachers felt an extra responsibility of both teaching students and appearing competent as a teacher (practice shock). *"Em, I think I'm worried about being the teachers that students are like "oh he was really, he couldn't control the class…he didn't know what he was talking about". That's the fear though.." – Teacher 2*

2. Teachers describe how their pedagogical content knowledge impacted their school placement experience

The second theme highlighted both teachers' experience of implementing new teaching approaches but also their concerns regarding their own lack of content and curriculum knowledge. Teachers discussed the access that they had to resources on school placement and the challenges they faced selecting resources and moving away from the textbook as the main resource when planning. Teachers noted how they felt self-conscious about their own content knowledge when teaching senior cycle students. Teachers found it difficult to think in terms of the questions that students would ask that seemed simple but they had not prepared answers for such as, "how would you explain that the air on the weighing scales isn't being included?". Teachers noticed that the main barrier that students faced when it came to any of the science subjects was understanding abstract concepts. When asked to reflect on whether this was domain specific, teachers said they hadn't really thought about it at the time. The teachers in this cohort also reported extensive experience of implementing new teaching approaches into their classroom practice. They discussed adapting teaching approaches by scaffolding learning, using student prior knowledge to inform approaches and build routines within their classrooms. The teachers expressed the difficulty they experienced assessing all aspects of student learning (student understanding, motivation and participation), assigning appropriate homework, using effective strategies to formatively assess and in some cases being faced with the challenge of assigning accredited grades.

> *"Em, yeah I think as well like, understanding em like I suppose work to give for homework, because I often gave students just the like the little*

questions in the book for homework because it like, I literally was like, right I've been thrown in the deep end here." – Teacher 5

3. Teachers highlighted that classroom management was the focus of their planning for teaching and learning

The third theme had a strong focus on teachers' classroom management. Here, the impact of COVID-19 was very evident as teachers discussed moving to online learning environments and experiencing students' disengagement as a result. Teachers had completed four weeks of their placement block in schools and then moved unexpectedly to online teaching. The issues teachers reported when teaching through an online platform ranged from varying teaching strategies, engaging students meaningfully and assessing student learning. Linked to this, teachers realised that face-to-face teaching highlighted the importance of student-teacher relationships and strategies to enhance classroom management. Teachers also reported classroom management issues in the face-to-face teaching setting. Some of the major contributors to teachers' classroom management issues reported by teachers were related to lack of contact with the students (team teaching – teachers had less contact hours with students as the cooperating teachers took over some classes) and lack of student interest in the subject. Most of these factors led to behavioural issues within the class which the teachers found difficult to manage.

"Em, learning difficulties but behavioural difficulties like as well in class like they were very loud and like constant like not listening to instruction not, like even if you were standing right beside them, they'd be shouting across the classroom and you'd be like "stop, stop, stop"." – Teacher 2

4. Teachers discussed the student and teacher role in the classroom

The last theme generated from teacher interviews centered around teacher's acknowledgement of the student role in learning. Teachers were beginning to notice their role as facilitator of student learning – they discussed this theme in terms of engaging students in the learning, harnessing student understanding and identifying factors that motivated students to learn. It was evident that teachers were beginning to centre their planning around these aspects of teaching when they discussed thinking of ways to build students' confidence and teach abstract concepts in an accessible way for students to understand. Teachers also realised

that they often overestimated the academic ability or level of understanding that their students had and allowing student input into their own learning helped to balance this discrepancy. Finally, teachers showed a real empathy for students who were having difficulty with the subject as they bring their own experiences of learning to their teaching.

> *"I think my best quality is that I'm learning alongside them at the same time in a way. That whenever that have difficulties that I might have had the same difficulties that I ran into just a week previous or something. But em, so I can kinda understand more where they're coming from," – Teacher 6*

5.4.3 Year Two – Week 1

In the first week that novice teachers started in their new schools, as newly qualified teachers (NQTs), they were asked to complete an open survey (the beginning of Year Two of the thesis study, See Figure 3.3). Teachers were requested to reflect on their expectations of the year ahead; what they were excited about; what they were concerned about; challenges that they expected and resolutions for the year to come (See Appendix E). Their responses were thematically analysed and the findings from this data were embedded into the subsequent Research Practice Partnership meetings with teachers for discussion. The themes generated at each stage were discussed with teachers and refined according to their comments in order to reflect the true meaning of teacher responses to the survey questions (See Section 3.3 for more details on data collection and analysis). There was one data point collected at the start of year two as a baseline for the RPP meetings (Week 1) and four data collection points during the RPP meetings (week 10, week 24, week 30, week 38).

This section reports the findings from teacher surveys collected in their first week of teaching in their new school. In some cases, teachers had begun teaching classes, in others they were involved in a week of planning and preparation with their colleagues. These themes are summarised in The themes generated in this first week of teachers' new careers reflected the anxieties they had and magnified their concerns after meeting their colleagues for the first time. It was evident that teachers were excited to start out in their new role and they expressed feeling that they had more autonomy. However, this also came hand in hand with further responsibilities and in some cases doubt about their career choice. One of the most predominant sources of concern for teachers was adjusting to teaching during the COVID-19 pandemic. In particular, teachers had to consider how they would perform experiments with the requirements of social distancing and sanitising of equipment. Catching up on course content missed during school closures while keeping students engaged in classes was frequently discussed by teachers. Teachers were also concerned that the restrictions in staff rooms and classrooms would inhibit their ability to build meaningful relationships with colleagues and students.

Table 5.4).

The themes generated in this first week of teachers' new careers reflected the anxieties they had and magnified their concerns after meeting their colleagues for the first time. It was evident that teachers were excited to start out in their new role and they expressed feeling that they had more autonomy. However, this also came hand in hand with further responsibilities and in some cases doubt about their career choice. One of the most predominant sources of concern for teachers was adjusting to teaching during the COVID-19 pandemic. In particular, teachers had to consider how they would perform experiments with the requirements of social distancing and sanitising of equipment. Catching up on course content missed during school closures while keeping students engaged in classes was frequently discussed by teachers. Teachers were also concerned that the restrictions in staff rooms and classrooms would inhibit their ability to build meaningful relationships with colleagues and students.

Table 5.4: Summary of Themes from Year Two - Week 1

Week 1 - Themes	Participant Quote
Teachers describe how they feel they are adjusting to being a "fully" newly qualified teacher	*"[Excited about] Having my own class for the first time and being able to teach the course my way" – Teacher 2* *"[Concerned about] That my abilities are up to scratch and that I am not really that good of a teacher." – Teacher 3*
Teachers discuss the new challenge of teaching during a pandemic	*"I am also concerned about how my teaching will have to change because of the covid restrictions and I am worried the classes could get boring with less interactive classes." – Teacher 4*
Teachers do not yet feel competent with their level of pedagogical content knowledge	*"I feel there is pressure to provide the students with the best possible lessons and content depth, this will be challenging to achieve as I have a full timetable and to dedicate large allotments of time to improving my own understanding may deem challenging to achieve in the times available." – Teacher 6*
Teachers discuss their philosophy of teaching and motivation for the profession	*"I want people [students] to be aware of how wonderful their subject is. I believe the best way to do this is to lead a class on a journey where they can develop a love of science and maths the way I did - through asking questions." – Teacher 5*
Teachers describe their desire to belong in the teaching community	*"I am looking forward to building good relationships with my new colleagues, getting the chance to work with fellow minded people." – Teacher 1*

Teachers pedagogical content knowledge was a persistent theme in the responses, as teachers described that they felt they still lacked competence in planning and organisation, content knowledge in specific areas (not identified), and selecting teaching approaches that were effective at engaging students. However, it was clear to see that teachers were beginning to refine their philosophy of teaching as they discussed designing lessons to meet the needs of students, building student-teacher relationships, encouraging a passion for science and adapting teaching resources to be relevant to students' background. Lastly, teachers wanted to belong within their school community which included colleagues, students and parents.

5.4.4 Year Two - Week 10

After ten weeks of teaching, the participants (teachers) met as part of a Research Practice Partnership (RPP) with two science educators (see Section 3.4.2 for detail). Again, teachers participated in an open-response online survey targeting the same areas used in week 1. The themes generated are summarised in Table 5.5. The RPP then focussed on establishing group norms, identifying problems of practice (from the survey – previous themes (The themes generated in this first week of teachers' new careers reflected the anxieties they had and magnified their concerns after meeting their colleagues for the first time. It was evident that teachers were excited to start out in their new role and they expressed feeling that they had more autonomy. However, this also came hand in hand with further responsibilities and in some cases doubt about their career choice. One of the most predominant sources of concern for teachers was adjusting to teaching during the COVID-19 pandemic. In particular, teachers had to consider how they would perform experiments with the requirements of social distancing and sanitising of equipment. Catching up on course content missed during school closures while keeping students engaged in classes was frequently discussed by teachers. Teachers were also concerned that the restrictions in staff rooms and classrooms would inhibit their ability to build meaningful relationships with colleagues and students.

Table 5.4) were presented to the teachers), introducing teachers to relevant literature, and beginning to formulate research questions and plans for inquiring

into their own practice (See Table 3.13). At this time teachers were becoming accustomed to face-to-face teaching with restrictions such as social distancing, face coverings, no group work and limited investigations using physical equipment.

Table 5.5: Summary of Themes from Year Two - Week 10

Week 10 (RPP 1) - Themes	Participant Quote
Balancing tensions between new information, roles, responsibilities and mistakes	*"I know that teachers will make many mistakes over the years and that each time they make a mistake they will learn from it so I am looking forward to gaining more experience of what works and what doesn't work in order to help with my teaching in the future." – Teacher 1*
Impact of COVID-19 on teachers' experience of teaching	*"I'm concerned that I am not experiencing a 'real' NQT year this year as Covid has put so many restrictions in place. e.g., No Extracurricular, No practicals" – Teacher 6*
Teachers measure their success through student achievement	*"I'm concerned that my students won't do well… I want to increase students' results." – Teacher 4*
Teachers are focussed on building meaningful relationships	*"Excited about the respectful relationships that I have the opportunity to build with the students for the year." – Teacher 5*
Teachers are developing their knowledge of the curriculum and resources	*"I also want to make better resources [linked to curriculum outcomes] that target each students' individual strengths and weaknesses." – Teacher 3*

Teachers discussed feeling overwhelmed with new information as they took on new roles and responsibilities as newly qualified teachers (practice shock – see discussion for further elaboration). Teachers described making mistakes and using them as learning experiences to inform their teaching practice. Balancing increased workloads, effective time management, maintaining a work-life balance and engaging in professional learning opportunities were just some of the tensions that teachers discussed. The COVID-19 pandemic played a major role in teachers' experience in their first year out. Teachers described aspects such as engaging students in learning, adapting teaching strategies from face-to-face to online and back to face-to-face, missing out on extra-curricular school activities and absence of practical components of lessons were all impacted by the restrictions imposed.

It was evident that teachers were constantly assessing their own progress and improvement as teachers. Tracking student achievement was used as a measure of teachers' success as they discussed whether their students did well in tests or were prepared for high stakes exams. Throughout the ten weeks, teachers were still prioritising building meaningful relationships with students and teachers as a goal they wanted to work towards. At this point they did not appear to have yet integrated into the school community as much as they would have liked. Finally, it was evident that teachers were developing a more in-depth knowledge for the curriculum (identifying gaps in their teaching) and attempting to tailor their resources to the needs of their students.

5.4.5 Year Two - Week 24

The second RPP meeting took place during week 24 of year two. Teachers completed an open survey at the start of the meeting to track their experiences at this point in time and to reflect on their journey from the previous meeting (previous themes were presented to the teachers). This RPP meeting was focussed on balancing the partner roles and teachers as well as researchers were invited to share useful tools/strategies/resources that they had used in their practice. Findings from a COVID 19 study were presented by the researchers in this meeting and partners worked together on further progressing an action plan to inquire into their practice. Teachers were now teaching in a remote setting using online forums due to the worsening COVID 19 pandemic. Details of the themes are summarised in Table 5.6.

Table 5.6: Summary of Themes from Year Two - Week 24

Week 24 (RPP 2) Themes	Participant Quotes
Planning for reintroducing students to face to face learning	*"Learning about the different ways and methods students like to learn now post-lockdown" – Teacher 3*
Teachers experience burnout from increased workload	*"Keeping up with my experienced teachers' pace." – Teacher 1*
Enhancing professional learning through networking	*"I'm excited about learning about what everyone else has been using as online teaching is new to me." – Teacher 4*
Lack of teacher confidence assessing students	*"I am weary of the lack of transparency given with the LC. I am not sure how to approach calculated grades if they are implemented." – Teacher 6*

Teachers discussed the return to face-to-face teaching within the first theme, expressing their concerns about building relationships with students, tracking student progress and differentiating student learning within COVID-19 restrictions. This return to in-person teaching also brought challenges with teaching strategies and planning. For example, teachers were now faced with catching up on practical aspects of the curriculum, changing classroom norms (removing group work, social distancing) and supporting students with the change back to face-to-face teaching. A second theme reflected teachers experiencing burnout from the increased workload at this time of year. Teachers described the difficulty they had balancing the expectations as a newly qualified teacher as they felt obligated to continue improving skills, keep pace (with colleagues) teach the curriculum, secure future jobs and establish a reputation among their colleagues.

The third theme generated from teacher responses was related to teacher professional learning. However, in this data set it was clear that teachers were focussed on networking with other teachers to learn from their experiences. They discussed sharing experiences in order to learn from their peers to improve their content knowledge, knowledge of differentiation and hear of other in-class experiences. Finally, teachers discussed their lack of confidence in assessing students, particularly when it came to assigning accredited grades to Leaving Certificate candidates in place of results from high stakes exams. Teachers also discussed keeping “on top of” weekly continuous assessments as part of their workload.

5.4.6 Year Two - Week 30

The third RPP meeting took place in week 30 of Year 2 of the study. Teachers completed open-response questions in an online survey at the beginning of the meeting and discussed the findings from the previous meeting. This RPP meeting focussed on addressing two problems of practice that teachers had identified in the previous meeting (assessment and differentiation). This meeting also focussed strongly on learning from each other's practice and linking literature to practice. During this time teachers had recently returned to face-to-face teaching and were negotiating social distancing guidelines and face coverings in the lab space as was evident from the themes (See Table 5.7).

Table 5.7: Summary of Themes from Year Two - Week 30

Week 30 (RPP 3) Themes	Participant Quotes
Teachers take stock of their experiences and begin to think about future prospects	*"I'm excited about having a full year teaching experience in both Physics and OL Maths….I'm concerned about job security next year. I've been told about opportunities in the school but I'm still nervous until it's concrete. – Teacher 6*
Teachers focus on student wellbeing and learning	*"Getting students back into a routine after being away from school for so long." – Teacher 3*
Teachers discuss planning and implementing effective teaching practices	*"Continuously assessing every class on different areas" – Teacher 5*

It was evident that at this point in school year the teachers became focussed on their own journeys and future careers. The first theme highlighted teachers' synthesis of past experiences into future actions. For example, teachers discussed maintaining a work-life balance and managing their time and workload rather than getting overwhelmed by it. Teachers were excited to be coming to the end of their first year of teaching with new experiences but also acknowledged the responsibility that came with it. However, with this came an apprehension as teachers were unsure of their job security and whether they would be kept on as teachers in their current school.

The second theme outlined teachers' professional maturity in considering the holistic nature of student learning, fostering student-teacher relationships, attending to student wellbeing and enhancing students learning while preparing

students for high stakes exams. The third theme reflected teachers' planning and preparation of effective teaching practices centered around curriculum. Teachers were concerned with keeping pace with the experienced teachers in their department and designing equitable learning experiences for all learners.

5.4.7 Year Two - Week 38

The final RPP meeting took place 8 weeks after RPP3 in Week 38 of Year 2. Here, teachers were at the end of their school year and beginning to think of what comes next. This was evident in the themes detailed below (see Table 5.8). The RPP meeting involved teachers and researchers working together to analyse data from their classroom practice and present key learnings in a meaningful way. The situation regarding COVID restrictions had changed little, however teachers were still managing increased absenteeism from both students and teachers.

Table 5.8: Summary of Themes from Year Two - Week 38

Week 38 (RPP4) - Themes	Participant Quote
Teachers had mixed feelings having reached the end of their first school year	*"I am excited about finishing up the year and also about experiencing the final few fun days of school with students for the first time." – Teacher 1* *"[concerned about] getting students re-integrated into normal school life [full term of face-to-face]" – Teacher 2*
Teachers are resolute to improving their organisation skills for Planning	*"Do the work for school in school and not bring my work home with me all of the time. Try not to leave planning until the night before. Better organise myself and my resources." – Teacher 3*
Teachers are committed to enhancing their PCK	*"I hope to get a job with more Maths I will need to get more prepared for Maths [broaden content knowledge]." – Teacher 6*
Teachers are excited to bring their learning forward to the next year	*"I'm excited to start fresh out next year and take what I have learned this year and apply it." – Teacher 4*
Teachers are worried about job security and fitting into a new school environment	*"A challenge will be fitting in to a new school environment and also getting to know another set of students." – Teacher 1*

The themes generated in week 38 reflected a real sense of relief among teachers, a feeling of 'making it to the end'. Teachers described their excitement at reaching the end of the school year and having a full years' experience under their belt in the first theme. Teachers also discussed feeling excited to start a new

year. However, this came together with concerns such as, integrating students back to school life after the pandemic and whether there would still be disruptions from the pandemic on their return in September. A clear aspect of teacher reflections in this data set was their resolution to try and improve their organisational skills so that they would be more prepared for the year ahead and manage their work-life balance more efficiently.

Teachers were determined to enhance aspects of their pedagogical content knowledge such as broadening their content knowledge in Maths, improving teaching methodologies, focussing on differentiation techniques, and preparing for classroom management issues. One teacher also expressed their concern at having extra responsibilities of preparing content for exam year groups next year. Another theme generated by teacher data outlined teachers' eagerness to bring their learning experiences and mistakes forward and inform their future decisions in teaching. Finally, teachers' concern about job security was evident in half of the cohort as they were unsure if their current positions would be available the next year. They spoke about their worry of reinterviewing and starting "all over again" to fit into a new school environment.

5.5 SUMMARY OF FINDINGS

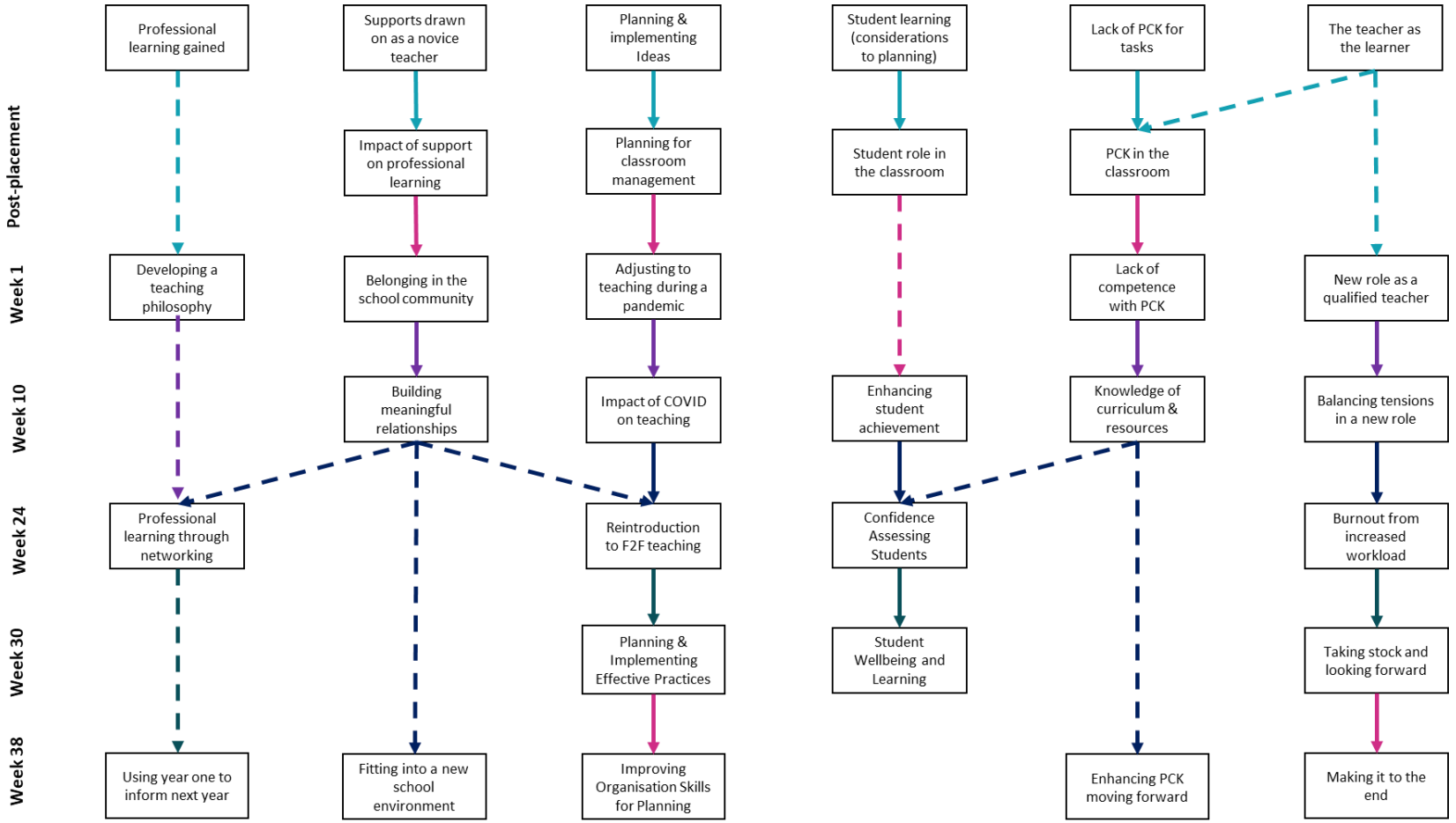
Theme mapping was applied to all the themes generated at each of these five data collection points in year two, in order to understand the teachers' experience moving from pre-service to in-service teaching. It was evident from the themes that were generated at each point with teachers that there were patterns between them (See Figure 5.3 - Theme Mapping Generated from Novice Teacher Data). The solid lines in this Figure (5.3) indicate the obvious presence of a theme from the previous data point. The dashed line indicates a break in the continuity of themes or the evolution of one theme into parts of other themes.

In some cases, there was a clear evolution of themes and shift in focus depending on the timing of the data collection. For example, initially teachers began to discuss their lack of pedagogical content knowledge and as time passed they moved to discuss how they could enhance their PCK. Similarly, planning and implementation was a consistent theme throughout the study but changed focus depending on the pressures at the time (e.g., classroom management, online teaching, face-to-face teaching) and then circled back to organisation and planning for the year to come. This was also evident with "support". Teachers identified the supports they leaned on and how support impacted their feeling of belonging and then circled back to fitting into a new school environment by the end of the year.

In other cases, the themes changed direction almost completely and either ceased to exist or transformed into a new or different theme. Professional learning was a broad thread that teachers highlighted at particular points during the study. However, it was not evident all of the time and each time it arose as a theme it presented differently (e.g., learning gained, developing a teaching philosophy, learning through networking and learning from experience). Student learning was also a thread that changed substantially throughout the study, as teachers moved from planning for student learning to assessing student learning and then student wellbeing. This theme seemed to cease existing at the end of the school year as teachers diverted attention back to their role as a teacher and the planning they had to do. Finally, a descriptive thread of the teacher's journey throughout the study was evident in their reflections. Teachers were initially experiencing becoming a teacher as a learner until they finished their school placement and entered a new role as a teacher. From this it was evident that teachers were

balancing all of the tensions that arose from this role change until they finally felt as though they had made it to the end showing their evolution as a professional.

Figure 5.3:Theme Mapping Generated from Novice Teacher Data

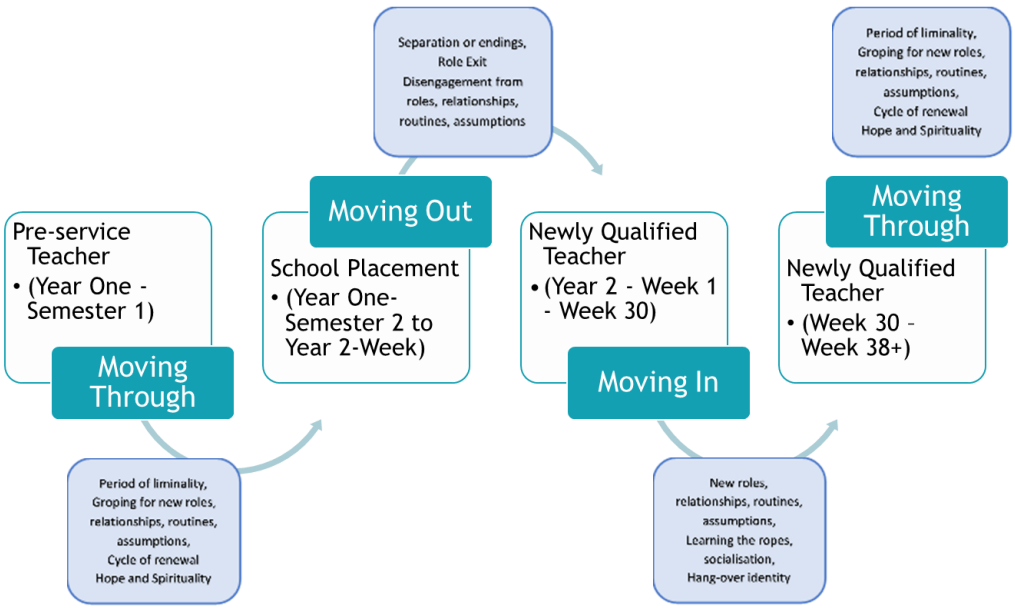


5.6 Discussion & Conclusions

Schlossberg's transition theory was applied in the data analysis to identify the stage of teachers' transition: moving in, moving through or moving out. Applying the first part of the transition model, *Approaching Transitions: Transition Identification and Transition Process*, the themes were mapped onto the indicators outlined (See Figure 5.4: Novice Teacher's Transition Identification). The pale blue boxes (in Figure 5.4) were the indicators related to the different transitions (e.g., period of liminality, groping for new roles, relationships, routines, assumptions, cycle of renewal, hope and spirituality period) taken directly from the theoretical framework. These indicators were then mapped onto the themes (in Figure 5.3) across the data set in order to identify the transition occurring.

Teachers' journeys from pre-service teacher to newly qualified teacher highlighted a "moving through" transition at the start of the study and teachers then began to "move out" towards the end of their school placement as they transition from learner to teacher. Teachers then began to "move into" a new transition at the end of school placement and experience this until sometime around week 30 and then began "moving through" that transition for the remainder of the year.

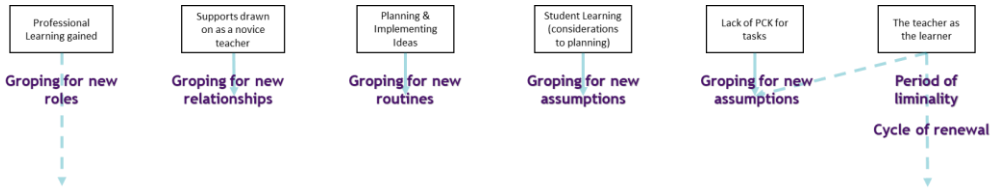
Figure 5.4: Novice Teacher's Transition Identification



5.6.1 Moving Through

The first transition was difficult to establish as it could not be seen how teachers approached their previous transition (where the starting point began e.g., had teachers "moved out" or were they "moving in" to a new transition). However, a change in themes was observed between data collected from teachers' last semester of structured lectures [reflective journals] to their school placement block [interviews] (which took place predominantly in school with some evening lectures in university) (see Figure 5.3). Figure 5.5 shows how the indicators related to the different transitions were mapped onto the themes in Figure 5.3 to identify what type of transition was occurring (See Figure 5.5).

Figure 5.5: Mapping of Schlossberg's Indicators onto Case Study A Themes (Moving Through)



At this stage, teachers were *moving through* a transition as they began ***looking for New Roles*** as practicing teachers (Nguyen, 2017). Here, teachers described the professional learning they had gained such as confidence teaching a particular topic, *"I am also now more comfortable with the topic of potential difference and after listening to everyone's lesson electricity does not scare me to teach anymore" – Teacher 4.* They also recognised other opportunities to improve their professional learning (reading literature), *"I do know myself that I don't read enough and could do more to improve my reading skills and speed and to improve my knowledge on different aspects of teaching." – Teacher 4*

Teachers described the ***New Relationships*** they would like to explore with such as connecting with teachers who were actively teaching the curriculum, "*I was very much looking forward to getting insight from people who have actually actively taught physics" – Teacher 1*. Within this transition the themes reflected that the teachers had reached a point where they could broadly identify many different aspects of being a teacher (planning lessons, student learning, pedagogical content knowledge) but this knowledge was also limited by their lack of classroom experience (implementing plans, catering for different learner types, knowledge of curriculum), *"I feel if another teacher was to follow the*

same lesson plan, it would create problems in the sense that teachers do things differently and classes require different learning needs" – Teacher 6. In some cases, teachers began projecting what experience they would expect to have and often this left them wondering if they were prepared to become teachers (lack of PCK). "*And another problem we had was coming up with the questions for IBL and predicting what the students may do. This is very hard when you have never thought the topic before." – Teacher 4 (**Groping for New Assumptions**).* Etkina (2010) describes a physics teacher preparation programme that embeds physics specific clinical practice. Here, PSTs engage in an "active process of knowledge construction" to enhance their PCK .through a cognitive apprenticeship (teaching that is scaffolded and supported by a coach) (Etkina, 2010b).

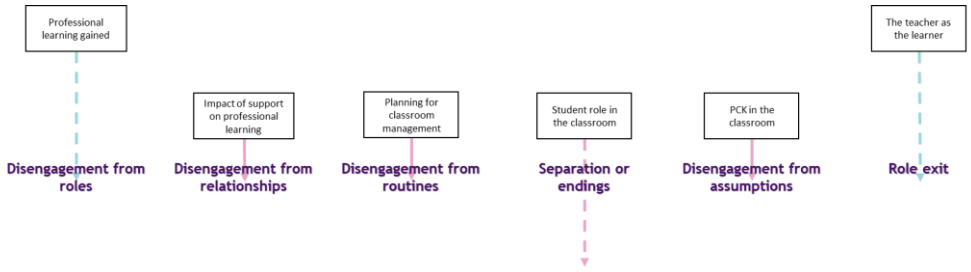
The most predominant aspect of identifying this transition was teachers' comments that aligned with a "***Period of Liminality***" and *"**Cycle of Renewal***" as outlined by Schlossberg (Goodman, Schlossberg and Anderson, 2006). It could be seen that the teachers were experiencing teaching as a learner, probably (could only be determined by collecting data earlier in their journey) throughout their university degree and were beginning to reach a point of knowledge saturation as a "learner" as they focussed more on challenges rather than solutions, *"Another challenge will be on how best to alter the class to suite any students with learning disabilities that may also be present – Teacher 2.* Throughout the duration of this study, it was observed that time and experience were needed for teachers to understand their role in the classroom. These lived experiences of novice teachers provided insights into some of the tensions that they must unravel as part of discovering their teacher identity. During their university modules in semester one, teachers highlighted their understanding of the student role as a consequence of their own learning as a learner. They focussed here on the learner experience and putting themselves in the shoes of the student. It was clear that teachers still felt, in part, a learner during their school placement as they describe their lack of PCK in both content areas (forces) and pedagogical approaches (IBL). This finding uses the teacher voice to highlight the gaps in PST professional knowledge and adds another perspective to the call for solutions to address this gap in pre-service teacher education (Gray, McDonald and Stroupe, 2022).

Findings from this study indicated that pre-service teachers would benefit from separate experiences to engage in inquiry as a learner and then to consider how to teach through inquiry. Inquiry based learning (IBL) was something that teachers struggled with throughout their journey as novice physics teachers. Initially teachers experienced IBL as a learner and participated in IBL activities that focussed mostly on investigating different levels of inquiry: open, guided and structured. Teachers discussed their discomfort at not having the outcome of an activity shared with them or formulating their own procedure for an investigation. It seemed that teachers' dual role (learner vs teacher) created a conflict between their learning and planning for teaching through IBL. This in itself is a transition (*moving through – moving out*) for pre-service teachers as up to this point they have been experiencing their university modules as learners and therefore requires explicit direction and transparent goals to support pre-service teachers at this stage of their professional development (Dillon, 2017). Pre-service teachers also had difficulty planning for IBL as their understanding of what IBL was, was disjointed (IBL had to happen in complete cycles that took several classes vs inquiry focussed on specific skills that could be integrated and scaffolded). Interestingly the literature highlights that STEM teaching and facilitating student-centered learning is a relatively new concept that adds another layer of complexity for novice teachers as they deal with moving away from traditional teaching methods, concerns about covering the curriculum and student exam performance (Keiler, 2018). Keiler (2018) highlights that often teachers can become a believer in student-centered learning without learning to implement it. McLoughlin and Sokolowska (2022) consider integrating practitioner inquiry (PI) (systematic studies of teachers' own practice) with inquiry based learning approaches. They propose that PI in the context of IBL can encourage teachers to conduct and reflect on their practice and inform future learning experiences for their students (McLoughlin and Sokolowska, 2022, p.218).

5.6.2 Moving Out

Teachers began to *move out* of this transition (moving through) by the end of their school placement (Semester 2) (See Figure 5.6). Teachers were ***exiting their role*** as the learner and beginning to think about aspects of teaching in the context of their teaching experiences. For example, rather than broadly considering planning and implementing ideas, teachers were now concerned about how to plan around classroom management and control issues related to behaviour. Professional learning was not a concern for teachers at this point as they juggled with the new roles and responsibilities that they were beginning to encounter.

Figure 5.6: Mapping of Schlossberg's Indicators onto Case Study A Themes (Moving Out)



Teachers began to move away ***(disengage)*** from the supportive ***relationships*** of their classmates as they felt their peers were also under the same pressure and the teachers didn't want to add to this, *"Not really [use peers as support], cause em, I suppose I didn't want to dive in because we were all sorta up in the air a bit," – Teacher 3*. Instead, teachers discussed how the support from their cooperating teachers influenced their experience of classroom practice, *"My coop teacher was really good, he sorta, every time I went to him with an issue he was like "oh you can try this," – Teacher 3*

There were many points during Semester One that teachers exhibited critical reflection about teaching approaches. During their methodologies module they discussed effective teaching approaches, different adaptations they could make to teaching approaches, suitability of teaching approaches and even analysed the thinking (lecturer's thinking) for choosing to teach a class in a particular way (See themes in Year One, Semester One). McLean & Price (2019) raise a similar interesting finding with pre-service tutors as they exhibit idealistic views based on their own learning experiences in the early stages of their training. This depth of reflection then seemed to become less, the more teachers integrated into the

school community during their school placement and they ***disengaged*** from their idealistic ***routines*** when planning for "theoretical classes", *"..so I suppose I had to take a step back in the level I was giving them and go through things, like give more time to things that I thought would be done in ten minutes." – Teacher 4* Evidence from teacher interviews after school placement also highlighted that teachers' attention shifted instead to planning for classroom management (Britt, 1997) however, teachers still remained adventurous in trying new approaches to see what worked effectively. Again, this aligns with the literature as teachers are faced with the realities of teaching as their new point of reference (McLean and Price, 2019). Findings from this study suggest that teachers require a space to reflect on their practice and grow professionally (Ellis, Alonzo and Nguyen, 2020).

After their school placement teachers again discussed the teacher and student role in the classroom. However, it was evident that teachers' view of what they thought the teacher's role was in the classroom began to shift as a result of the experience they were gaining. This finding indicated a "***separation or ending***" in teacher beliefs from their immersion in university based modules. Teachers were now considering how their role (as a teacher) in the classroom could facilitate student learning and how they could plan around engaging students in meaningful learning. They were beginning to discuss balancing teacher and student roles so that students could be more active in their learning (*"Now they were good with inquiry based and I'm not going to tell you the answer you's have to go find the answer and stuff like that," - Teacher 1*), but it was difficult to say at this point if teachers were implementing this approach into their role as a teacher during their school placement. School placement gave teachers a space to reflect on their teaching strategies and bring their own experiences into practice. Ultimately learning to teach is a complex issue and is reported so in much of the literature (Bullock, 2017; Ellis, Alonzo and Nguyen, 2020). Bullock (2017) describes findings from a self-study in which a student teacher is provided with extended experiences of teaching the same classes with no feedback early on in order to form relationships and focus on the students versus an experience of teaching "learned in the messiness of unexpected experiences" (p.188). Here, he refers to the *"Freedom with Foundation"* for teachers to begin to develop their teacher identity (what their role is in the classroom) and deal

with the dynamic aspects of teaching be it; controlled and well thought out, or sudden and dealing with complex situations (Bullock, 2017).

Rather than being concerned about their own pedagogical content knowledge teachers were taking stock of the knowledge and experience needed to "*get through*" teaching (implementing restorative practice and keeping track of student progress). *"I was sitting at the computer for quite a while trying to fully get my head around what needed to be taught and how I was going to teach it that sort of thing," - Teacher 1*. This can also be seen clearly as one teacher describes their experience with having to adapt teaching strategies and planning to the changing circumstances that impeded on transition year attendance (***changing assumptions***).

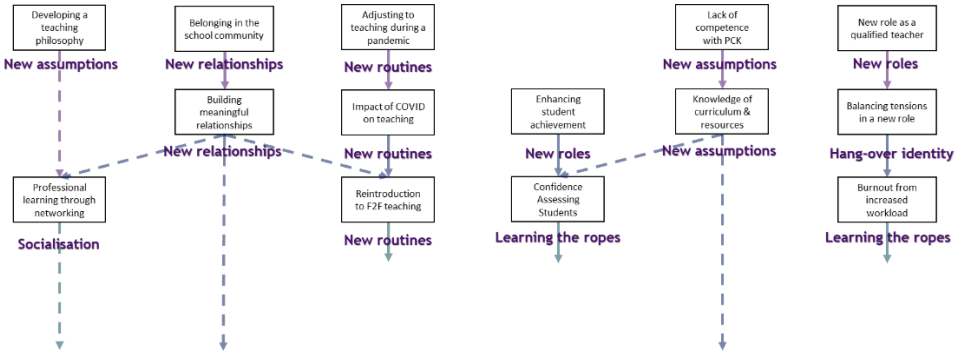
> *"I was given a transition year group and told just do whatever you want with them. And so, I started doing physics and….. I suppose you didn't know what students, there could be a day when only two students come to class or a day where there could be twenty. So, I was really trying to do it [plan each lesson] as something that didn't have to be continuous." – Teacher 5*

Research suggests that methods for developing content competencies are needed in teacher preparation (Buabeng, Conner and Winter, 2015).

5.6.3 Moving In (But still Moving Out)

As the teachers started their first week as a newly qualified teacher there was a clear shift to new roles, relationships, routines and assumptions indicating an entry into a new transition (*moving in*). This transition progressed from week 1 through to week 30, at the start of the third Research Practice Partnership meeting.

Figure 5.7: Mapping of Schlossberg's Indicators onto Case Study A Themes (Moving In)



Teachers' professional learning was evolving from identifying what they had learned to reflecting on how they could continuously develop their knowledge as novices, through their philosophy of teaching and networking with others (***socialisation***). *"[I hope to] continue having learning discussions with other teachers of all subjects on tips for differentiation" – Teacher 5.* Pietsch and Williamson (2010) report that newly qualified teachers, in their study, spent the first 6 months of their first year of teaching integrating into the school community and developing their PCK. It was not until the end of the first year that teachers looked beyond their own classroom practice to how the wider school community and socialisation could be incorporated into practice (Pietsch and Williamson, 2010, p.336).

During this *moving in* transition teachers began to notice their belonging in the school community and the relationships they had with their colleagues. It was evident that they were beginning to build ***new and meaningful relationships*** with colleagues and students. "*I am looking forward to building good relationships with my new colleagues, getting the chance to work with like-minded people" – Teacher 1.* Supports in the context of pre-service teacher education was also discussed by teachers. During their school placement and first year of teaching, teachers felt that their experience from university was quite

theoretical and there was less focus on the difficulties or the implementation of IBL. Lack of time, resources to prepare for IBL, managing group work, curriculum delivery, assessment and accountability are reported to be the constraints that practicing science teachers experience adopting IBL approaches (Romero-Ariza *et al.,* 2020). Buabeng, Conner and Winter (2015) investigate Finnish teachers' perceptions of preparedness after their initial teacher education. They found that more than a quarter of the cohort of teachers felt that they were unprepared in the use of inquiry-based learning and assessment of students' learning when they began to teach. Allowing space and time for teachers to consider the implications of IBL on student learning, relevance to the curriculum and development of instructional tasks (Sikko, Lyngved and Pepin, 2012) may be a helpful solution to support novice teachers (and their colleagues) in the classroom to ensure IBL practices are being carried forward from their pre-service teacher training.

Adjusting to new norms that resulted from teaching through a pandemic was a large focus of teachers planning and implementation as they moved between online teaching and face-to-face teaching. These ***new routines*** were a predominant focus of teachers' reflections in each of the RPP meetings. Teachers were continuously adapting to online and face-to-face teaching according to changing government guidelines, and this in turn impacted the routines they implemented in the classroom, *"I'm concerned about the transition from online learning to school…how to deal with students who have fallen behind," – Teacher 4.* These adjustments also led to more responsibility on teachers to implement continuous based assessments and accredited grades for their students, adding yet another new role to their experience as a novice (high stakes exam assessor).

Throughout this phase of ***new assumptions***, it could be seen that teachers were assessing and reassessing their knowledge for teaching as they balanced the tensions in their new role and managed burnout from an increased workload. They experienced a lack of competence when compared to their fellow experienced teachers. *"[Excited] To grow both my skills and my reputation. [Challenged by] Keeping up with my experienced teacher's pace." – Teacher 1* As time progressed teachers became concerned with their knowledge of curriculum and resources. At times, they reported being unsure if they were

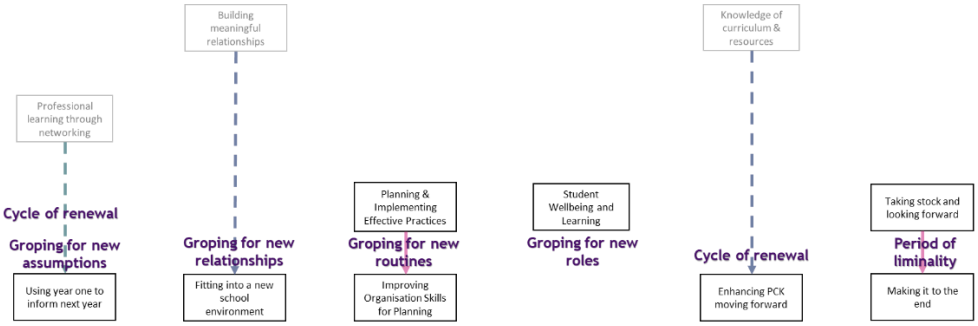
considering the depth of treatment of the curriculum correctly and whether their pacing would ensure the course would be complete in time, *"I'm concerned on occasion that I am missing elements of content within topics" – Teacher 6*. Pietsch and Williamson (2012) suggest that novice teachers should be encouraged to collaborate with experienced colleagues at "point-of-need" to develop novices professional identity and feel like they belong within the school community. Tammets, Pata and Eisenschmidt (2019) highlight the value of fostering reflection for novice teachers post-university in order to highlight learning and knowledge building practices that could be supported in the wider school community (Tammets, Pata and Eisenschmidt, 2019).

Once teachers had integrated into their new school, reflection on practice and critical thinking about teaching approaches were overshadowed by increased workload and teaching during a pandemic. Here, teachers were experiencing, ***new roles*** (responsibility of a qualified teacher), ***hang-over identity*** (still a learner) and ***learning the ropes*** (experiencing burn-out). It was evident here, that teachers were still moving out of their previous transition as they had to become accustomed to being accountable for their students and were no longer shielded by their cooperating teachers. 'Practice shock' is the term given to the period of time that beginning teachers experience in their first job, that is much different than their expectations of pre-service teacher education and is focussed on survival in the classroom rather than their ideals of teaching (Stokking *et al.*, 2003, p.340). Stokking *et al.*, (2003) suggest that this phenomenon can be mitigated by creating a more gradual progression from pre-service teacher to newly qualified teacher (supported by a mentor within the school, encourage reflection, formulate their own learning goals).

5.6.4 Moving Through

After data was collected from week 30, there was a notable shift in teachers' outlook on their experiences. It could be said that teachers were entering a *moving through* transition as they began taking stock of their experiences so far and were looking forward to what was coming next. It was evident that the end of the school year had come with a sense of accomplishment for these teachers.

Figure 5.8: Mapping of Schlossberg's Indicators onto Case Study A Themes (Moving Through Again)



It was obvious from the themes that teachers were returning full circle as Hudson (1999) describes the ***cycle of renewal*** (*getting ready,* to *launching,* and *plateauing,* to *sorting things out)* (cited in Goodman *et al*., 2006)). The themes identified in this study suggest that teachers are now using their past experiences to inform their approach to the next year, *"I'm excited to start fresh out next year and take what I have learned this year and apply it" – Teacher 4.* The themes reflected teachers' future ambitions of enhancing their PCK, learning from the year that had passed and improving their planning and organisation skills, *"Using the time off in summer to further improve my teaching practices (CPD workshops, creating resources etc.)" – Teacher 3.* However, teachers were also concerned about having to move school and fit into a new school environment (***new relationships***) or had to deal with the uncertainty of being kept on in their current school, *"A challenge will be fitting in to a new school environment and also getting to know another set of students" – Teacher 1*. This suggests that they are ***groping for new relationships*** and perhaps considering the relationships that may be maintained to support them into the next school year, as is similarly reported by researchers who suggest these relationships are critical to a teachers' professional growth (Wilson, Schweingruber and Nielsen, 2016, p.178)

Teachers outlined the ***new routines*** that they would like to focus on moving forward such as planning and implementing effective practices and improving

their organisation skills, *"I'm committed to keeping my drive and students results more organised as the predicted grades this year really showed me my own organisation flaws – Teacher 4.* Teachers began to discuss the more holistic aspects of student wellbeing which exhibited their understanding of teaching to be concerned with wider issues other than that of content and assessment, *"[I am concerned about] getting students back into a routine after being away from school for so long" – Teacher 3.* This finding compliments the literature that reports on the teacher's role in the classroom as supposed by Sockett (2008). They consider four models to explain the goals of teacher education centered around the scholar professional, the nurturer professional, reflective-adaptive model and the moral agent professional (Sockett, 2008). This study aligns with findings that describes graduate teachers' perceptions of teaching as a combination of "the nurturer" and the "moral agent" (Ezer, Gilat and Sagee, 2010).

This transition would suggest that teachers had begun to overcome the challenges that faced them earlier in the school year as, again, a ***period of liminality*** is observed across the themes. Teachers began to take stock of their experiences and were focussed on making it to the end of the school year, *"[I'm excited about] Finish up my first year"* – Teacher 6. However, the transition is somewhat incomplete, similar to the first transition, as it is necessary to see where teachers are going next. The suggestion of teachers' "groping for new roles" in a "period of liminality" proposes a shift away from the moving in transition and onto a new transition. *"[I am excited about] Repeating the process again next year and apply what new things/skills I learned during my first year out." – Teacher 3*

5.7 CHAPTER CONCLUSIONS

This chapter focussed on capturing the experience of novice physics teachers over a two-year period, from their pre-service teacher education to their in-service teaching profession, in order to investigate if there are indicators of transitions occurring and answer the resaetch question:

2. What are teachers' experiences of becoming a novice physics teacher?

a. What transitions are occurring throughout teachers' experience?

This was achieved by investigating teachers' experiences (collectively) at various points in their two-year journey and analysing the themes that were generated. These centered around professional learning, support, planning and implementing ideas, student learning, pedagogical content knowledge and evolution of roles through a transition.

Observation 1 – Identifying Transitions

Transition theory was a significant contribution from the findings of this case study and its application (by mapping onto reflexive themes) indicated a useful approach to examine novice physics teachers' experiences. Schlossberg (1981) highlights that in order to examine an individual as they experience a transition, the transition must not be assumed. Transitions can be anticipated, unanticipated, an event or non-event but it must be characterised by the individual in order to be considered a transition (Goodman, Schlossberg and Anderson, 2006). This study's method and findings were cognisant of this underlying principle and provided an evidence-based approach to identify teacher transitions through the teacher voice. The study highlights the novel way that trends in themes, generated from teacher data, can inform the transition that teachers are undergoing at a specific moment in time. Here, the teacher's journey as a novice has been documented and the teacher voice is at the center of the findings.

The findings presented in this chapter highlighted trends in teachers' experiences and identified multiple transitions that overlap and span the entirety of their final year in university and first year of teaching. Goodman et al., (2006) outline that for this reason (variable and changing circumstances of the individual during a transition), transition theory provides a structural approach to examine experiences rather than considering them "anew". The findings from this study

also indicated that the transitions for these newly qualified teachers are ongoing and may extend for several years. This can be explained through the understanding of transitions as a process over time with no beginning or end (Goodman, Schlossberg and Anderson, 2006).

Observation 2 – Smoothening Transitions

Examination of themes generated from teacher data indicates specific moments of intervention needed by teachers to ***smooth the transition*** from pre-service to in-service teaching. The application of this model can help researchers understand at which developmental stage novice teachers are in their career and therefore contribute to differentiated support for teachers during their transition from pre-service teacher to newly qualified teacher as is called for in the research (Zhukova, 2018, p.111).Supporting novice teachers as they navigate changing roles, develop new relationships, transform prior assumptions and trial new routines during their early years of teaching are presented in this thesis as considerations for designing professional learning opportunities. These themes are similar to those reported in the literature as challenges faced by teachers in the first years of their teaching (Fantilli and McDougall, 2009, p.823). However, the organisation of these challenges and experiences (as shown in this study using transition theory) can be helpful in identifying aspects of professional learning that are relevant to novice physics teachers at a specific time in their career (according to the lived experiences of teachers). Through the examination of teachers' experiences over a two year period, it became apparent that their problems of practice change and evolve over time, with some of these issues dissipating with experience (e.g., building meaningful relationships) and others remaining persistent throughout the year (enhancing PCK).

This thesis highlighted that lesson planning in pre-service teacher education often seemed to be the crux of teachers' workload during school placement, especially around classroom management (See Section 5.4.2). Although lesson plans are theoretically underpinned by sound consideration for teacher planning and most educators recommend altering these plans according to the teachers' own professional preferences, pre-service teachers are not professionally sophisticated enough to see this process as anything other than a box ticking exercise that focusses mostly on instructional strategies (John, 2006; Juhler, 2016).

Helping teachers to manage their expectations before they enter school placement and in their early weeks of the first year out teaching (to relieve practice shock) (Rieg, Paquette and Chen, 2007), assigning teachers with subject specific mentors that can advise on content and curriculum needs on an ongoing basis (Nguyen, 2017) and facilitating opportunities for novice teachers to network outside of their own school context (Mercieca, 2018), are just some of the solutions that could be implemented to address the problems of practice outlined by teachers in this study and smooth their transition from pre-service teacher education to in-service teaching.

6 CHAPTER: CASE STUDY B

"We are journeying, not arriving!"

(Braun & Clarke, 2019, p.592)

6.1 INTRODUCTION

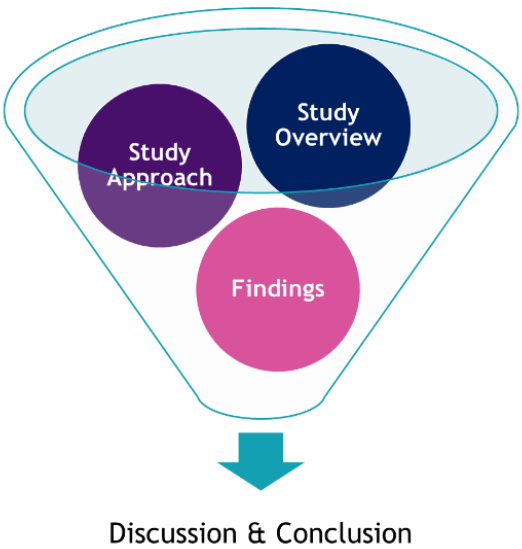
This chapter examines six novice physics teachers' experience of transition from pre-service teachers to newly qualified teachers, looking back on their first year of teaching as newly qualified teachers (Case B). These teachers were the same cohort as in Case Study A but examined at a different point in time (end of Year Two of the study) using one-to-one interviews. This study aims to understand how novice teachers experience *adaptation* to their transition from pre-service teachers to newly qualified teacher. Adaptation is seen here, as Whitmore (cited in Goodman et al., (2006, p.21)) conceptualises it; *"the continuous evaluation of life experiences rather than reactions to discrete events".*

The research question that guided the design and analysis of this study was:

3. What adaptations do novice physics teachers experience across transitions?

An outline of Case Study B is first presented in order to define the case, highlight key learning from Case Study A that informed this study, describe the approach and data collection and analysis (See Figure 6.1). The findings from Case Study B are then presented according to the resources: Situation, Self, Support and Strategies (Goodman, Schlossberg and Anderson, 2006);. Finally, the findings are discussed and observations from the findings are described.

Figure 6.1: Outline of Chapter 6



6.2 CASE STUDY B – OVERVIEW

This section outlines the context for the findings in Case Study B. Firstly the case is defined and key learnings that informed the design of the study are outlined. Details of the study approach and data collection and analysis are then described in section 6.3.

6.2.1 "The Case"

The case investigated in this study was teacher ***adaptation*** to their transition from pre-service teacher to newly qualified teacher. Within this case there were six embedded units of analysis (six novice physics teachers experiencing the transition). Similar to Case A (See Chapter 5) the case was bounded by time (start of final year of university until the end of the first year of in-service teaching) and context (novice physics teachers in the Irish education system). The aim of this case study was to identify how novice teachers adapt to the transition while capturing individual teachers' experiences.

6.2.2 Key Learnings from Case Study A

Findings from Case Study A (Chapter 5) identified the possible transitions that novice teachers experienced as novice physics teachers. Case Study A suggests that teachers were beginning to *move out* of a transition during their final semester in university to their first week of in-service teaching. Teachers then experienced *moving into* a transition from their 1st and 30th week as a newly qualified teacher. At the point of data collection for this case (Case Study B), novice teachers were beginning to *move through* their transition.

Researcher's Note

During this study, the researcher had developed a close working relationship with the teachers. This relationship was considered a strength of this study as the teachers felt comfortable to discuss their experiences. The researcher's role in this instance was solely to listen to teachers' experiences and probe where there may have been a lack of clarity in what the teachers were discussing to an outside reader (this was where the researcher relationship with the teacher was invaluable in the data collection process).

The researcher kept a journal of nuances and questions during the data collection and analysis to maintain validity and reliability. Member checking was also employed to ensure that meaning in teacher's comments was not misconstrued.

6.3 STUDY APPROACH

This study focusses on how novice teachers experience adaptation to their transitions as novice physics teachers using Schlossberg's 4S model (See Chapter 2). The study focussed on a snapshot of novice physics teachers' (same participants as Case A) retrospective experiences of their transition from pre-service teacher to novice teachers over the previous two years. Teachers' resources i.e., Situation, Self, Support and Strategies (Schlossberg, 1981), were examined from their self-reported experiences.

The participants of this study were the same teachers as in Case Study A. Data for this case study was collected at the end of their first year of in-service teaching and after one year of participating in RPP meetings.

6.3.1 Data Collection & Analysis

One to-one interviews were conducted online in May 2022 at the end of teachers' first year of teaching. Although findings from Case Study A identified what transitions occurred for the novice teachers, Schlossberg highlights that transition is the perception of change by the individual and is defined by the person experiencing it (Schlossberg, 1981). This consideration was taken into account in the design of the interview protocol (See 0). The six novice physics teachers participated in one-to-one interviews within two weeks of completing their first year of teaching. Teachers were asked to reflect back on their experiences over the previous two years and share their experiences of the most significant changes they encountered.

The interview protocol was designed to incorporate the transition model and focused on two aspects in particular: i) the 4S model and ii) teachers experiences of their first year of teaching. Each interview lasted around 60mins and was conducted online over Zoom by the researcher (See Section 3.3.3 for more details).

Reflexive thematic analysis was applied to the data collected from interviews and used to deductively incorporate teachers' experiences within the 4S model and factors affecting adaptation (detailed in Chapter 3) (See categories in Table 6.1). Protocols to ensure validity and reliability (multiple sources, member checking, rigorous reflexive analysis, researcher reflections, statement of positionality of the researcher – See Chapter 3 for further details) were carried

out to maintain the integrity of the study and ensure that data was not-over-read. Findings from this chapter were compared to findings from Case Study A to inform the final conclusions and implications of this research (Chapter 7).

Table 6.1: Model for Analysing Human Adaptation to Transition

Resources for Transition	Situation	Self	Support
Factors Affecting Adaptation to the Transition	Perception of the Transition - Role Change - Affect - Timing - Onset - Duration - Degree of Stress - Source	Characteristics of the individual - Psychological Competence - Sex/Gender Identification - Age - State of Health - Race/Ethnicity - Socioeconomic Status - Value Orientation - Previous Experience	Characteristics of the Environment - Internal Supports - Institutional Supports - Physical Setting
Resource for Transition	**Strategies**		
Factors Affecting Adaptation	- Control the Situation - Control the Meaning of the Situation - Control the Stress		

6.4 CASE STUDY B FINDINGS

The data from this case was analysed according to each of Schlossberg's 4S resources: Situation, Self, Supports and Strategies (Table 6.1). The findings from these themes are reported according to the aspects of each 'factor affecting adaptation' to answer the research question:

3. What adaptations do novice physics teachers experience across transitions?

6.4.1 Situation

Within the theme of *Situation* there were six indicators explored: Role Change, Affect, Timing, Onset, Degree of Stress and Duration, as detailed in Table 6.2. The seventh indicator, *Source,* was internal for all teachers (the transition was an anticipated event in their lives) and a consequence of completing a teaching degree.

Role Change

Role change details the gains and losses of the individual during a transition. An increase in responsibility was reported by five of the six teachers. The type of responsibility described by teachers varied between increased responsibility for student learning, student wellbeing and students' wider needs (whether it be content, social skills or confidence). Teachers also reported an increase in responsibility such as: being the only physics teachers, becoming a class tutor and their own transition from student to adult. All of these teachers saw this responsibility as a *gain* in their role. Only two teachers reported *losses* during the transition as a result of their new role. Teacher 1 discussed the difficulty of changing their relationship with students from teammates to their teacher and Teacher 2 felt that there was expectation that NQTs should know what they are doing, thus feeling a loss of their previous role as a student where they were guided and supported. *"Whereas you're coming into a new school [as an NQT] you're kind of expected that you're supposed to know everything you're doing that kind of thing." – Teacher 2*

Table 6.2: Teacher Adaptation related to "Situation"

Situation	Teacher 1	Teacher 2	Teacher 3	Teacher 4	Teacher 5	Teacher 6
Role Change	Had to create a boundary of their relationship with students inside and outside school	Increased responsibility (for their student wellbeing) Expected to know what you are doing	Increased responsibility for student learning Responsibility associated with being a class tutor	Increased responsibility (as an adult) Embraced the role change by getting involved in the school community	Increased responsibility for students' wider needs New social experiences with colleagues	Increased responsibility associated with being the only physics teacher Gained independence as a teacher
Affect	Noticed that confidence as a teacher has increased Initially felt too busy to get involved in the school environment	Planning for material outside of their discipline Aware of the overall welfare of their students	Tried to understand the student perspective and make learning fun Became more disorganised due to the increased workload	Financially independent Better relationship with colleagues and students (than on placement)	Teaching during a pandemic had a positive effect on building relationships with staff	Surprised by the effect they had on students More efficient with time (planning) More in tune with the student perspective
Timing	Ready for the transition although it was daunting	Final year of placement meant they were eager to get started in their first year	Initially did not want to be a teacher	Ready for the transition but COVID brought a lot of unknowns	Teachers were ready for the transition before they started the degree	Ready for the transition although they didn't believe they were ready

Situation (*cont.*)	Teacher 1	Teacher 2	Teacher 3	Teacher 4	Teacher 5	Teacher 6
Onset	Felt the transition was sudden – needed more time/transition to happen at a slower pace	Transition was gradual from college experience to workplace	Almost sudden - feeling overwhelmed at the start due to starting a new job	Nervous initially about starting but very content in their decision to pursue teaching	Too gradual – teachers would have liked to start earlier	Transition was gradual from college
Degree of Stress	Was stressed before starting - reality was not as bad as initial expectations First few weeks were overwhelming	Was stressed but mostly attributed to pre-teaching nerves Correction of tests were the root of most stress	Very stressed and did not settle until at least second term	Was stressed before starting due to planning for subjects outside their discipline	Somewhat stressed at the start but mostly concerned about job security for the next year	Not overly stressed When difficulties arose, they adapted to them and tried to solve them as they happened without worrying ahead
Duration	-	Uncertain - may take a break from teaching	Uncertain – option to change career if do not like it	-	-	-

Affect

Affect (See Section 2.2.3) describes whether the transition was positive or negative for the individual. Each of the teachers had different experiences of the influence of the transition both positive and negative. The positive aspects varied from increased confidence, awareness of the wider needs of students (welfare, wellbeing, student-teacher relationships), financial independence, planning for subjects outside of their discipline and in one case more efficient use of their time. Here, teachers expressed that the (longer) time they had in their first year teaching (compared to teaching placement) was a strong contributing factor to all of the positive effects they experienced. Fewer negative effects were reported by teachers although two of the teachers did express negative effects on planning and involvement in the school community as a result of a very busy first term and increased workload. *"…the staff were saying, 'gosh, I never see you' and I'm like 'it's because I'm just running around doing stuff all day, all the time…", - Teacher 1*

Timing

The timing of this transition was anticipated by teachers, however most of them still admitted they had reservations starting out. For some they reported that it was a daunting experience and sometimes did not believe they were ready to be a teacher (Teacher 1 & 6). One teacher expressed concern at the uncertainties that teaching during a pandemic would bring (Teacher 4). Apart, from one teacher who was not sure if they wanted to be in the profession the remaining two teachers were eager to get started in their new role. *"Like I knew I wanted to go and be a teacher after 4 years when I started the course .." – Teacher 5*

Onset

The timing (whether it was the right time for the individual) of the transition linked closely to the *onset* (whether the individual viewed this as a gradual or sudden transition) for the teachers. As mentioned previously, five out of the six teachers said they were ready for the move to in-service teaching. The degree of their readiness was evident in whether they felt the move was gradual or sudden. Two teachers felt that the transition was gradual from their experience in university and Teacher 5 felt that it was too gradual and they would have liked to start teaching independently earlier. Those teachers that reported reservations with the timing or did not want to be in the profession also felt that the transition

was somewhat sudden, with one teacher in particular stating that they would have liked a more gradual lead in to their first year teaching at a slower pace.

> *"I just mean it's a busy enough profession to go into at the start NQTs…It feels quite almost sudden, I suppose, last year. It would have been better if you were out for a full term last year, then we would have settled in as teachers we would have felt more normal.." – Teacher 1*

Degree of Stress

Teachers' *degree of stress* was difficult to measure due to the highly subjective nature of stress. Teachers were asked to rate their stress from 1-10 but this proved to be an ineffective way of comparing teacher experience as one teacher's perception of a stressful "6" was another person's perception that this was not stressed. And so, these metrics were also paired with quotes from teachers that described aspects of their experience that they described as stressful. One teacher described a particular amount of stress that remained until the second term of teaching. This could have been attributed to some of the previous factors mentioned - timing, onset, role change - and also to some yet to be discussed such as supports. These same factors may also have contributed to teacher 6's lack of stress as they described themselves as just adapting to whatever issues arose at the time.

> *"I'm good at kind of like just letting things happen around me and then adapting to them at the same time. I find that if I try and look to forward into the future I won't be able I'm not able to control anything that can't happen right there and then, so I kind of adapt as best as I can.." – Teacher 6*

Most of the other teachers' stress was related to starting a new job and taking on increased workloads with one of the teachers expressing their concern of job security moving into the next year.

Duration

Duration was not specifically probed by the researcher, but in two cases teachers indicated that they were uncertain if this was going to be a permanent transition for them. One teacher indicated that teaching could offer an opportunity to travel or perhaps move from the profession completely for a break. Another teacher did not make any suggestions of alternative professions but suggested that if they

still felt unsure about teaching, changing career could be an option. *"Em, it is mainly just because I'm looking to go traveling and stuff obviously teaching is needed everywhere. But I might just…take a break and work at something else…I was looking at master's degrees and stuff like that.." – Teacher 2*

6.4.2 Self

The theme of "Self" was described using the characteristics of the individual such as: psychological competence, age, socioeconomic status, value orientation and previous experience with a transition of a similar nature (See Table 6.3). Sex/gender, state of health and race/ethnicity did not feature in teachers' accounts of their experiences.

Psychological Competence

Psychological competence as a resource refers to one's ego development, optimism, self-efficacy, commitment, values, spirituality and resilience (Schlossberg, 1981). Within this theme, it was found that teachers frame their psychological competence through their lens as a teacher mostly. For example, teachers highlight their impact on students as a factor that impacts their belief in their capability as a teacher. This can be seen were Teacher 2 describe the pride felt when they see their students show an interest in their subject. Similarly, Teacher 3 believes that their influence as a role model can have a positive impact on students. Teacher 4's outlook on their journey was very positive as they list their next steps, opportunities and ways to integrate further into the school community. Contrastingly three of the teachers relayed feelings of imposter syndrome, *"I was concerned about, was I going to be the very clear new teacher, who doesn't know anything or whatever…" – Teacher 5*. Teacher 6 describes how they just wanted to keep under the radar and not draw attention to themselves by making mistakes in their first year. This was usually attached to stereotypes associated with their capability as a young teacher and actual competence to be an effective teacher.

Age

Teachers' age was an aspect of self that three teachers felt very strongly about. On several occasions the teachers referred to an uncomfortable feeling that they associated with being too young as a teacher.

> *"..they're like 10 years older and I'm like, 'oh, maybe I'm not meant to be here', so like I do feel a bit intimidated by them all because like, they're so much older but then also like oh I did the same course so.." – Teacher 3*

Table 6.3: Teacher Adaptation related to "Self"

Self	Teacher 1	Teacher 2	Teacher 3	Teacher 4	Teacher 5	Teacher 6
Psychological Competence	Experienced imposter syndrome initially Conscious of appearing incompetent in their teaching	Feelings of reward, job satisfaction and pride in students Exhibit an enhanced feeling of competence	Experienced imposter syndrome throughout Passionate about having a positive impact on students Confident in being a role model for their students	Increased confidence in their teaching Planning forward, creating opportunities to be more involved in the school community	Experienced imposter syndrome initially Increased confidence quickly after starting	Initially they did not believe in their capability to be an effective teacher Avoid unnecessary attention being drawn to them in the first year
Age	Age had an impact on the relationship with students	-	Self-conscious of their age among colleagues who are older	-	Feel youth gives the teacher an advantage as students are expecting new teaching approaches	-
Socio-Economic Status	Being from a similar background as their students is their strength	Identify socioeconomic background as important to their identity and felt they had a different upbringing to their students	-	-	-	-

Self (*cont.*)	Teacher 1	Teacher 2	Teacher 3	Teacher 4	Teacher 5	Teacher 6
Value Orientation	Values are centered around the student achievement	Values are centered around student wellbeing	Values are centered around student growth and progress	Values are centered around being passionate about teaching and imparting that onto students so they succeed	Values are centered about being the best teacher	Values centered around designing engaging and interesting lessons
Previous Experience of Transition	Comparing pre-service teaching to in-service teaching – lack of support	Comparing pre-service teaching to in-service teaching – more accountability now Comparing transition to that from second-level school to university	Compare transition to previous experience of new jobs – more obstacles encountered with teaching	Comparing pre-service teaching to in-service teaching - length Comparing transition to that from second-level school to university – more responsibility	Comparing pre-service teaching to in-service teaching – similar experience but less pressure to take on advice now	Comparing transition to that from second-level school to university – both result in an increase in responsibility (for self vs for students)

For one teacher their closeness in age to the students was the contributing factor. For the other two teachers the age gap they felt between other staff members, had resulted in what they felt was a barrier to being accepted among their colleagues. All of these teachers were evidently those that also reported the feeling of being an imposter, as previously mentioned.

Socioeconomic Status

Socioeconomic status was only mentioned by two teachers as a significant characteristic that influenced them as a teacher. One teacher describes how their knowledge of the locality and the typical expectations of students from agricultural backgrounds helped them to empathise with their students and the extra responsibilities that are placed on them at certain times of the year outside of school. Another teacher felt that their socioeconomic status was very different to that of the students that they taught and as a result felt that they may not be able to relate to their students on some levels:

> *"didn't come from a very very wealthy background…and so that's a big difference between me and [my students] because they all have their electric scooters and stuff like that…" – Anon (further precaution taken to protect identifiable information of teachers)*

Value Orientation

Teachers' value orientation was discussed in terms of what they value in their profession as a teacher. All of the teachers described mostly a tendency towards the social service value (social awareness and interactions of students) as they discussed their interactions with their students. The way in which this value manifested was different from teacher to teacher. Teacher 1 valued student achievement and helping students to perform (academically) to the best of their ability. Teacher 2 focussed particularly on the wellbeing of their students and the importance of becoming familiar with their students in order to assess their day-to-day engagement in the class. Teacher 3 was interested in students' overall growth and progression as well-rounded students inside and outside the classroom. Teacher 4 and 5 valued being the best teacher that they could for their students to succeed and Teacher 6 always considered how to engage their students through their lesson design.

"I think it's less to do with the students' achievement and more so do with their understanding and how they perceive the class in the whole, like if they enjoy it I think that's you being a good teacher.." – Teacher 6

Previous Experience with a Transition

Teachers' previous experience with a transition of similar nature showed some differences across the cohort. One teacher discussed compared this transition to previous jobs (part-time, non-teaching), but rather than describing ways in which the roles were similar the teacher could only identify how the responsibility seemed much more intense as a qualified teacher. Three of the teachers compared the transition to that of their transition from second-level school to university due to having a change in responsibility at both times. Teachers describe how their transition from second-level school to university brought with it an increased responsibility for themselves as students as they navigated attending lectures, living away from home, completing assignments on time etc. They then compared this responsibility with the increased responsibility that teaching brought with it, but instead of responsibility for themselves, they now had the added responsibility for their students' progress. Four of the teachers compared this transition to their transition into school placement and their teaching experience as a pre-service teacher. Here, teachers reported having to deal with an increased workload and responsibility for students (as they did during school placement) but this time, they felt that they had less support and were more accountable for their actions. One teacher positively mentioned that the longer time they had with their students made a difference to building relationships with students and colleagues. Here, the influence of the pandemic needs to be taken into consideration as teachers had only four weeks of face-to-face teaching on school placement (See Table 5.1):

"…like our placement were so so short. I feel like going in and then we were in for a full year, I felt like I was more involved in this school than I got to be in the rest of them… [during placement] you know, it's, you're kind of just like here, and you're gone again…" – Teacher 4

6.4.3 Support

The theme of support was one that was discussed in detail throughout teachers' discussions (see Table 6.4). Within this theme *internal supports* referred to intimate relationships, family unit, network of friends. *Institutional supports* considered the supports in place in the teachers' schools and the supports they drew on outside the school (mostly university supports). Often, teachers drew on aspects of the physical setting to set the scene or justify their use of the above supports.

Internal Support

Teachers' internal supports mostly consisted of family and friends and provided a specific type of support to them, usually non-teaching related. Five of the teachers felt that they could talk to family or friends if they were stressed as a result of their teaching. Two of the teachers found that coming home to the routines of having a dinner on the table and talking with siblings helped to de-stress after the school day. *"Like, I probably almost rely on them more so to de-stress me after the day, rather than, like, help me out in that sort of way. For calming down and getting fed ... They weren't helping me with the teaching…" – Teacher 1*

Two teachers felt that because their family and friends did not have teaching experience they could not understand or support them by giving advice. Three of the teachers mentioned their university friends (who were also teachers) as a strong support system for advising on issues in the classroom and staffroom. However, the remaining three teachers indicated that they had lost contact with this network due to moving location, increased workload or COVID restrictions.

Table 6.4: Teacher Adaptation related to "Support"

Support	Teacher 1	Teacher 2	Teacher 3	Teacher 4	Teacher 5	Teacher 6
Internal Support System	Routines at home helped to ground them Difficult to collaborate with classmates outside of school	University friends were still a contact point for advice Family and friends who are not teachers cannot relate	University friends, home friends and family are all strong supports	Relied on parents and home friends - Routines at home helped to ground them Felt that they lost contact with university friends and some others	Felt that friends and family could not support as they did not have teaching experience	Always had someone to talk to if needed Mostly discussed school issues with friends that were teachers
Institutional Supports	Could have been more support in the school, although some individual teachers were helpful University could have prepared them better to brush up in their content knowledge and yearly planning	Felt supported by particular colleagues whom THEY asked for advice and help, not school supports in particular Would have liked more preparation in out of field subjects in university Found RPP meetings, and methodology modules useful	Did not feel included as a staff member but after some time knew where to find support (colleagues) Felt that university resources need to be adapted further to be more practical	Felt fully supported and belonged in school through interactions with colleagues, management, other NQTs Methodology modules, internships, placement and approaches to teaching were all useful in their teaching	Mostly supported by the other NQTs that started at the same time Structures such as Droichead and general school ethos aligned with teachers' beliefs Professional internship prepared them most for teaching	Many school structures to support NQT's e.g., buddy system, Droichead, secret friend etc. Colleagues were actively trying to support them

#Support (*cont.*)	Teacher 1	Teacher 2	Teacher 3	Teacher 4	Teacher 5	Teacher 6
			University did not prepare them fully for teaching	Found RPP meetings good for keeping contact with peers and get resources		Felt supported by university staff, RPP meetings and teaching methodology modules from their degree
Physical Setting	Classroom management, COVID restrictions and student-teacher relationships were challenging in the first year	Online learning caused them to sit back too much Building student-teacher relationships was difficult	Classroom management and student-teacher relationships were challenging Students' preconceptions of subjects created stereotypes within the school Students needed specific interventions to engage	Online learning was lonely for them Digital learning did provide solutions to some issues with students Access to equipment was limited in the school	Teaching during a pandemic (It was a new experience for everyone not just NQTs), online learning was challenging Familiarity of the school made it easier to settle in Tensions existed between staff and school management	Familiarity of the school made it easier to settle in Student collaboration was the norm in the school Classes had very varied abilities

Institutional Support

Teachers described a lot of supports (or lack thereof) in their school or university during their first year of teaching. School, as a support, was one of the most populated themes of all themes in this study. Here, all of the teachers describe scenarios when they received support and advice from another teaching colleague. In particular, the two types of colleague that the teachers made reference to were either a fellow NQT or a teacher within their subject department. Teacher 2 and Teacher 6 spoke very specifically of their inclination to ask as many questions as possible in order to avoid making too many mistakes in their first year. Other structured supports for newly qualified teachers were less common across the schools that the teachers were in. Teacher 6 was most supported within the school structure, compared to all other teachers, as they described a buddy system between experienced teachers and newly qualified teacher, a secret friend (anonymous pairing of teachers through email) and the Droichead system (school based induction framework (Smyth *et al.*, 2016; The Teaching Council, 2022)).

This teacher discussed the benefit of their colleagues in the science department knowing that they were a novice as they were actively trying to support them throughout the year. Teacher 4 also reported being very supported within the school as they got fully involved in extracurricular activities that involved interactions with colleagues, management and other NQTs. Teacher 5 felt that the school's ethos of student growth aligned with their approach to teaching and considered this as a support in their planning. In contrast to this, Teachers 1, 2 and 3 felt that there could have been a more structured support within the school as they describe instances where they felt alone or on the outside of the staff initially until they found individual colleagues they could rely on for advice.

> *"..Myself and another NQT came together with us and she was ag science and biology. So, we kind of helped each other a bit but it was like the blind leading the blind like we weren't much help for each other either. And I suppose if we had a better setup in the school" – Teacher 2*

University supports both as pre-service teacher and now newly qualified teacher were mentioned within this theme of institutional support. Three of the teachers felt that modules related to teaching methodologies (teaching, learning and assessing) were applicable to their current practice in classrooms. These teachers

also mentioned school placement and a professional internship (STEM Teacher Internship, 2022) they carried out during their third year in university as useful to their teaching. Research Practice Partnership meetings were discussed by three teachers as a useful initiative to network and gather new resources.

Three teachers felt that university did not prepare them sufficiently for teaching. In one case the teacher felt they needed further support with their content knowledge in university to feel like a competent teacher. Two teachers would have liked further preparation preparing subjects outside of their disciplines (CSPE, SPHE, ICT) or outside of the regular teacher role (being a class tutor or the only physics teacher in the school). One of the teachers felt that the resources they thought were useful in college were not practical when carried out in the classroom e.g., lesson plans or activity ideas were not accessible to students in disadvantaged schools.

> *"..they just they don't work so you have all these expectations of these like worksheet packs and resources that you'd have from college, then you bring them into school and then they're terrible…like they [students] just don't like them, the lessons don't flow..." – Teacher 3*

Physical Setting

The physical setting in this study was interpreted as any aspect within the school system that teachers described as impacting on their stress, sense of wellbeing or general outlook that may have played a role in their adaptation to the transition. The most obvious aspect of physical setting that was discussed by four teachers was teaching during the pandemic. One teacher admitted that they took advantage of online learning a bit as they did not have to deal directly with classroom management issues or tracking student's progress so closely. Another teacher found that as they had to keep to smaller pods with teachers, they created a stronger bond with some colleagues that they would not normally have mixed with in the larger staff room. However, four of the teachers found online learning challenging in terms of connecting with their students in an online setting and in one case a teacher reported feeling disconnected from colleagues and friends:

> *"I think I'm a people person I like to be around people. I think that was the big thing like being alone. Yeah, just communication is a big thing. Keeping in contact with people." – Teacher 4*

For two of the teachers, familiarity of the school setting (they had taught or been a past student in the school previously) made it easier for them to settle in. Another two teachers had difficulty with classroom management as student behaviour seemed to be an issue in the school. Some of the more specific aspects of the school settings described by teachers included: stereotypes associated with physics as a difficult subject, limited access to equipment, tensions between staff and management and difficulty attending to different levels within the class (differentiating).

> *"So, it's kind of hard for me myself to keep up…with what questions they had while also attending to those students who were doing ordinary level and hadn't really, didn't really engage with that they read or weren't listening or didn't have any interest. They wanted the information that was needed to pass and that was it." – Teacher 6*

6.4.4 Strategies

Within this theme teachers highlight what they felt were the strategies most helpful in adapting to the transition (See Table 6.5). In some cases, teachers reflected back on what worked well or didn't work and what they would change as a result. In other cases, teachers were still thinking of how they continue to cope as they are moving through this current transition.

Controlling the Situation

Improving planning and organisation skills was mentioned by all teachers as an aspect of the situation that they tried to control. It was evident from this theme in particular that these were the strategies that teachers were still actively trying to implement to cope with the transition. Some teachers had begun to prepare work for the classes they knew they would have over the summer holidays. Most teachers felt that they needed to improve on their planning in advance as they felt under pressure when they were left to plan lessons the night before. Two teachers in particular found that keeping on top of classwork corrections was very taxing on their time. On the other hand, two teachers focussed more intensely on the planning side as they described setting goals or targets for their students to meet (description of what is next to come on the scheme of work) and planning ahead to help with classroom management (preparing extra worksheets). *"Yeah, yeah, that was probably another tough thing as well but eventually like I came up with like always having a spare worksheet and always having three plans going into the one lesson." – Teacher 3*

Teachers discussed their journey as a professional and set strategies for them to enhance their professional learning going forward as a means of controlling the situation. These strategies resonate particularly with the moving through phase of the transition as teachers were setting new routines and thinking forward to what comes next. Here, teachers discuss getting more involved in the school community (engaging in extracurricular activities), upskilling in the use of digital tools in the classroom to support planning and assessment and engaging in professional learning opportunities (webinars, observe colleagues lessons for ideas).

> *"I might kind of go into one of her classes and observe and see the differences between them, because I'd say we are completely polar*

opposites that like what do I actually want to bring forward for my classes? What do I kind of think might be better to implement?" – Teacher 5

Controlling the Meaning of the Situation

The next strategy that most (5 out of 6) teachers referenced was related to understanding the meaning of the situation. Here, teachers discussed aspects of the situation that they could improve or reflect on in order to successfully adapt such as, critically reflecting on practice, in order to focus on the needs of the student in their practice. Three teachers discussed how they tried to incorporate the student voice into the design and implementation of their lessons. Two of the teachers described the necessity of including student feedback on tasks to inform the pacing and content of their lessons. For example, Teacher 4 describes different ways that this can be achieved through exit slips, questionnaires or just asking the students questions. Teacher 6 focusses specifically on facilitating student learning through formative assessment. Here, they describe how creating opportunities for formative assessment not only keeps track of student progress but also boosts their confidence in the subject. Teacher 3 was very passionate about encouraging their students to pursue physics for senior cycle and actively worked at providing their students with information on the accessibility and usefulness of the Senior Cycle curriculum. Two of the teachers focussed on reflecting back on their practice and how it can influence the student learning. This included believing in their abilities as a competent teacher ("*don't doubt yourself*") and engaging in critical reflection by evaluating teaching approaches that could be improved to suit their students better.

"You can work around a lot once you have the time to think about it to figure it out. I think you need to be able to build a relationship with your students to understand the individuals that you have in your classroom to not just keep going with whatever you know what works with last year's [students]" – Teacher 1

Table 6.5: Teacher Adaptation related to "Strategies"

Strategies	Teacher 1	Teacher 2	Teacher 3	Teacher 4	Teacher 5	Teacher 6
Control the Situation	Focus on improving planning and organisation skills Get involved in the school community	Focus on improving planning and organisation skills	Focus on improving planning and organisation skills Engage in professional learning opportunities	Focus on improving planning and organisation skills Maximising use of digital tools for planning and assessment	Focus on improving planning and organisation skills Get involved in the school community Engage in professional learning opportunities	Focus on improving planning and organisation skills
Control the meaning of the Situation	Critically reflect on practice	Focus on the needs of students to inform lesson design	Encourage students to study physics	Focus on the needs of students to inform lesson design	-	Create formative assessment opportunities
	Build student-teacher and collegial relationships	Learn from colleagues	-	-	-	Use teachers/colleagues' expertise to inform your practice
Control the Stress	Maintaining a work-life balance	Maintaining a work-life balance	-	Maintaining a work-life balance	Maintaining a work-life balance Believe in your abilities as a competent teacher	-

Teachers also focussed on the interactions they had with colleagues and students within the school community. One teacher said they would like to connect more with their students as they felt like they created too much of a formal relationship in the first year in order to maintain classroom management. Teachers also discussed building relationships with other teachers through spending more time conversing in the staff room or asking colleagues for advice on specific issues. Two of the teachers felt that learning from their colleagues was the best way to understand the meaning of the situation more effectively.

> *"..just ask questions, like … if you have any sort of like misunderstanding or any sort of question that anything to ask someone. And if you want another opinion ask somebody else. No one's going to really think twice about it." – Teacher 6*

Controlling the Stress

Maintaining a work-life balance was a central focus for almost all teachers (four) under the theme of controlling the stress. Four of the teachers described how they tried to improve their organisation skills to maintain a better work-life balance. They gave examples of what they currently try to implement to overcome their increased workload and manage their time efficiently, for example, trying to complete all school related work in the school, or confining planning and corrections to the working week and leaving weekends free. One of the teachers highlighted that acknowledging that you cannot be completely prepared for a lesson as a novice is an important realisation to accept. They felt that if they believed in their own ability as a competent teacher they would be less stressed overall. *"..but to become more comfortable with understanding that I'm not going to know everything." – Teacher 1*

6.5 DISCUSSION

This chapter investigated how a particular transition affected the teachers' lives using Schlossberg's 4S resources (Situation, Self, Support and Strategies). Teachers were interviewed at the second *moving through* phase and drew on their lived experiences over the previous two years to describe how they dealt with the transition.

6.5.1 Key findings related to *Situation*

It is worth considering the ways in which novice teachers' expectations of starting a teaching career can be nurtured. Within the domain of *Situation*, the degree of stress seemed to be teachers' main indicator of whether they were adapting successfully or unsuccessfully to the transition. In the early weeks of teachers beginning their role as newly qualified teachers in their respective schools, teachers described their apprehension related to starting a new job and expectations of the unknown as issues. It is striking when one teacher described googling all the questions and queries they had related to starting in a new school in the week leading up to their first day. Considering what teachers' expectations (unrealistic expectations (Kindall, Crowe and Elsass, 2017)) are, in terms of starting a new role, could be an uncomplicated approach to preparing teachers for what is to come. Gavish and Friedman (2010) found that novice teachers, in their first year of teaching, struggled to comprehend the schools' organisational situation (familiarity of the environment, professional and personal support or recognition and appreciation by others). They suggested that novice teachers' burnout, measured in November, was a result of build-up of stress even before they are employed at their school and was caused by their limited perceptions of the working environment (Gavish and Friedman, 2010).

Teachers' level of stress in this study remained high from the first week until they felt that they were settled into the school community (around week 30) as they felt prepared to take on new challenges and integrate further into the school community. Burkman (2012) reported that often support through professional development is not aligned with novices' high stress areas. This is surprising considering the countless studies (including this one) that describe novice teachers' problems of practice to be centered around classroom management, increased workload, more responsibility, low teacher self-efficacy and unsuitable support (Burkman, 2012; Caspersen and Raaen, 2014). Burkman

(2012, p.30) also found that although stress management was one of the top five challenges, only 30% of novice teachers in the sample had received training in managing professional stress (one of the factors that leads to burnout and further issues of teacher attrition). Within the cohort in this study, two out of six teachers did not consider the transition a permanent one and felt that they might explore options to move out of the profession. These findings hold significant concern for teacher retention, especially in physics, where numbers of new teachers registering each year is very low (Teaching Council of Ireland, 2021).

6.5.2 Key findings related to *Self*

Consideration of novice physics teachers' identity (Nguyen, 2017) is necessary to understand the experiences of individuals adaptation to transition. During this data collection, the researcher set out to document the experiences of teachers, considering the different aspects that make up teachers' identity through the resource *Self*. Rather than teachers choosing from a list of options related to their identity, they were asked to share aspects of their identity that contributed to their journey in any way. Most teachers commented on their personality traits or interests in response. Teachers reference to personality traits and interests as part of their identity brings to light an extra dimension to teacher identity that may need to be considered within *Self* in the transition model. Makovec (2018) also found this to be true as she determined that teachers irrespective of their subject discipline tended to "*..define their professional identity and consequently, their role through personality traits"* (Makovec, 2018, p.42). Teacher identity proves to be a complex navigation of roles that requires regular repositioning as a novice (Nguyen, 2017).

Researcher's Note

Measuring teacher identity was one of the questions that teachers struggled to comprehend in the interviews. Self-declaration (declaring what they thought was important) of identity was an important aspect considered in the research design of the interview protocol. Further research with more specific probing questions around identity is needed to investigate the gaps that was evident in the findings of this study.

A second observation within the resource *Self* was related to diversity in the teaching profession. Only two teachers commented on their differing

socioeconomic background as a differentiating factor. When teachers were further probed on any socio-demographic information that might be unique to their case, again they discussed experiences or rationale for becoming a teacher as a response to the question. This interesting gap in the data revealed two possibilities for teachers not declaring particular aspects of their identity (state of health, race, ethnicity, gender/sex as per adaptation to transition) that might influence their experiences. Firstly, teachers did not feel they were unique in any way to other teachers in the field. One of the teachers even explicitly stated that they were "in the majority" of the population of teachers in every way. This is unsurprising as the most common profile of teacher, white-Irish and middle class individuals, still remains today in Ireland (Keane and Heinz, 2016; Heinz and Keane, 2018). Creating a profession that is accessible to all learners from diverse backgrounds would greatly benefit our students and create new types of role models in our classrooms. Creating professional learning opportunities for teachers to explore issues related to privilege, disadvantage and consequences of inequities related to socio-demographic positionality of their students would greatly benefit an inclusive environment and in turn encourage teaching as a more accessible profession for all (Keane and Heinz, 2016; Heinz and Keane, 2018; Ní Dhuinn and Keane, 2021). The second possibility for teachers not declaring particular aspects of their identity could be related to their understanding of what identity is and is also linked to a limitation of this study (See Section 7.5). Stenberg and Maaranen (2021, p.3) assess the evolution of I-identities: didactical (relationship to student learning), pedagogical (educational, interactive and caring aspect), context (school parents, society) and teacher (teacher relationship), that teachers experience in their first year of teaching. However, they conclude that, understanding "I" as a person becomes part of the interplay when developing a professional identity and call for further studies to investigate how teachers negotiate these identities (Stenberg and Maaranen, 2021).

Teachers also discussed their self-consciousness in relation to their youth when integrating into the school and reported it being a barrier to engaging with their colleagues. They felt that they were a minority in the school community as their colleagues had many more years' experience than them. Long *et al.,* (2012) attributes this feeling of the "visitor" (outsider) among staff, due to the established teachers positioning in the staff room and school. They describe that

routines of established staff, that are already negotiating school politics or happenings at the time which can cause the new teacher to feel unwelcome and like an outsider (Long *et al.*, 2012).

6.5.3 Key findings related to *Support*

Targeted support, informed by the findings from the study, for novice teachers both in university and in their early years of teaching could help improve teachers' overall experience of transition. *Support* was a prevalent theme throughout all of the teachers' journey as novices. Teachers felt the support that benefitted them most was that of colleagues or friends that were teachers. However, this was not always easily accessible and relationships had to be built to earn advice and support. Flores *et al.*, (2011) highlight the importance of building trust between a mentor (colleague) and mentee (novice teacher) to give the mentee a space to seek validation or receive evaluative feedback and specific strategies. They outline that this relationship has the power to alleviate stress through venting about difficult or uncomfortable situations. Here, the mentor (with teaching experience) has the expertise to offer assistance by organising their thoughts (thoughts of the novice), redefining the issue and identifying realistic solutions (Flores *et al.*, 2011, p.377).

The schools that the novice teachers were working in were all involved in the national teacher induction programme (known as Droichead) (The Teaching Council, 2022). However, only two teachers mentioned this programme as a support and they did not give details of how they were involved or benefitted from the successes of the programme quoted in literature (Nally and Ladden, 2020). Teachers communicated the need to have a structured support within their schools, with access to colleagues within their subject discipline (Clark, 2012a), support outside of the school to discuss (without judgement) issues they are having and opportunities to network with other teachers and educators. Teacher induction is not a new concept and many programmes advocate for creating communities of practice or professional learning communities to support novice teachers (Herrington *et al.*, 2006; Saka *et al.*, 2013; Tahir *et al.*, 2014; Akiri and Dori, 2022). Akiri and Dori (2022, p.122) describe an induction programme that adopts three support levels in the first two years of teaching: individual mentoring by experienced teacher mentors, group mentoring based on professional development workshops, and mentoring networks. Results of their

approach show an increase in novices' teaching efficacy, professional growth, personal and social growth. They also found that individual mentoring had the greatest impact on the growth of teachers (Akiri and Dori, 2022). Group mentoring provided pedagogical support and opportunities to develop relationships with other teachers in the school, while the mentoring network enhanced teachers professional knowledge, helped them to reflect personally and connect socially (Akiri and Dori, 2022, p. 139).

Teachers in this study discussed the usefulness of Research Practice Partnership meetings to achieve two of their needs (support outside the classroom and networking opportunities) but perhaps the scope of these meetings would benefit from having further reach within the school community with layers of accessibility to network with colleagues within and outside their school (Clark, 2012b; Penuel and Gallagher, 2017). It is evident that novice teachers value emotional, contextual, relational, academic, and social supports in their beginning years of teaching, when they are available (Sikma, 2019).

6.5.4 Key findings related to *Strategies*

Finally, teachers were mostly focussed on managing their time and planning in the last resource *Strategies*. Findings suggest that teachers spend most of their pre-service teacher education writing plans. They then try to re-organise those plans into more simplified schemes of work with just a brief outline of a lesson plan in their first year of teaching as an NQT. These teachers have come from a culture where they are introduced to a set template of planning in their first year of pre-service education and required to populated tables to meet the expectations of their course assessment as is also reported by John (2006). Once they transition to in-service teaching, these types of plans are no longer required and teachers are required again to think of how they will design their lesson plans and units of learning in a way that is accessible to their teaching style. Tahir *et al.,* (2014) describe how novice teachers feel that they are not competent in writing lesson plans and as such do not feel their plans complement their teaching strategies. Their participants suggest that exposure to effective lesson plan writing whereby their technique is critically evaluated would benefit their teaching approach (Tahir *et al.,* 2014; König *et al.,* 2020; Ndihokubwayo, Ndayambaje and Uwamahoro, 2020). This time-consuming practice could be better scaffolded in an inclusive way to promote teacher creativity and flexibility

in their planning and move away from the suggestion that planning is a linear and concrete practice (John, 2006).

Teachers associated their stress with an increased workload (teaching hours) in their first year, accompanied by an increased focus on planning and preparation. They saw this increased workload as decoupled from time to focus on meaningful student learning. In their first year, teachers were mostly concerned with teaching content to meet requirements for end of term tests or high stakes exams. However, by the end of their first year teachers begin discussing how they can improve their planning to facilitate meaningful student learning and foster deeper understanding. This frustration is also reported in the literature, where teachers feel that their involvement in extracurricular activities and even the new responsibilities associated with their role diverts from their desire to improve their teaching (Tahir *et al.*, 2014). Bettini et al. (2018) found that relationships between novice's roles, social resources and managing workload may be connected through interactions with colleagues. They suggest however that the frequency of these instructional interactions, is a fickle relationship and too many (or too few) interactions may have a negative effect (Bettini *et al.*, 2018).

6.6 CHAPTER CONCLUSIONS

This chapter was focussed on exploring novice physics teachers' adaptations during their transition from pre-service teacher to in-service teacher. One-to-one interviews with teachers at the end of their first year of teaching examined their retrospective experiences of the previous two years within Schlossberg's model with a view to analysing adaptations. Teachers' problems of practice were centered around their degree of stress, managing work-life balance and integrating into the school community. Findings from this study reveal that teachers' adaptation to transition can be supported by improving internal and institutional support structures and management of expectations for novice teachers joining the school community. Implementing these resources would help novice' teachers transition from pre-service teacher to newly qualified teacher more gradually.

Observation 1

This study presents evidence of novices' adaptation to the transition at the point where they are moving through their new transition. Here, Schlossberg's model proves effective as an analysis tool that could be embedded into the data collection and analysis in order to understand how teachers adapt to a transition. This research explored Schlossberg's 4S's in relation to the teachers' transition (Situation, Self, Support and Strategies) according to the features of adaptation (perception of the transition, characteristics of the environment and characteristics of the individual – See Table 6.1). Cross-case analysis of the teachers' resources informed the findings of the study as they were situated, according to aspects of their own self, considering their supports and identifying their particular strategies for adapting successfully to the transition. Ziegenfuss (2020) created a matrix to utilise the Transition Model in order to support graduate student needs. They proposed an assessment tool based on the integration of two models and applied themes from the assessment of students needs to inform actions required to support students (Ziegenfuss, 2020, p.313). This approach could also be a possible next step to apply the findings from this thesis to design an assessment tool that could support novice physics teachers.

This research also shows how it is useful to consider the trends presented in the themes by teachers but also respect the individual nuances of teachers' experiences on a case by case basis. Case Study A highlighted the general trend

of the data when establishing the transitions that were taking place. Case Study B focussed on each individual teachers journey through that transition. This allowed for the data to be scrutinised; generally, then with more granularity and finally the data could be compared to either confirm findings or highlight nuances within the data set. For example, Case Study A highlighted that teachers experienced burnout between week 24 and week 30 (See Section 0). Case Study B attributed this burnout with a high degree of stress, onset and timing of the transition and supports that teachers felt they lacked (See Section 6.5). Although this approach was not the focus of the thesis (the researcher wanted to ensure the data was not over-read), value can be seen in hoe this approach to shed light on specific instances that may need more insight from the participant (or vice versa [the collective]). Overall this study provides novel evidence that transition theory can be effective to examine the context of novice physics teachers needs and consider the uniqueness of each individual teacher transition, as Schlossberg's theory suggests (Goodman, Schlossberg and Anderson, 2006).

Observation 2

Schlossberg's model for analysing adaptation to transition is a useful model for understanding the holistic nature of novice physics teachers' transition from pre-service teacher to in-service teacher. However, a limitation of this model is its ability to capture teacher identity. This study probed teachers' perceptions of their identity using the interview protocol (connected to the resource *Self).* Here, teachers' initial responses described their personality traits and interests to convey their identity as is also reported in the literature (Makovec, 2018). When probed for further detail about their identity, teachers could not see how any aspect of them would be different from any other teacher (See Table 6.3).

It is worth considering here, what the resource *Self* represents. Perhaps it constitutes all of the indicators related to identity or contrary to that, identity, teacher identity or teacher professional identity are separate and unique indicators. Considering the developmental nature of teacher identity (Mockler, 2011) that occurs within social settings (Smagorinsky *et al.,* 2004) this study suggests adapting the "*Self*" resource, in Schlossberg's transition theory, to incorporate and integrate teacher identity in order to capture this important evolution of novice teachers' adaptation to a transition.

Observation 3

Examination of teachers' experiences related to the supports they utilized over the two years indicated that teacher collaboration was an important aspect to consider for novice physics teachers. Firstly, there is a strong connection between the themes that are focussed on support (in Chapter 5) and how novice teachers viewed support individually during these two years (in Chapter 6). Themes from Chapter 5 were centered around different sources of support and how they changed over time e.g., peers and pre-service teacher education -> cooperating teachers and newly qualified teachers -> colleagues, students and networking outside of the school. In this study (Chapter 6) teachers also spoke about the different sources of support combined with the purpose of that support to them such as, family and friends (for social outlet), colleagues, students and pre-service education (for professional support) and RPPs and other networking events (for professional support outside of their school). These findings align with the literature to suggest that support is a key aspect of novice physics teacher transition (Akiri and Dori, 2022).

RPPs were established in the middle of this study as a consequence of teachers feeling disconnected from their peers during school placement and the lack of support they reported during this period. Half of the cohort described RPPs as being a useful support during the first year teaching (See Table 6.4). The implementation of the RPP model, in this case study, adds to the findings in the literature that describe the attributes of an RPP as creating mutualistic relationships with participants, negotiating norms and fostering networks for collaboration (Coburn and Penuel, 2016, p.49). Interventions that were incorporated into the RPP design included: establishing shared goals and shared group norms, effective role division, adapting a critical reflective attitude, developing mutual trust, encouraging task ownership, enhancing perceived interdependence as well as a collective memory as is documented in the literature (Brouwer *et al.*, 2012, p.340).

The research in this thesis was cognisant of previous research findings that warned of the challenge of hierarchal roles within an RPP (Guerrero-Hernández and Fernández-Ugalde, 2020). Researcher reflections were implemented in the design of the RPPs to inform the design and enhance mutualism (See Appendix – researcher reflections and RPP agendas). Caution was also warranted where

teachers that were part of an RPP still saw their role as secondary status to the researcher and in these cases an emphasis on mutualism (See Researcher notes-Appendix H) and promoting teachers as researchers in the process was a necessary step (Penuel and Gallagher, 2017; Guerrero-Hernández and Fernández-Ugalde, 2020).

7 CHAPTER: CONCLUSIONS & IMPLICATIONS

"To think of a thing is just to be conscious of it in any way whatsoever"

(Dewey, 1910, p.1)

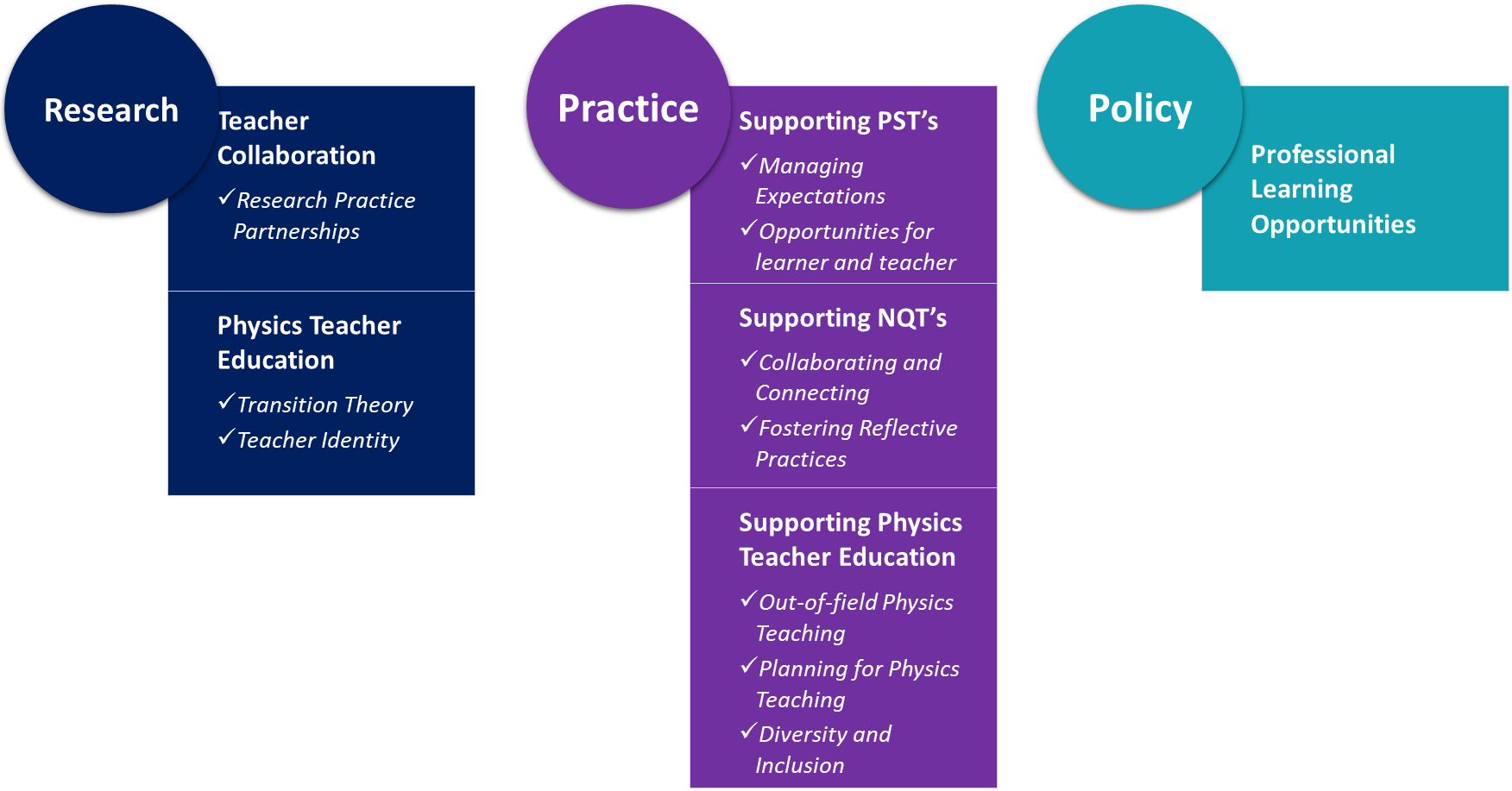
7.1 INTRODUCTION

This research explored the overarching question, "*How can we enhance physics teacher professional learning in Ireland?".* The overall aim of this research thesis was to inform the teaching and learning of physics and to enhance professional learning of physics teachers by gaining a deeper understanding of how they experience the transition from pre-service teacher to newly qualified teacher. This chapter presents the conclusions and implications of the findings from the research questions of this PhD thesis:

1. What are science teachers' experiences of engaging in professional learning for physics at Junior Cycle?
2. What are teachers' experiences of becoming a novice physics teacher?
    a. What transitions are occurring throughout teachers' experience?
3. What adaptations do novice physics teachers experience across transitions?

This first section of this chapter discusses the conclusions and implications of this research related to teacher collaboration and physics teacher education (Section7.2). Conclusions and implications of this research on practice (in teacher education) focusses on supporting pre-service teachers (PSTs), newly qualified teachers (NQTs) and all physics teachers. The final section, 7.4, presents conclusions and implications related to policy and outlines how we can enhance physics teacher professional learning opportunities. Figure 7.1 presents an overview of the implications of this thesis on Research, Practice and Policy.

Figure 7.1: Implications of this Thesis on Research, Practice and Policy



7.2 RESEARCH

This section highlights the relevance of the research presented in this thesis to existing theory. The first section outlines how this thesis has added to the literature in the description of the implementation and design principles of RPPs in Irish physics education. Section 7.2.2 highlights the gap in literature related to examining novice teachers' university experience through to their early years of teaching and how the theoretical framework adopted helps to explore teachers' experiences during a transition. A gap in the findings related to teacher identity is also described in Section 7.2.2 and suggestions for further study are presented.

7.2.1 Teacher Collaboration

The process adapted in this thesis emphasises the "co" in collaboration which should be the backbone of the design process – "a process of joint inquiry and imagination" (Steen, 2013, p.18). Findings from the pilot study highlighted the ways in which collaboration manifests in the teaching and learning of science (See Section 4.6.1), in a formal (subject department meetings) and informal capacity ("chats" with colleagues) and highlighted the need for collaborative professional learning opportunities (Petroelje Stolle and Frambaugh-Kritzer, 2014). Findings from the pilot study (Chapter 4) also indicated the benefit of including a variety of facilitators with different perspectives and so a Research Practice Partnership model (RPP) was introduced in Case Study A to fulfil the needs of novice teachers.

Research Practice Partnerships

The RPP approach incorporated in this thesis reinforces a holistic perspective (considering the shared goals of all its members – research conducted with the teachers rather than onto the teachers) to collecting data in a meaningful way through the RPP model. Here, participants were involved in the data collection and could use the findings from the data as a point of self-reflection and to inform their classroom practice. However, research related to RPPs must go beyond defining problems to presenting the importance of the problem to all stakeholders, include a commitment to systematic inquiry and evaluate multiple qualities and research products through co-design (Penuel *et al.,* 2020). Co-design has been credited with high quality professional learning (Kelly *et al.,*

2019; Juuti *et al.,* 2021), increased collaboration resulting in stronger workplace relationships (Brown *et al.,* 2013; Juuti *et al.,* 2021) and a focus on supporting student learning outcomes (Campbell *et al.*, 2019; Juuti *et al.,* 2021). Some of the steps in co-design are outlined by Penuel, Roschelle and Shechtman (2007) and include taking stock of current practice and classroom practices, constructing metrics of success and providing opportunities for sharing experiences.

This research in this thesis also highlighted the challenges associated with the specific support required by novice physics teachers and how RPPs could be further improved to support their needs (See Table 6.4). Creating various levels of support within RPPs to meet the professional, personal and social needs of teachers (Sikma, 2019; Akiri and Dori, 2022) has been identified from teachers' transition (Chapter 5) as necessary to their successful adaptation to in-service teaching from pre-service teachers' education (Chapter 6). However, further research is needed to understand how to navigate and integrate supportive groups (experienced teachers, novice teachers, subject specific teachers, science educators, management) and organise meetings that meet the needs of all partners involved.

This research acknowledged the necessity of implementing RPPs for long periods of time in order to implement actions and present research practice outcomes (Penuel and Hill, 2019). However, access, funding and participant continuity (retention of teachers and researchers) become significant barriers to the process. There is a need to investigate further the impact of participation in RPPs on teachers' understanding of the research process, appreciation for the value of research to inform decisions and engagement in research informed practices (Coburn and Penuel, 2016). Some research findings indicate that teachers can see the benefit of including research and processes of inquiry in their practice (de Paor and Murphy, 2018). However, more is needed to embed structures to facilitate these processes into RPPs.

Studying partnership effectiveness is also an area that is under-researched and lacks depth of knowledge to support claims of progress of an RPP (Penuel and Hill, 2019. The RPP Effectiveness Framework assesses five dimensions of an RPP: building trust and cultivating partnership relationships, conducting rigorous research to inform action, supporting the partner practice organization

in achieving its goals, producing knowledge that can inform educational improvement efforts more broadly and building the capacity of participants to engage in partnership work (Henrick *et al.,* 2017). Within this framework Henrick *et al.,* (2017) outline indicators of success and call for researchers to customise the framework to consider the goals of the RPP. Penuel and Hill (2019) build on this suggestion to include gathering evidence of how each of the dimensions manifest within the RPP in order to support claims of progress. The research presented in this thesis promotes the need for further studies on RPPs that detail the outcomes of RPPs and measure the impact of RPPs on professional learning (Henrick *et al.,* 2017).

7.2.2 Physics Teacher Education

Teacher transition is sparsely reported in the literature and there are even less studies documenting the application of Schlossberg's transition theory to teacher education. The findings from each of the studies in this thesis make significant contributions to literature in this field, in particular the use of transition theory as a lens to investigate teacher professional learning.

Transition Theory

This research delved into formally identifying teachers' transition from pre-service to in-service teaching (Case Study A, Chapter 5) and reporting on their adaptation to the transition at a particular point in that transition (Case Study B, Chapter 6). Schlossberg's transition model was shown to be effective in documenting novices' process of transition from pre-service teacher to newly qualified teacher. The application of this model can help researchers understand at which developmental stage novice teachers are in their career and therefore could contribute to differentiated support for teachers during their transition from pre-service teacher to newly qualified teacher (Zhukova, 2018, p.111).

It was found that change in transition was a difficult point to determine especially between *moving out* and *moving in*, as the lines between leaving behind old roles and taking on new roles was blurred. For our teachers these two aspects of transition were sometimes happening simultaneously as teachers were experiencing school placement both as a learner (old role) and a teacher (new role). Although teachers started their role as newly qualified teachers in Year Two of Week 1, they began moving into this role by the end of school placement (Year One Semester 2) up to at least Year Two - Week 30 until such time they felt settled in their new school. The themes identified during this transition aligned with findings in the literature that report on different aspects of teachers' transition (Pietsch and Williamson, 2010; Bullock, 2017; Nguyen, 2017; Keiler, 2018) and also with Schlossberg's transition model and was a way of conceptualising the themes in terms of novice teacher transition. The application of the Schlossberg's model also helped to document and examine novices' experiences in terms of a journey through a transition and help understand the teachers' needs at different points in time.

It was important in this study not to assume that an anticipated event, such as starting a new job, was the exact point at which these teachers moved into a new transition (Goodman, Schlossberg and Anderson, 2006, p.34). Case Study B valued this conceptualisation of transition in the design of the data collection tool (where the protocol probed what the individual viewed as the most significant transition over the past two years) and also in the reporting of the experiences of individual teachers. The analysis of teacher data in Case Study B was a novel way of providing insights into the teacher as an individual, identifying issues in professional learning as it was lived by the teacher, gaining a holistic perspective of the teacher as more than just "the teacher" but as a person with personal experiences and contextual environments that affect their journey. This research provides an opportunity to address calls from researchers to involve teachers at several points in the development of professional learning opportunities (Montalbano *et al.*, 2012). The findings from this thesis may provide a closer stepping stone to transform the current theorisation of effective professional development, into a reality, by involving the "interpreters" (the individual through which the professional learning is lived in the classroom i.e., the teachers) viewpoint (Choi and Walker, 2018; Huang *et al.*, 2022).

The application of transition theory, more broadly, has proven an effective lens to examine teacher adaptation to transition as changes occur in physics education. In a similar way, transition theory may prove useful to examine the experiences of teacher transition within other areas of reform such as curriculum changes, technological advances or engagement in professional development, or other subjects. These insights could enable teacher educators to design and adapt professional learning that addresses the specific needs of the participant teachers as is used currently to troubleshoot graduate student needs (Ziegenfuss, 2020) or identify supports for enrolled nurses (Wall, Fetherston and Browne, 2018).

Teacher Identity

Teacher identity emerged as a missing construct of Schlossberg's transition theory particularly in Case Study B. Teachers reference to personality traits and interests as part of their identity brings to light an extra dimension to teacher identity that may need to be considered within *Self* in the transition model. This interesting gap in the data revealed two possibilities for teachers not declaring particular aspects of their identity (state of health, race, ethnicity, gender/sex as per adaptation to transition) that might influence their experiences. Firstly, teachers did not feel they were unique in any way to other teachers in the field. The second possibility for teachers not declaring particular aspects of their identity could be related to their understanding of what identity is and is also linked to a limitation of this study (See Section 7.5).

Brown (2006) claims that teachers' identities are formed as a consequence of their interaction with their historical self. He suggests that we, as teacher educators, must understand how pre-service teachers engage with their self and their acquisition of a functional teacher identity (Brown, 2006). Nguyen (2017, p.406) explored pre-service teachers' identity using Engeström's (1987) structure of human activity system and found that these teachers entered the practicum with multiple identities such as university student, student teacher and classroom teacher. They suggest that teacher identity development evolves through interactions with their teacher education, relationships with cooperating teachers or mentors and interaction with professional practices (Nguyen, 2017). This aligns with the findings in this study as the pre-service teacher reports balancing roles in the *moving out* and *moving in* transition period (See Chapter 5). Pietsch and Williamson (2010) identify the second stage of teaching (6 months after they enter the profession) as the point at which novice teachers begin to focus more on their professional identity. Case Study A identifies specific instances (Year Two Week 24-Week 30) when teachers began to engage in these different aspects such as considering professional learning through networking, using past experiences to inform future practices, focusing on how to improve organisational skills and enhancing PCK (See Figure 5.3).

Teachers engage in cycles of negotiating their professional knowledge of practice, profession and self in their development as a teacher and each aspect determined the success of the next (Pietsch and Williamson, 2010, p.337). The

phenomenon of nurturing each of these domains in order to develop professional teacher identity is evident in the findings from this study. It was found that if an individual's adaptation to the transition caused too many deficits of one resource that these deficits were also seen across other resources e.g., when teachers felt like they were experiencing imposter syndrome in the *Situation* resource, they may also have had little internal or institutional *Supports* (See

Table 6.4). Understanding the dynamic nature of novice teacher identity could provide information-rich findings that contribute to the Transition model and make it more holistic and adaptable to novice physics teacher education.

Integrating a model such as the extended didactic triangle (Stenberg and Maaranen, 2021, p.2) in the data collection and analysis phase could provide an opportunity to capture this aspect of teachers' transition. Stenberg's *et al.,* (2014) model incorporates Dialogical Self Theory (DST) to examine identity through the self, according to different I-positions ("I" as the co-teacher, "I" as an orchestrator of teaching, "I" as a pedagogue, "I" as a work community member, "I" as a collaborator with parents, "I" as the teacher) (Stenberg and Maaranen, 2021, p.5). Considering the implication of the pedagogical relationship, the didactic relationship, the content relationship, the teacher relationship, and the context relationship could inform how physics teachers position themselves and create their identity as a physics teacher (Stenberg *et al.,* 2014). It would be interesting in this future work to establish if the content domain features in the examination of novice physics teachers I-positions (as this was not a factor to consider for primary teachers in this study) (Stenberg and Maaranen, 2021).

7.3 PRACTICE

The conclusions and implications of this thesis on practice (teacher education practice) builds on existing literature and are considered the findings related to all teachers of physics (both novice, experienced and out-of-field). This section describes ways of supporting pre-service teacher education, teacher education for newly qualified teachers and physics education for all teachers.

7.3.1 Supporting Pre-service Teachers

This section describes the implications related to the two main findings associated with pre-service teachers that are presented in Case Study A and Case Study B: managing expectations, opportunities as learner and teacher.

Managing Expectations

Case Study A and Case Study B findingsrelating to novices' experience of their transition highlighted the practice shock they had moving from university to the working environment (Stokking *et al.*, 2003; Ballantyne, 2007). Teachers had to manage a new role change with extra responsibility and accountability, increased workload and integration into a professional community while also focussing on their teaching. These expectations seemed to be challenging for teachers as they describe their high degree of stress during this period (during school placement and at the start of the school teaching year). Some of the factors contributing to this stress was described by teachers as juggling their limited knowledge of equipment, knowledge of curriculum, pitching lessons at the correct level, selecting resources, sequencing lessons, assigning homework, balancing traditional teaching approaches, familiarity of the school, organisation of school inducting new teachers etc. Ballantyne (2007, p.184) investigated the underlying factors that result in practice shock for early career music teachers and identified the "physical and professional isolation within the school; and high workload and multiple responsibilities associated with the extra-curricular music programme". Similar to the case of physics teachers, music teachers are often the only teacher in their department (Ballantyne, 2007) and this feeling of isolation often results in teachers struggling to find support from subject specialists (See Teacher 6 – Case Study B).

Pre-service teacher education has the opportunity to offer some insight into in-service teaching to help manage novice teacher expectations and transition into

the workplace through interactions with early career teachers (Kelly, Clarà and Kickbusch, 2015). Early career teachers could be a useful resource to support pre-service teachers in their navigation of school life, where to find resources, how to be accredited etc. Mercieca and Kelly (2018) describe how novice teachers already navigate social media groups (private Facebook groups) for job seeking support (point of connection with peers from pre-service education, initially formed to share resources), subject support (also with pre-service peers) or situation support (anonymous group where struggles could be shared). Kelly, Clarà and Kickbush (2015) developed an online community for teachers (pre-service teachers and early career teachers) to network and support their transition into in-service teaching through the enhancement of teachers' situational knowledge (related to items of confusion for resolution) (Kelly, 2019, p.11). However, they found that the social connections of these environments were insufficient to support this situational knowledge and more is needed to understand how set design, social design and epistemic design interact to provide effective online communities (Kelly *et al.,* 2018; Kelly, 2019).

Consideration of stress management, efficient time management and organisational techniques to assist an increased workload are just some aspects that would help to support novice teachers (Stokking *et al.,* 2003; Rieg, Paquette and Chen, 2007; Gavish and Friedman, 2010; Zhukova, 2018). Researchers propose mentorship as a suitable vehicle to support pre-service teachers in developing their teacher identity and situating themselves in realistic teaching scenarios to learn in a scaffolded way (Nguyen, 2017; Zhukova, 2018). The finding suggests that priority should be given to developing effective mentoring relationships (Nguyen, 2017; Ellis, Alonzo and Nguyen, 2020). Many parallels can also be drawn from Ballantyne's (2007) study of music teachers to pre-service physics teacher education. Inclusion of real teaching experiences in pre-service teachers' study and discipline specific induction are some of the more subject-related interventions that could support physics teachers in their transition (Ballantyne, 2007; Etkina, Gregorcic and Vokos, 2017).

Opportunities as Learner and Teacher

Findings from this research also suggest a shift in novices understanding of teaching and the role of the teacher in student learning (Case Study A – Chapter 5). This study showed that often teachers' transition from student to teacher was a barrier to their understanding of their role in student learning. Hopper (1999) shares this interest in his report reflecting on pre-service teachers' experience of being taught. By using a grid (tool to identify characteristics of student teachers), he exemplifies how teachers can reframe their experiences of being taught as experiences of learning to teach. He found that pre-service teachers use the grid to "make explicit many aspects of their implicit beliefs regarding effective teaching" (Hopper, 1999, p.57). Dillon (2017) highlights that often pre-service teachers engage in the coursework of their degree as a student and bring these behaviours to teaching modules which often try to create a more professional environment. They suggest specific interventions to target the student to teacher transition and also align with messages from other professionals in their course (e.g., cooperating teachers and university supervisors) (Dillon, 2017). Creating a space for teachers to challenge their ideas by experiencing teaching approaches as a learner and then a teacher may help in this transition.

This study shows that pre-service teachers would benefit from interventions to shift their perspectives from "teaching" to "student learning" early on in their pre-service education. Modelling practice in university offers pre-service teachers opportunities to see experience (develop perceptual knowledge), see different types of teaching decisions in practice, understanding action (what they actually teach) and intent (what they intend to teach) and reframe ideas through collaboration (Loughran and Berry, 2005, p.202).

Providing opportunities for pre-service teachers to critique their lecturers' teaching approaches (See Chapter 5) and then try to implement how they see them being lived to enhance student learning could help teachers critically evaluate teaching approaches and shed light on some of the "invisible thinking processes behind the scenes" (Etkina, 2010, p.4). Etkina (2010) describes a graduate program for preparing physics teachers that adapts a cognitive apprenticeship approach. This type of approach champions observation of desired practices, carrying out the practice and receiving expert feedback, coaching and scaffolding (Etkina, 2010b).

7.3.2 Supporting Newly Qualified Teachers

This section describes the implications related to the three main findings associated with pre-service teachers that presented in Case Study A and Case Study B: Collaborating and Connecting and Fostering Reflective Practices.

Collaborating and Connecting

This thesis emphasizes the importance of support by identifying the internal, external and physical setting that teachers drew on during their first year of teaching (See SectionTable 6.4). Teachers in this study report strategies related to belonging as they suggest getting involved in the school community and building student-teacher and collegial relationships (See Chapter 6). As is widely reported in the literature, support for novice teachers is an integral part of their feeling of belonging in their working environment (Kelly, 2013; English, 2021). Tammets, Pata and Eisenschmidt (2019, p.38) also suggest practices such as networking (socialisation), self-learning activities (plan and reflect) and collaborative knowledge building (sharing of professional practices) in their model to provide a better experience of induction for novice teachers.

The findings presented in this thesis identified the gaps in support as; structured supports within the school system for newly qualified teachers, relevant and tailored support from university based on their problems of practice and networking opportunities to connect socially with other teachers experiencing the same transition (Flores *et al.,* 2011; Clark, 2012b; Fresko and Nasser-Abu Alhija, 2015; Sikma, 2019; Akiri and Dori, 2022). Fresko and Nasser-Abu Alhija (2015) report that communities with teachers of the same professional status (novice teachers) and outside of school in a familiar surrounding made PLCs non-threatening environments for emotional support. The research presented in this thesis also highlighted the importance of novices having a colleague within their subject discipline to ask for advice on specific teaching approaches or content related to their subjects (Ellis, Alonzo and Nguyen, 2020).

Gordon (2020) highlights the importance of centering the support for teachers around the individual and moving away from a "one size fits all" intervention. She advocates for links between university and schools, developing CoPs and high quality mentoring support (Ellis, Alonzo and Nguyen, 2020; Gordon, 2020). Higgins *et al.*, (2013) describe university-school partnerships with

experienced teachers (practice educators) to support pre-service teachers in the classroom. These practice educators provided support (feedback) and guidance for pre-service teachers and also a connection to university tutors to discuss the progress of teachers (Higgins *et al.,* 2013) that could be useful for novice teachers. Utilising Research Practice Partnerships (Penuel and Gallagher, 2017) so that they involve multiple avenues for different types of support such as subject discipline expertise within the school, novice teacher network within and outside the school, university support based on specific needs and professional learning opportunities could be a solution to novice teachers call for support. This model (RPP) also has the capacity to consider support tailored to the individual teacher (Gordon, 2020) and encompass the emotionality of collaboration with each of the partners involved (Higgins *et al.,* 2013).

Fostering Reflective Practices

The findings from special cases within this thesis presents justification for the value of reflective practices to support newly qualified teachers during their transition from pre-service teacher. These special cases arose from the comparison of findings between Case Study A and Case Study B. An important part of reporting the findings of Case Study B was to respect the individual cases within the study. In doing this, particular observations arose that showed inconsistencies between the adaptations reported in this chapter and how they correlated to the themes reported on in Case Study A.

Special Case 1 and 2 below show how teacher reflections at particular points in time, evolve in retrospect. In some cases, issues that were emphasised at the beginning were no longer relevant. In other instances, new issues were presented, as a consequence of changing contexts (school environments) or life events (transition).

- *Special Case 1*

Findings from the teacher journey represented in Case Study A (the teacher as the learner > new role as a qualified teacher > balancing tensions in a new role > burnout from increased workload > taking stock and looking forward > making to the end) appeared to differ for one participant when they looked back on their experience as a whole in the final interview.

In the initial analysis, this teacher appeared passionate about teaching and wanted the very best for their students which was also often the main source of stress as reported in the journey represented by the whole cohort in Case Study A. They describe their concerns at the point at which the study identified that teachers were experiencing burn-out:

> *"Having to rush practicals due to time constraints or room availability. Preparing a Leaving cert class to be in a comfortable place to sit their state exams at the end of the year. The extreme variation in class numbers due to the pandemic causing me to be both teaching in class and online simultaneously. The correction and upkeep of student works both online and in class with restrictions in place." – Teacher 6 (Year Two – Week 24 – RPP reflection)*

However, during their end-of-year interviews this urgency and stress was not reflected in the teacher's overall perception of their experience.

> *"I find that if I try and look to forward into the future I won't be able ..to control anything that can't happen right there and then, so I kind of adapt as best as I can, and then kind of wait for it to happen and adapt there and then.." – Teacher 6 (End of Year Two Interviews)*

This observation was not so unusual as the source of stress had passed, however reflecting back on the experience could be an opportunity for novice teachers to plan ahead and develop strategies for adapting to situations of high stress (Tammets, Pata and Eisenschmidt, 2019).

In the final interview this teacher also felt they had adopted an identity as an "invisible learner", keeping under the radar in their first year of teaching.

> *"Not really I kind of was as attentive as I could to most things I was doing this year just because I didn't want to stand out or make any*

mistakes. If I flew under the radar that was perfectly fine by me." - *Teacher 6, (End of Year Two Interviews)*

This was a particularly unusual statement as most of the other teachers reported trying to fit into the school community. Here, this teacher may have been negotiating isolation as the only physics teacher in the department (Long *et al.*, 2012).

- *Special Case 2*

Findings from data collected at the end of Semester 1 (see Section 5.4.1) reported how teachers considered planning and implementing lesson ideas presented to them as part of their Physics Methodologies module in final year. Here, the data suggested that teachers considered suitable adaptations to make to resources and critically analysed their use in the classroom.

"*If I were to use it in a classroom scenario I would use it to introduce method writing in experiments. By starting off with this activity before starting the experiments I could see what the students thought process for writing step by step instructions could be and help them make changes where appropriate." – Teacher 3, (Year One, Semester 1 – RPP reflection)*

Contrastingly, the findings presented in Case Study B show that Teacher 3 in particular deviates from this practice by the time they have completed their first year of teaching and reports the impracticality of some of these resources presented during their pre-service teaching.

"..like they just don't like them, the lessons don't flow as nice as they would have like I did the one on forces with the class where like they had the blu tac ball and they change into different shapes and I was like oh yeah this would be a really lovely class. Yeah no, they just they don't work so you have all these expectations of these like worksheet packs and resources that you'd have from college, then you bring them into school and then they're terrible," – Teacher 3, (End of Year Two Interviews)

As a novice, this teacher was overwhelmed by increased level of work and responsibility and do not seem to have time or teacher maturity to adapt resources easily. This finding may suggest that teachers need time and space to

critically reflect on the usefulness of their resources as they did in their pre-service teaching modules (See module outline Table 3.11).

This special case 2 also highlights that newly qualified teachers would benefit from targeted support in university to learn how to adapt teaching resources in order to make them more accessible for the variety of circumstances found in different classrooms (Gordon, 2020).

- *Key Learnings from Special Case 1 and 2*

These special cases highlight two main points. Firstly, these research studies are a form of teacher reflection that can be shared with pre-service teachers to learn from the experiences of newly qualified teachers. Cochran-Smith and Lytle (1993) proposed that the expertise of teachers should be made accessible to provide teacher educators, school communities and teachers alike with unique perspectives on teaching and learning. They described an analytical framework of teacher research that outlined a systematic collection of empirical evidence (journals, oral inquiries and classroom studies) and conceptual research (teacher essays) by teachers. Schön suggests that reflection-in-action can act as the bridge between university and practice where practitioners reflect on tacit theories behind practice (those that are difficult to read about) and compare them to formal learning theories in an effort to encourage practitioners to learn from each other and from the literature (Schön, 1987, p.321).

Secondly, the value of reflective practice as a newly qualified teacher may be a solution to some of the issues mentioned previously such as managing stress and taking stock of experiences. Moon (1999) considered five conditions for reflection: sufficient time and space, a facilitator that understands the nature and purpose of reflection, reflection supported through the curricula or institutional environment, an emotionally supportive environment and consideration of hidden agendas of the environment. These teachers had been exposed to this type of reflection as part of their Physics Methodologies module in Year One (See Table 3.10 for outline). However newly qualified teachers may also benefit from having this space for reflection and reframing of their practice. In this thesis, teachers were beginning to take stock of their experiences to inform their experiences for the new year to come at the end of the study. This practice could be seen as a consequence of the reflective practice involved in the data collection

of this research (regular check-in surveys during the RPPs and talking about experiences during the interviews). Practitioner inquiry also lends itself to the implementation of reflective practice, evidenced-based practices, documentation of impact on student learning, enhancement of teacher leadership abilities, principal professional development and development of knowledge related to the complexities of teaching (Fichtman Dana, 2016). MacDonald and Weller (2017) describe how their involvement as novice inquirers to experienced facilitators of practitioner inquiry with their colleagues helped them to expand their roles as teachers to leaders. This suggests that teachers' involvement as reflective practitioners could enable them (in time perhaps) to champion reflective practices with their colleagues. Increasing academic equity in their assessment practices was just one of the impacts of collaborative practitioner inquiries cited in the literature (MacDonald and Weller, 2017).

7.3.3 Supporting Physics Teacher Education

This section discusses the conclusions related to ***all*** teachers associated with enhancing the teaching and learning of physics. These included conclusions and implications related to out-of-field, planning for physics teaching and diversity and inclusion.

Out-of-field Physics Teaching

Du Plessis (2020) tried to understand the issues faced by out-of-field STEM teachers through a qualitative investigation of directors, principals, teachers and parents from two countries. They conceptualise the experience of out-of-field teachers as their lived experiences that are outside of their expertise, their unsuitable qualifications in a subject area and their struggle to effectively align theories and practice within the discipline (Du Plessis, 2020, p1470). Their (Du Pleiss's) findings report that out-of-field teachers express concern with how to effectively connect concepts, incorporate real world science, link concepts to other subjects. However, these findings also highlight the influence these concerns of teachers have on their professional identity (Du Plessis, 2020). Teachers in this thesis highlighted their persistent lack of confidence with the teaching of physics at Junior Cycle in the Pilot study (Chapter 4). Their call for sustained professional learning focussed on enhancing their physics content knowledge was also reflected in the themes presented in Case Study A. Here, it

was evident that there was a strong focus on pedagogical content knowledge in physics teaching.

The findings from the pilot study (See Chapter 4) indicate that teachers enjoyed engaging in professional learning in physics and it influenced their practice in a positive way as they began to implement some of the ideas from workshops. This aligns with Mizzi (2021) who reported that teachers teaching outside of their specialism felt more confident to take risks and try activities in their classes after engaging in professional development in the chemistry. Their professional learning experiences were centered around hands-on activities, collaboration and reflection (Mizzi, 2021). This study also discussed the effect of teaching a new subject had on teachers' professional identity. They suggest that along with professional development support, teachers must be open and willing to alter their beliefs and values in order to reshape their identity (Mizzi, 2021, p.719). Researchers advise that collegial support and external input in a strong learning environment may be needed to enhance identity learning (Kenny, Hobbs and Whannell, 2020).

Planning for Physics Teaching

One of the tasks that novice teachers reported to be the most onerous in their final school placement and first year of teaching was their lesson planning. Teachers felt overwhelmed during school placement to complete lesson plans in a timely manner and also prepare everything that came with a lesson e.g., organising equipment, carrying out background research, preparing assessments and other resources to teach a lesson. They also reported the issues they had implementing the lesson, despite their hours committed to lesson planning related to classroom management, assessment, knowledge of curriculum and resources (see Figure 5.3). As outlined by John (2006, p.489) novices describe their planning as time consuming because they cannot conceptualise the happenings in the classroom due to their lack of experience. When teachers completed their first year of teaching, becoming more organised and planning to focus on deeper student learning was their priority (See Chapter 5 & 6). This research identifies an opportunity to center lesson planning around a model of creative lesson planning that focusses on the processes of planning and enhancing PCK (Juhler, 2016) rather than the outcome of a lesson plan as a finished product. In a study reported by Loughran, Mulhall and Berry (2008),

pre-service teachers' lesson plans were found to exhibit a stronger conceptual base and teachers developed a sense of confidence in their planning after being introduced to PCK through CoRes and PaP-eRs. They highlight that teachers adopted a language that enabled them to communicate with more experienced colleagues in order to integrate theory and practice in positive ways in their own practice (Loughran, Mulhall and Berry, 2008).

Formal lesson planning is a less common practice among in-service teachers which in turn can lead to very narrowed teaching of "topics" rather than "big ideas", As was observed from the planning workshops with teachers in Chapter 4, giving teachers the time and space to creatively plan and organise their resources as a department was a valuable practice that led to more unified thinking and collaboration on how to teach physics concepts (See Section 4.5).

> *"Bringing all the physical world and the chemical world and the biological world and science and whatever altogether.…definitely I'd say the involvement with um [the facilitator] hugely helped that. I'm not sure whether we would have come to that conclusion ourselves without some direction." – Teacher 8 (IST)*

Encouraging creative planning opportunities for all teachers and scaffolding planning so that teachers become skilled in lesson planning and draw on their learnings from university may be a solution to addressing part of the overwhelming experience that novices have reported in this study related to lesson planning (Chapter 6). John (2006) proposed a model that changes as the teachers move through their initial teacher education and highlights the iterative process of planning. This model can be applied at different levels of complexity to encompass the function of a lesson plan, connections between classroom management, subject content and the curriculum, real teaching situations, joint planning and guided reflection. John (2006) then describes how the model can act as a creative tool as teachers become more experienced. Windschitl, Thompson and Braaten (2011) also acknowledge the challenges novice teachers face in the planning process and conceptualise collegial analysis (analysis with colleagues) and discussion of student work in planning. They facilitated sessions with pre-service teachers after they had engaged in school placement to analyse student work for trends in how students learn differently (Windschitl, Thompson and Braaten, 2011, p.1319). These processes of planning may offer some

transferability from pre-service teacher education to in-service teacher education both for novices and experienced teachers.

Diversity and Inclusion

Preliminary findings from the pilot study suggest embedding awareness of inclusivity and diversity practices across the whole school and creating opportunities for teachers to reflect on how their specific subjects may contribute to negative stereotypes that create barriers for student participation. Banks & Banks (2019, p.19) highlight that in order to embed meaningful and equitable learning there must be content integration, knowledge construction, prejudice reduction, equity pedagogy and an empowering school culture. They propose a framework to include these aspects in order to achieve a culture that promotes positive attitudes toward diverse cultural groups and helps students from these groups experience academic success (Banks & Banks, 2019).

The findings from Case Study A and Case Study B also suggest that teaching would benefit from reflecting the multi-cultural and diverse student population that has evolved in our classrooms today, as teachers view the demographics of the teaching profession to be very homogeneous (Rushton *et al.*, 2017). Keane, Heinz and Lynch (2020) report that student teachers wish to be relatable and inclusive teachers for their students even if they are from different socioeconomic backgrounds. They suggest that initial teacher education should focus on preparing teachers to be supportive of all pupils, as journeys from more privileged background to attending to students from less privileged backgrounds could be a difficult undertaking for novices (Keane, Heinz and Lynch, 2020).

7.4 POLICY

These studies highlight conclusions and implications for policy related to professional learning opportunities for physics teachers. Induction for newly qualified teachers, working relationships between schools and universities, physics specific professional learning, creative planning and reflective practice were all outcomes of this research and this section suggests possible interventions to address the issues highlighted by the teachers in this thesis.

7.4.1 Professional Learning Opportunities

Firstly, findings from this thesis suggests that professional learning opportunities for novice physics teachers should focus on formalising ***meaningful*** induction that involves both schools and universities to support teachers in their early years of teaching. All of the teachers in this study were participants in the Droichead scheme (both school-based and additional professional learning activities), however none of them spoke of this to be an adequate support in the transition to in-service teaching. The more that novice teachers feel well prepared by professional preparation at university and the more that they feel supported in the beginning of their teaching, the more coherent they experience their transition into the profession (Alles et al 2018). This research suggests that the formal induction that is currently in place in schools is not filling novices need for internal support, especially within their schools (see Section 6.5.3).

Secondly, creating a more organic link between universities and schools to support these novice teachers would be beneficial (Saka *et al.,* 2013) to;i)novice teachers for their professional growth (Luft, 2001), ii) their cooperating teachers for connecting with research and keeping current in their practices (Day, 2005; Rushton and Reiss, 2019), iii) the wider school community for teacher retention and iv) for universities to connect with schools for more in-depth and realistic feedback for teacher education programmes (Day, 2005; Higgins *et al.,* 2013). Th literature also outlines some of the issues that may arise from engaging teachers in induction that is too onerous on novices or cooperating teachers such as; occurring too frequently (or in-frequently), or being focussed on similar aspects to their undergraduate degree rather than their current problems of practice as they navigate their new role (Gordon, 2020).

Thirdly, providing professional learning opportunities for all physics teachers (including out-of-field physics teachers) to enhance their content knowledge for teaching and develop strong professional identities in the field would display a commitment to the teaching and learning of physics. Du Plessis (2020) emphasizes the necessity of creating subject specific professional development to attend to out-of-field physics teaching and show commitment to the teacher shortage.

This research suggests focussing on the ***process of planning*** to incorporate a more creative assignment that critically evaluates and exhibits teachers' knowledge and competence in planning an effective lesson. John (2006) highlights teachers' evolution of thinking from learning "how to teach" to learning "how to support student learning". He suggests that the policy surrounding design and implementation could encompass this evolution if it were used within university modules and is scaffolded across pre-service education modules. This may be lived out by creating meaningful opportunities for teachers to collaborate and develop PCK (Loughran, Mulhall and Berry, 2008).

Finally, the role of reflective practice and collaboration that supports the enhancement of physics teaching and learning is another key contributing factor that this research alluded to (see Chapter 5 & 6). Reflective practice has a key function of developing novice teachers' professional identity (Brown, 2006; Nguyen, 2017; Stenberg and Maaranen, 2021) and reshaping out-of-field physics teachers professional identity in their new subject (Du Plessis, 2020; Mizzi, 2021). Mechanisms such as practitioner inquiry (Fichtman Dana, 2016; MacDonald and Weller, 2017; McLoughlin and Sokolowska, 2022) and Research Practice Partnerships (Penuel and Gallagher, 2017; Akiri and Dori, 2022) are possible ways to systematically enhance the teaching and learning of physics. Policy also has the opportunity to reflect on the professional development of teachers to support personal and professional growth. Creating a pathway for teachers to develop and envision career opportunities (Luft, 2001) would be a positive step in professionalising teaching and making it a desirable option for our students choosing their career prospects.

7.5 LIMITATIONS TO THE STUDY

Limitations were recorded throughout the research by means of the researcher's reflective journal. For the most part when a limitation was encountered the researcher addressed the issues by either consulting the literature or altering the study design. For example:

One significant limitation on the research carried out in this thesis was that of the occurrence of the global COVID 19 pandemic from March 2020. There were many repercussions of this situation as raised throughout the thesis and in particular when introducing the context for Case Study A and Case Study B. Firstly, the study design had to be adjusted to carry out research practice in an online setting. Data collection also had to be conducted online which presented its own advantages and challenges (See Section 3.2.6). Finally, the influence of COVID 19 was very evident in the experiences of novice teacher's transition. As a result, it was difficult to separate some of the issues that arose as a result of a transition, from those that were present primarily as a result of the pandemic.

Overall, the generalisability of the results was acknowledged by the researcher as a limitation due the size of the sample in each study. However, as case study research suggests, this limitation is outweighed by its capability to provide information rich findings that can inform research policy and practice rather than provide a procedure for repeatability (Flyvbjerg, 2006). The findings presented in this thesis describe the power of recognising aspects of one's own experience in others' stories and that individual crises are often collectively experienced in different contexts (Brookfield, 1998, 2002).

The time frame of this research proved to be a limitation especially in continuing the Research Practice Partnership with novice teachers. Many of the teachers indicated that they would have liked to continue meeting and the findings from this thesis suggest that longer interventions are necessary to measure the impact and observe outcomes from a successful RPP (Coburn and Penuel, 2016). A similar limitation was experienced with the pilot teachers as they highlighted the need for further support in enhancing the teaching and learning of physics teaching (see Section 4.6.3).

The purpose of a pilot study is to inform the development of questions, conceptual insights and research design (R. K. Yin, 2009b). The pilot study that

was carried out with in-service science teachers (Chapter 4) was part of a wider initiative and periodically lacked rigour compared with a formal case study. As a result, findings from the wider study although comprehensive suggest key findings that require further research.

7.5.1 Opportunities for Further Study

This research detailed how Research Practice Partnerships were implemented to support teachers and collect data organically. However the findings from this thesis indicate further studies are needed to examine the influence of Research Practice Partnerships on teachers' practice and supporting novice teachers (Henrick *et al.,* 2017). Henrick *et al.,* (2017) suggest a framework to assess the effectiveness of RPPs and implementing this tool in a longitudinal RPP may have the capacity to further inform better avenues for teacher collaboration.

The implementation of RPPs is reported on in this thesis from the perspective of the teacher partners (Case Study A). Further studies to understand the influence of researcher involvement in the RPP to inform the design (See RPP agenda Table 3.13) and reflect on teachers' experience (See researcher reflections, Appendix H) would add another lens to inspect RPP impact.

One teacher from the novice physics teacher cohort did not continue in the profession. Further study is needed to explore the reasons for novice physics teachers exiting the profession after completing their university degree. Saka *et al.,* (2012) present a case study of a teacher in their early years and how their transition was disrupted due to conflicts with identity, context and realities of school. They suggest that these cases can inform schools and universities of the specific supports needed to prevent novice teachers leaving the profession (Saka *et al.,* 2013, p.1240).

Further opportunities for study arose from considering findings of documenting novice teachers' transitions. This study highlighted that it would be informative for future studies to investigate the transitions that teachers experienced up to and after the point of getting their first job as a qualified teacher (See Section 5.6). The research presented evidence of teacher's adaptation to transition at the end of their first year of teaching. Similar studies could investigate this adaptation over subsequent years to explore how teachers experience the benefits

and drawbacks of each transition and to identify what resources are needed to support their professional learning at different career stages.

7.6 CHAPTER SUMMARY

This thesis set out to investigate the teaching and learning of physics in Irish second level schools, from the lived experiences of the teachers. The studies presented in this thesis explored science teachers experience of teaching physics at Junior Cycle (particularly out-of-field physics teachers) and novice physics teachers' experiences of transition from pre-service teacher to newly qualified teacher. Building a strong connection with these novice teachers, who will be championing physics in second-level schools in Ireland, may help to strengthen the quality of both pre-service teachers' education and in-service physics teaching for students and teachers alike. Through maintaining a relationship with teachers and developing a partnership to connect with participants on a deeper level the research has tried to document teachers' experiences and provide useful insights into enhancing their professional learning.

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Appendix A FOCUS GROUP QUESTIONS

1. How do you approach your planning for the Junior Cycle?
    a. Individually
    b. As a department
2. What resources to you draw on for teaching the Junior Cycle?
    a. Book, Internet, PowerPoints, Other
3. Can you give examples of any of the Junior Cycle concepts you have difficulty teaching?
    a. Why?
    b. Teacher understanding, Student understanding, Teaching Approaches
4. Do you think reflective practice is part of your preparation as a teacher? In what way?
    a. Reflective practice of students?

Appendix B PILOT STUDY – POST-INTERVENTION INTERVIEW PROTOCOL

We would like to speak with you for approximately 20 minutes. ***Is it ok with you if we record the interview?***

Q1) To start with, could you briefly describe your participation in Improving Gender Balance Ireland?

Probe

- How project was introduced and socialised
- Expectations regarding participation
- Levels of support from immediate colleagues and senior management
- Colleagues reactions and perceptions

Q2) What, if anything, did you learn from the Improving Gender Balance Ireland workshops?

Probe (n.b. avoid leading questions)

- Comments relating to unconscious bias
- Comments relating to careers awareness
- Comments relating to confidence and resilience
- Comments relating to physics subject knowledge
- Comments relating to pedagogy
- Differences between whole school workshops and science teacher workshops

Q3) What, if anything, have you changed in your practice as a result of participating?

Probe

- Specific examples
- Impacts on students
- Establish teacher's science background if not already mentioned

Q4) Have you noticed any changes in your department or the school as a whole as a result of this programme?

Probe

- Nature of culture change (e.g. in relation to collaborative working)
- Working with other schools
- Impacts on students
- Extra-curricular activities

Q5) As I mentioned, there are plans to roll this programme out across Ireland. Do you have any advice for the programme organisers about this?

Probe

- Elements essential to making the programme a success
- Things that were un-necessary
- Things that could be improved

Q6) Finally, do you have any other feedback or comments about Inspiring Gender Balance Ireland?

Appendix C CASE STUDY A – INTERVIEW PROTOCOL

Thank you for agreeing to take part in the research which will be conducted by DCU researchers Ms. Deirdre O'Neill and Dr. Eilish McLoughlin. This study aims to support newly qualified teachers in the teaching, learning and assessment of physics at second level.

Interview 1 (May 2020):

Hi_____, I am going to record this meeting so I can transcribe it afterwards. I will also record on this device (dictafone) in case of any technical difficulties with Zoom.

There are no right or wrong answers for these interviews, I really just want to find out your feelings on your experience on teaching placement.

1. What experiences stood out to you on teaching placement? Why?
   Prompt: This can be in the context of teaching and learning approaches or strategies, assessment, differentiation, planning lessons, implementing resources, reflecting on practice etc.
2. Did you find that there were any supports in place that were helpful to you in the school you were teaching?
   a. or in university?
   b. Is there anything in particular you would have found helpful in your teaching that was not available to you/ you needed more of?
3. Can you describe any experience you had working/collaborating with others during your teaching placement?
   a. Who were they?
4. In your teaching of physics specifically, were there any challenges/barriers that you can remember encountering?
   a. Did you uncover any strategies/ways to overcome these challenges?
   b. Were there any experiences with your students' learning that were new to you?
5. Can you describe any particular physics concepts (at any level) during your placement that your students found difficult? Explain.
   a. Can you describe any particular physics concepts (at any level) during your placement that you found difficult? Explain.
6. What experiences have you learned from/ bring with you going forward now in your first year as a newly qualified teacher?
7. What tips/advice would you give to next years' teachers before entering their final year placement?
8. Any concerns before starting out in September?
9. Anything else you would like to comment on?

Appendix D CASE STUDY B – INTERVIEW PROTOCOL

Note: Intro with general chat to relax participants and start flow of conversation

PART I: Transition Questions (at what stage do teachers see themselves moving into transition)

1. What has been the biggest change in your life over the past two years (last year of college to now)? Aside from COVID. [Situation]
    a. Why was this change substantial to you?
    b. What concerns did you have?
    c. Did you feel like you were gaining or losing something during this change? (explain)
        i. What did you feel you were gaining?
        ii. What did you feel like you were losing?
    d. How did the timing of this change suit you?
    e. On a scale of 1-10, with 10 being the highest, how would you rate the stress in your life that resulted from you _____[leaving college/starting teaching etc]? Why would you give yourself a score of ?

2. Had you experienced any change similar to this? [Self]

3. In what way is did this event cause you to change? [Self]
    a. Positively
    b. Negatively
    c. Not at all?
    d. What did you feel you were leaving behind?
    e. What did you feel you would/have gained?

4. How did you cope with the change? [Support & Strategies]
    a. On a scale of 1-10, with 10 being the highest, how would you rate your coping skills? Why would you give yourself a score of _____?
    b. Who did you rely on?
        i. Did you discuss this change with your family?
        ii. Did you discuss
    c. Did you find that there were supports in place that were helpful to you as a newly qualified teacher?
    d. either in the school you were teaching?
    e. or in university? – already in previous section
    f. Is there anything in particular you would have found helpful this year that was not available to you/you needed more of?

5. What strategies did you use to adapt to the change? [Strategies]
    a. What was your greatest barrier in getting to the point you are at now?
    b. When things aren't working out are you the type of person who Endures, Quits, tries to Change your Behaviour, or tries to Change the Circumstances? Direct from Powers thesis

6. What aspects of your identity (have come to the fore for you and for others over the last two years)

    do you think are important for people to know about in the context of this transition you experienced?

PART II: Probing Questions (general) – see initial interview

1. What experiences stood out to you in your first year teaching? Why?
    - How did you find it?
    - What aspects of your year were particularly successful for you? What aspects did you find unsuccessful?
        - Prompt: This can be in the context of teaching and learning approaches or strategies, assessment, differentiation, planning lessons, implementing resources, reflecting on practice etc.

2. What does collaboration mean to you now?
    - Who does it happen with?
    - What are the benefits?
    - What are the challenges?

3. Reflecting on your undergraduate course which aspects of the programme do you value most now that you are in the workplace?
    - Can you give me an idea of some of the reasons/constraints that might have prevented you from putting into practice what you learned in college?

4. In your teaching of physics specifically, were there any challenges/barriers that you can remember encountering?
    - How did students react to learning physics as opposed to Biology or Chemistry at Junior Cycle?
    - Follow up: Did you uncover any strategies/ways to overcome these challenges?
    - Were there any experiences with your students' learning that were new to you?
    - Can you describe any particular physics concepts (at any level) during your placement that your students found difficult?
    - Can you describe any particular physics concepts (at any level) during your placement that you found difficult to understand?
    - Difficult to teach, how?

5. What does 'being a good teacher' mean to you now?
    - What is your passion – what drives you to be a teacher?
    - How has your experience to date influenced your perspective in relation to teaching as a profession?

PART III: Closing Questions

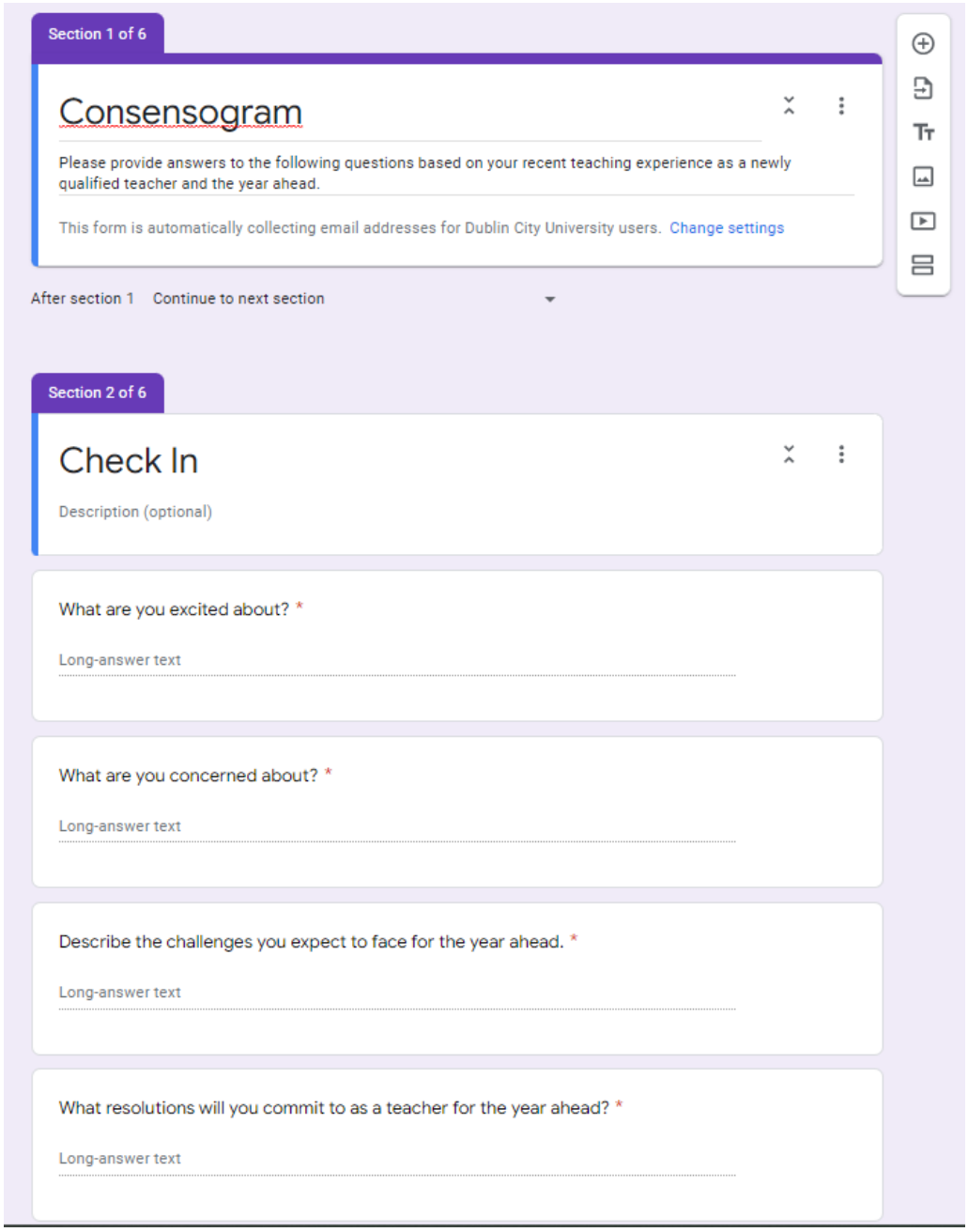
6. What experiences have you learned-from/ bring-with-you going forward now after your first year as a newly qualified teacher?

7. What tips/advice would you give to next years' teachers before their first year out teaching?

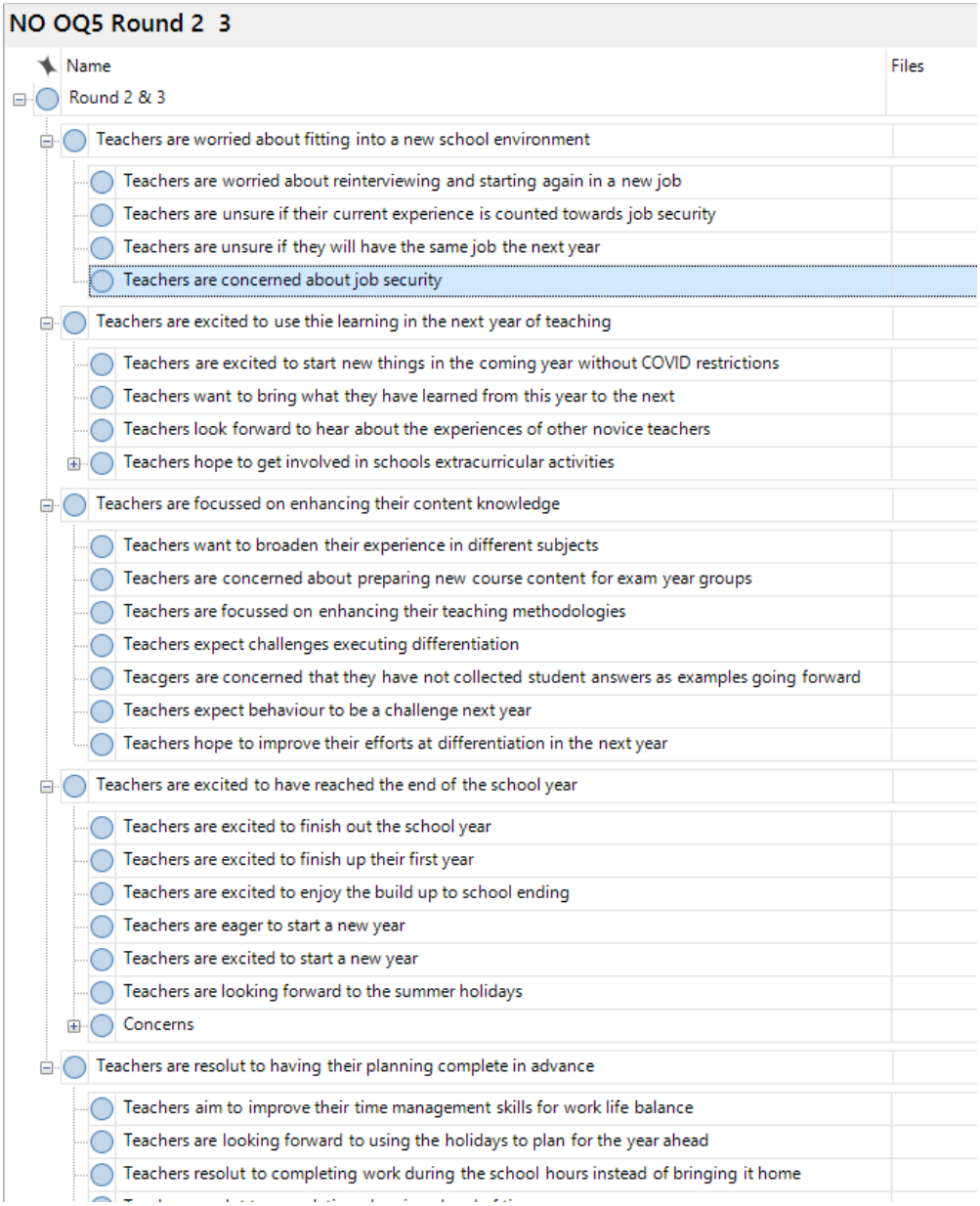
8. Any worries for next September?

9. Anything else you would like to comment on?

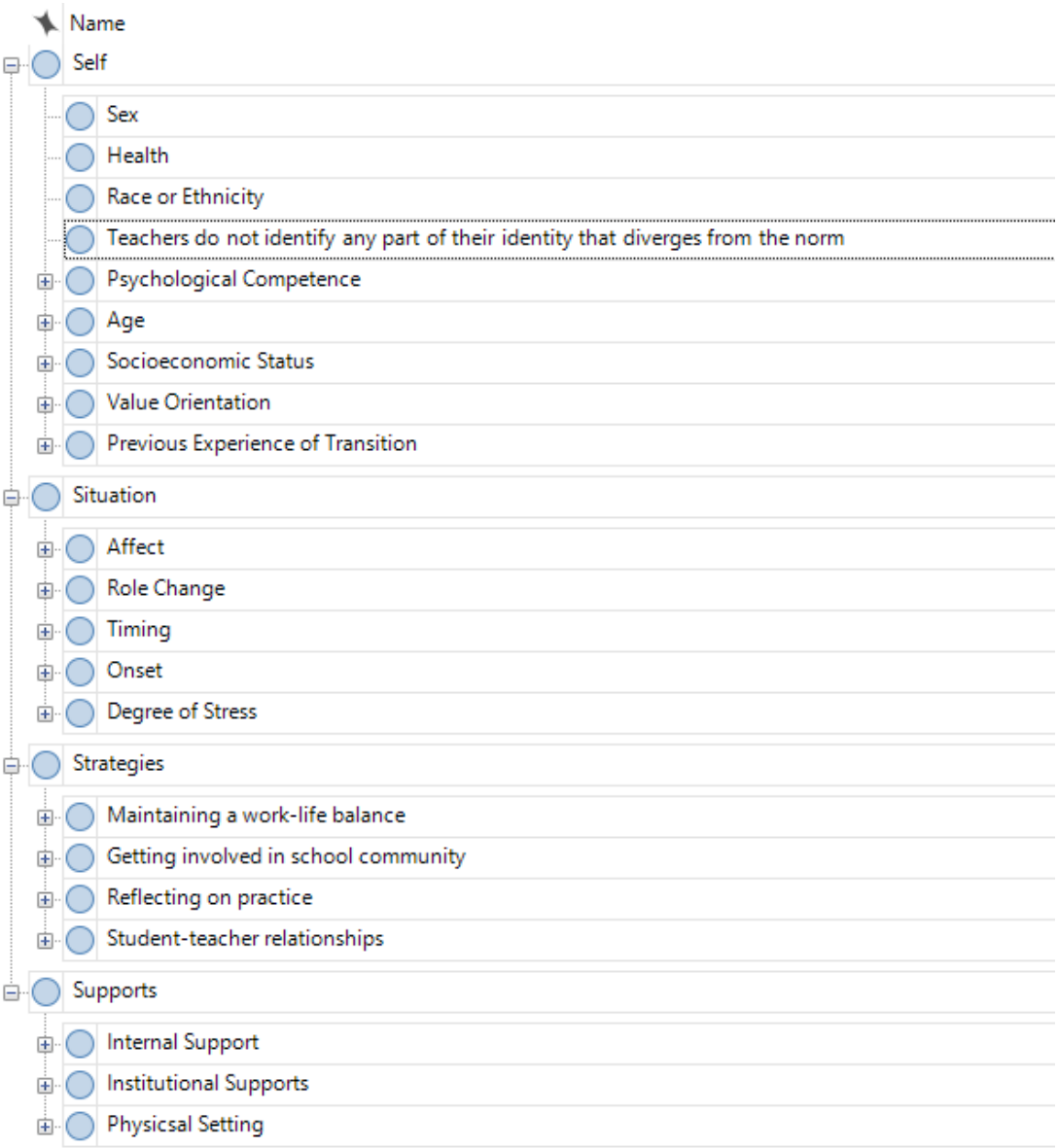
Appendix E QUALITATIVE SURVEYS



Appendix F SAMPLE CODING FOR PILOT STUDY/CASE STUDY A



Appendix G SAMPLE CODING FOR CASE STUDY B



Appendix H KEY POINTS FROM RESEARCHER REFLECTIONS

(RPP1)	Researcher 1	Researcher 2
What are your first impression?	● Teachers were eager to share experiences with each other. They wanted to talk about how they were getting on and what issues they were having. ● Most conversations focussed on issues rather than wins. Teachers listened and provided comparison stories to their peers. They were not yet at the point of providing possible solutions to their peers. ● By the end of the meeting teachers seemed tired and separated to how the group could benefit their progress. It seemed they almost felt like they were back on their own trajectory in tackling their problems of practices. ● Online tools provided transparency in sharing findings - teachers were not afraid to type exactly what they felt. Perhaps this would be a good way for getting true feedback moving forward. ● At some points (Survey in particular) I felt that the teachers were quite conscious of what they were saying and didn't feel fully comfortable, some of the comments were vague like "Yeah there is a wide variety of experiences here and I'm not surprised." Perhaps this was the online environment, they may have felt a bit targeted rather than sharing their opinions.	● Problems of practice very focussed on covid and not NQTs. ● have not discussed any issue with each other or used each other as support? ● Very open and keen to share experiences, probe each other. ● Unmotivated and overwhelmed. ● Negotiating norms - was effective in discussing reaching a consensus ● Survey- did share real practice and experiences and see differences ● Session on linking RPP data to literature was useful. ● Use of tools to collect data and displaying was effective in sharing for transparency and to show the work of the group. ● Do they feel this RPP will be a support? ● One member missing - why?
What would you change?	● More natural discussion opportunities. A chance for everyone to feel totally comfortable in disagreeing with statements without feeling under judgement. ● Opportunity for teachers to feel that they are useful to each other. Having a critical friend. ● More one-on-one interactions with participants to allow for constructive feedback to members	● More time for them to share/discuss -experiences at this stage - this should be the focus of the first 2 hour session. ● Another 2 hour session on collecting and analysing data. ● Need to consider shorter meetings every month as a check in meeting.
Was mutualism achieved? In what way? How could it be changed?	● Sharing my difficulty teaching students. ● Unsure that hierarchy was absent in the meeting and may have interfered with participants speaking up ● Critical friend may be a solution	● Not sure if teachers saw that everyone had a goal in the RPP? ● Imbalance between researchers and teachers.

(RPP2)	Researcher 1	Researcher 2
What are your first impression?	● Teachers were very comfortable during the meeting. Very eager to share what they are doing (sign of confidence). ● Optimistic atmosphere with the teachers - they seemed to enjoy being present and participating. ● I wonder if they see this as professional learning. What do they think they are gaining from participating? ● Starter worked well for easing in to balance the powers of the group. ● Still feel that one teacher somewhat reluctant to share - what are the reasons for this? ● Noticed an aspect of adaptability with some of the teachers - e.g. one teacher had nothing prepared and still felt confident to share something with the group. ● Teachers are not in contact with each other. ● Group dynamics are shifting - less “them” and “us”. ● Some members stayed after the meeting was over for a further chat (not documented).	● Teachers were more relaxed and comfortable during all parts of RPP in an online environment. ● First part worked well to allow for open conversation and initial thoughts and that set a positive tone for what followed. ● Teachers still have not discussed any issue with each other or used each other as support since last RPP.
What would you change?	● More opportunity for discussion as in the starter activity - perhaps break out rooms etc? ● I think teachers are at a stage now to share an agenda and come with some preparation to meetings as they have “bought in”.	● Good structure and flow to the session. ● 90 mins was a good duration. ● Always give explanations of what is the process and why.
Was mutualism achieved? In what way? How could it be changed?	● Shared contributions gave every member a chance in the “spotlight” - this was important for teachers to feel heard and listen to others. ● Personally, I am finding it difficult to break down the “teacher” role from when members were students. This may be improved by sharing personal experiences, sharing the design of the workshop - split up roles of the members. ● More group activities where the individual and group voice is seen.	● Each RRP member was given specific time to share something with the group - make a valuable contribution. ● Everyone was conscious of keeping to time and respecting other’s times. ● Researchers need to constantly aware and use inclusive language, ie. not us and them and everyone does all of the activities. ● Brainstorming activity worked really well, open contributions of ideas, sharing of resources - and this needs to be followed up with.

(RPP3)	Researcher 1	Researcher 2
What are your first impression?	● Very engaged from the start. Chatting to each other and looking for advice in the first few minutes. Teachers were very focussed on assessment before the agenda started. At the same time teachers were relaxed and came across more confident in sharing their experiences. You could see that they now knew their expertise was valued and they could bring something to the table. ● In relation to engagement in activities, teachers showed a high level of critical thinking and reflection on their teaching approaches. ● Teachers showed powerful understanding of the key points in literature and appeared to genuinely want to apply what they had read about to their own practice. ● One of the participants in particular came across much more confident and spoke for much longer periods of time than in previous sessions. ● Another teacher was very eager to use the group as a sounding board for the issues they were having in assessing LC students and selecting concepts from the curriculum to focus on. ● Often teachers interjected with solutions to other teachers' issues and offered to share resources or guide them to appropriate resources. ● At the end of the two hours teachers remained on the call to chat to each other which showed further evidence of a strong community of teachers. ● I'm still not sure they see involvement in an RPP as engagement in professional learning.	Joined at 11:45 (At end of assessment task) ● Teachers were very focussed and absorbed in the task and took ownership of adding responses to each other's ideas. Very strong attitude towards teamwork and collaborative learning. No time for chatting and focussed on giving their full attention to the task at hand. ● Link to literature. Much more in depth answers and considered responses. Strong skills evident in reading chapter, extracting key points and making links to their own practice. Having to do each chapter was very important and raising interesting contrasts as well as similarities in key points identified. their experiences were linked to what are the needs of their students and what will benefit their students. ● LC Questions - Teachers engaged well in the process of applying taxonomy to LC Physics questions and there was a rich discussion/debate between pairs to complete classifications. Opinions were openly shared and justified. ● Overall, very positive learning environment, teachers started to identity the RPPs meetings as part of their own professional learning. ● At end of two hours teachers were actively engaged in conversations to learn from each other on imminent issues relating to their teaching. e.g. what LC physics topics can I omit covering? which is easier? what are others doing? what evidence are you using for predicted grades for students? ● Overall increased confidence and professionalism evidenced.
What would you change?	● I would have liked more time for each member to discuss their findings within each activity. Perhaps focus on one thing in the next meeting and spend more time on it. For me we were rushing onto the next thing a bit too much.	● I would have liked more time for each member to discuss ideas at the end of each session - but was conscious to keep to time.
Was mutualism achieved? In what way? How could it be changed?	● Yes, I feel like any barriers that existed previously had dissolved in this meeting. Teachers were ready to talk from the get-go and there were no awkward silences between activities. ● I did feel that because teachers were so eager to chat and share experiences that I fell into the role of timekeeper and moving things along. ● Next time I would delegate this role to other members to maintain the feeling of mutualism rather than falling into the static role of researcher vs teacher.	● Yes, strong evidence of shared responsibility, open sharing and discussion. ● Could see the benefits of careful planning for achieving mutualism in this meeting. ● Delegate the role of timekeeping - so not the researcher's job.

(RPP4)	Researcher 1	Researcher 2
What are your first impression?	• Teachers were under pressure to complete tasks that would benefit from a slower process of unpacking each step e.g. more time refining questions, researching literature. • It was difficult to ensure all teachers were at the same stage and progressing with their research in the online space. I feel it would have been easier to read the teachers that were having difficulty in an in-person meeting. • Teachers responded well to developing a research question and the litmus test coupled with researcher input was effective in refining questions. • Teachers engaged with analysing their data and were confident in asking for help. • The section on researching literature worked for some of the teachers and others had difficulty finding relevant and readable papers. • Overall teachers summarised findings from their analysis concisely and it was evident that they had learned something surprising from their own data. • One student did not use her own data and perhaps her investment in the findings was less (something to be probed further). • I felt that because the teachers were working with data they had personally generated with their students that more sensitivity was needed in the analysis process as was seen with one student who became frustrated that her research question and data was not relevant.	• Teachers were excited to meet and delighted to be part of something. made arrangements to meet on a busy evening. • The order of the activities was appropriate and sending teachers and agenda in advance is necessary. • Teachers were able to think about different types of data they had collected from their students. • Teachers were very open and confident in contributing their ideas to the jamboard and wrote questions quickly and re-worded several times - the Litmus test worked well for this. • Coding of the data was done well and quickly. Teachers developed their skills of observation and noticing. • Time is needed for students to search for literature and a clear question/ search terms are needed to do this effectively. • All teachers were able to articulate their key findings and were confident in sharing these with the group.
What would you change?	• The meeting would benefit from more opportunities for all participants to share at the end of each step of the research cycle and use each other for advice and direction. • Incorporating more role changes for participants i.e. getting teachers to facilitate aspects of the workshop would be beneficial to share the roles and work towards mutualism. • I think I would incorporate the research cycle at an earlier RPP meeting so that more time could be spent on each part of the process.	• Too much too fast in this last session. Not all teachers had their data ready. Time was taken to upload data. • Give teachers more advanced guidance on examples of data they might collect. • One teacher arrived late and had to be caught up - so this distracted from working with other teachers. • One teacher got lost on finding literature and linking to their question and data - so care needs to be taken to have a quiet/safe place so teacher's are not overwhelmed.
Was mutualism achieved? In what way? How could it be changed?	• All participants were much more confident at the end of the meeting for open questions to the group and I think this aspect of informal "bonding" really adds to building more mutualistic relationships. • Format of the meeting undermined the mutualistic relationship.	• yes, open dialogue and sharing of ideas and suggestions in formulating questions, suggesting papers, etc, • Teachers took ownership of the process and researchers collaborated and contributed to what they were doing. • Round table discussion was open and all were eager to engage and discuss their next steps and were reluctant to leave the call.

Appendix I EXTENDED THEMES FROM REFLECTIVE JOURNALS

Year One - Semester One

Teachers completed a weekly reflection after every lecture (workshop) in their Physics Methodologies module. The reflections were thematically analysed see Sectionand six themes were generated from the data.

1. Teachers described how they would plan and implement ideas *(257 codes)*
2. Teachers critically analysed teaching approaches *(142 codes)*
3. Teachers described instances where they lacked the overall pedagogical content knowledge for a task *(136 codes)*
4. Teachers outlined specific learning gained from the module *(91 codes)*
5. Teachers mentioned the supports in place to develop their learning *(79 codes)*
6. Teachers discussed student learning in their reflections of teaching *(64 codes)*

These themes were then mapped onto the theoretical framework to observe teachers transition at that point in time.

Theme 1 - Teachers discuss how they would plan and implement ideas

In this theme, teachers discussed how they would prepare themselves for teaching classes in the future as they were still in completing their pre-service teaching. Here, teachers described effective teaching approaches, adaptations they would make to teaching approaches, assessment strategies and classroom management strategies. Time considerations, implementing inquiry based learning and linking to the curriculum were all aspects of planning that teachers discussed.

Teachers described several teaching approaches that were adopted during their weekly workshops that they felt would be effective to incorporate into their classroom practice. Most of these approaches were general to all subjects (e.g., group work, real life applications, effective questioning). However, in some cases teachers specified how the teaching approaches would be particularly useful to teach physics. For example, teachers described how specific topics

(forces) could be approached to utilise students' prior knowledge and student-centered learning. Teachers also drew attention to the cross-curricular links and emphasised approaches to strengthen student skills in physics through maths: *"I like how we were shown how the speed activity could not only be done in our physics class but also in our maths classes especially when clearing up how we use, read and make graphs and showing where the deeper connections between maths and physics are."* – Teacher 2

In most cases when teachers described effective teaching strategies they also suggested adaptations that they would implement to suit their own classroom practice. Some of the adaptations described by teachers referred to changing the order of activities or altering their timing. Other adaptations included supplementing activities with clearer instructions, further information or probing questions: *"If I were to do these experiments with my own students I would recreate the worksheets and alter them in different ways so that they are more catered towards my students."– Teacher 3* There was also evidence to suggest that teachers were still not confident to take complete responsibility of their classes as they feared losing control of the class or having to consult other teachers' approach in the school before trying something: *"It would probably usually be the case that this would work, the only worry I would have when trying this method of leaving students outside the class when it is a disruptive class is that it may disturb other teachers."* – Teacher 5

Within this theme, teachers also identified aspects of assessment throughout the module and how they could be implemented in the classroom. In some cases, teachers spoke about how their own experience of continuous assessment in the module was helpful for them to experience as learners. Here, teachers also outlined some of the challenges with assessment strategies such as, summative assessments resulting in students losing confidence in their abilities and particular rubrics that are not fit for purpose. They reported that experiencing the assessment as learners meant that they gained a student perspective to inform how they would design assessment tasks for their students. Teachers were also now able to give the advantages of using particular strategies such as peer feedback: "*It was good to get peer feedback as I feel that your classmates would be more critical in analysing your work and giving advice on where to improve*

since they have also gone through the same activity and know what is expected." – Teacher 3

Lastly, this theme encapsulated teachers' discussion of implementing effective classroom management strategies to complement their lesson ideas. Classroom management consumed a large proportion of teacher discussion. They considered how class length, seating plans and available resources were all factors that had the potential to support or cause classroom management issues. For example, protocols for entering the classroom, incorporating clean up within class time and moving to different spaces in the classroom to vary the environment were strategies that teachers discussed as being helpful to maintain classroom management but depended on the school resources whether they could be implemented. Teachers also considered how they would use classroom management strategies to create an engaging learning environment. Here teachers gave examples such as changing the layout of the classroom, rationalising the purpose of activities with students and makes lessons relevant to students. Teachers highlighted the importance of teacher-student relationships as a classroom management strategy. They discussed both the advantages of good relationships and the problems that may arise with negative relationships: *"Knowing a student's name is very important when I'm teaching as it creates a relationship with the student and they know you take an interest in them." – Teacher 4*

Challenges that teachers encountered within this theme included, difficulty planning inquiry based learning activities, underestimating the amount of time it takes to plan an activity, considering curriculum links in their planning and establishing the teacher role in students learning. Overall teachers acknowledge that a lot of time and careful planning is needed to implement ideas that they learn during their pre-service teacher education: *"I feel that you really have to plan and prepare when and how you are going to introduce these simple examples to your lessons and if they will really benefit the students learning." - Teacher 3*

Theme 2 – Teachers critically analysed teaching approaches

Novice teachers' critical thinking skills were very evident in this theme as they critique the lecturers' approach to teaching topics in physics and discussed aspects of the workshops they would have reservations using in their classrooms. They specifically spoke about inquiry based learning and group work and how these strategies might look if they were to adopt these approaches.

Most surprisingly, it could be seen through this theme that teachers had begun to critically analyse the teaching approaches of their lecturer within the workshop. All of the teachers reported wanting more time to complete activities in the workshops and their eagerness to learn new approaches. Teachers provided justification for why the lecturer made certain decisions to approach a topic in a particular way. In some cases, the teachers tried to explain the thinking behind some of the lecturer's lessons. For example, in one case the teacher explained why they thought the lecturer had decided to ask students to move seats and how this might affect the learning: *"We all moved from where we ordinarily sit in the room over to another section, which I felt possibly signified a slightly different type of lecture format where we would be the teachers in this setting." – Teacher 1*

In most cases the reservations that teachers had to adopting workshop ideas were in relation to their novice experience of teaching. Teachers were concerned about how they would maintain classroom management carrying out some of the tasks due to their novice experience. One teachers discussed their apprehension towards asking students to "volunteer answers" rather than "picking on" particular students to answer as they say: *"It's hard to know when students don't want to contribute to a class because they are shy, but it is also difficult to pick up on whether the kids who are trying to act too cool are quite shy too." – Teacher 5.* Teachers reported concerns about allowing students to have autonomy of their own learning. In most cases this was due to teachers' lack of experience of practically implementing inquiry based approaches. One teachers felt that giving students autonomy of learning contradicted the approach of following the curriculum: *"The mention of allowing students to take control of their own learning also seems to come into conflict with the idea of a syllabus as students don't know what they want to learn and how they want to learn it." – Teacher 2*

It was evident from this theme that teachers had mostly experienced inquiry based learning as learners, than they did planning for IBL as teachers. Teachers were able to analyse their experiences of IBL and discuss the benefits and difficulties of their participation in activities. Teachers felt that implementing inquiry based learning resulted in deeper learning for the students. They also highlighted that some students may take advantage of the fact that they direct some of the learning to disengage from the lesson altogether. When faced with the task of planning and implementing similar IBL activities into their own practice teachers found this challenging. Teachers identified their own concerns carrying out some of the tasks [such as learning through IBL] and as a results felt that they would not be equipped to use these strategies in the classroom, *"The discussion on IBL did help clarify a little about what students should be doing during this type of lesson, however I'm still struggling to see how to set up an IBL lesson and how to execute it in a class." – Teacher 2*

Group work was a particular strategy that teachers focussed on within this theme. Teachers regularly referred to moments where they collaborated with their peers and learned from each other. Teachers outlined that it was helpful to know how other group members liked to work in order to have positive experience of collaborating with each other. Teachers also synthesized these experiences into future implications in the classroom such as assigning roles to students during group activities. Overall teachers highlighted that groupwork provided an opportunity to learn from a different perspective and broaden the scope of an activity, *"I liked being able to see the other questions and explanations that people came up with as it gave me an insight into how creative you can be.." – Teacher 3*

Theme 3 - Teachers described instances where they lacked the overall pedagogical content knowledge for a task

This theme reflected teachers' motivation to improve their professional learning. Teachers reported difficulty in different areas within the module, namely, how to teach a topic and learning the content of the curriculum. Teachers acknowledged that they lacked confidence teaching a topic and identified gaps in their content knowledge that may contribute to this. This lack of confidence was also attributed to their difficulty completing activities or understanding a

teaching approach. Overall teachers felt that they needed more experience to feel competent as a physics teacher.

The biggest area teachers felt they could improve on for their own professional learning was spending time to complete the Leaving Certificate mandatory experiments themselves. Most of the teachers reported that they had not carried out these experiments since their own school education and were surprised that they had forgotten so much of the detail in them. This realisation left teachers uneasy about the fact that they would have to now teach them to their students: *"Again, this provided me with a bit of a reality shock as I couldn't even remember the basic mandatory experiments…. It made me feel uneasy that I will be expected to teach something that I can hardly remember doing myself a few years ago."* - *Teacher 3*

Teachers also discussed improving specific skills such as reading outside the classroom, using particular equipment and reflecting on practice effectively, as part of their professional learning. In other cases, teachers content knowledge gap was related to issues they had completing activities in lectures. For example, teachers highlighted that they struggled to find scientific explanations for phenomenon that were presented during the workshops: *"I am yet to figure out how this works (beyond changing his centre off mass) as we did not discuss it in the class, and I have no idea what to look up to find out." – Teacher 5*

There were several instances in this theme where teachers discussed their lack of confidence teaching a particular topic. Teachers were still unsure of the depth of knowledge that they required as teachers. They described trying to decipher whether information was relevant (or not) and being surprised by the amount of background knowledge a teacher might need to teach a topic effectively. In most cases teachers highlighted that their knowledge of the curriculum was lacking and that they would need more time and support until they had sufficient knowledge to teach it. Teachers had not yet accepted full responsibility for their role as a teacher and expected some assistance in making decisions about the content they would have to learn and their approach to teaching: *"This made me wonder if it was me who should be able to understand the relevance of the information or if the information was not relevant." – Teacher 6*

Teachers highlighted times when they were out of their comfort zone with some of the teaching approaches they were being advised by the lecturer to try. Implementing inquiry based learning techniques, short attention grabbing activities and assessment strategies were all teaching approaches that these teachers felt that more experience was needed. Teachers explained that classroom experience would help them to formulate effective plans, predict student questions, misconceptions and difficulties that may arise and ultimately enhance their own pedagogical knowledge: *"And another problem we had was coming up with the questions for IBL and predicting what the students may do. This is very hard when you have never taught the topic before." – Teacher 4*

The above sub-themes were the self-reported issues of teachers related to their pedagogical content knowledge. However, throughout the reflective journals there was evidence that highlighted difficulties in the teachers conceptual understanding of particular content or teaching approaches. In some cases, teachers took the advice of the lecturer quite literally and misinterpreted a suggested approach as "the right way to do something". Some of the teachers found it difficult to step back from the activities and approach them from the point of view of a teacher. Making this distinction was a common issue amongst all of the teachers. Teachers found themselves regularly switching between the role of the student and role of the teacher. Teachers' novice approach to planning was also evident when they discussed the difficulties they had in applying the knowledge they had for Junior Cycle lessons to Senior Cycle: *"I was very familiar with students learning through inquiry but had always been looking at it in a junior cycle setting." – Teacher 6*

Theme 4 - Teachers outlined specific learning gained from the module

This theme reflected teachers' experience of the professional learning gained from their weekly workshops. Teachers evaluated their performances, explained the thinking behind the activities and discussed other aspects such as career awareness and real life applications that should be included in their lessons.

As teachers participated in the workshops they reflected on their own performances and how that may have affected the success of the activity. Communication and collaboration in group activities was often discussed by teachers. Teachers attributed good communication and understanding of how

group members worked to effective collaboration. Teachers also evaluated their performance in presentations and moments where they had to teach their peers. Upon reflection they highlighted areas for improvements and suggested changes: *"Looking back at this, I do not think that this was the most appropriate time for this discussion with the students. In the future …I would explain each activity in due course throughout the lesson when students reach the stage of needing it." – Teacher 1*

A common practice undertaken by teachers in this theme was their description of the thinking behind the activities. Teachers did not simply describe the activities, they analysed their use in the classroom, specific changes that could be made to adapt the practices and also tried to justify the approach the lecturer took in introducing them. Declaring the purpose of the activity was a central focus within this theme as teachers discussed activities that had multiple curriculum links, enhanced student learning and assessed prior knowledge. One teacher describes her interpretation of the lecturers' actions and its relevance to their learning, "*I understand [the lecturer] taking the reflections back up so we don't begin to reflect on styles which are incorrect, and I understand her reasoning behind finishing on time because if she hadn't… other members of the class would have been giving out about it." – Teacher 5*

Teachers were very attuned to other aspects of the curriculum that weren't so obvious. They described the benefits of including real life applications of concepts to capture student attention and enhance student understanding. This included making lessons relevant, including using interesting diagrams and incorporating causal explanations. Teachers also frequently highlighted the importance of relating physics concepts to jobs and careers. Here, they emphasized that highlighting skills that are used in the classroom could be equated to skills and knowledge used in the workplace: *"I thought the most valuable activity of this period of the class is how to get students to link the chapter, ideas and concepts of physics to real life jobs and then…. come up with what these people do in these jobs that use these concepts." – Teacher 2*

The last aspect of this theme outlined teachers' interest in strategies to recruit students into their subject. Teachers recognised the importance of promoting physics as a subject due to the low uptake of the subject at Leaving Certificate level. To do this, they suggested strategies such as creating cross-curricular links

with Physics, promoting physics careers, directing students to informative and engaging websites and using specific praise in the physics classroom. Teachers were also intrigued by the effect that negative stereotypes caused by unconscious bias could affect student decision to choose the subject. However, this concept was still quite new to teachers and although they discussed some actions such as considering imagery, language and resources in their lesson planning, it was clear that they required more support to create actions for their classroom practice:

> *"I am very intrigued by unconscious bias. I would like to learn more about the topic in the future….I was happy to see the lesson reflection-tally sheet as I was confused at how this unconscious bias could be measured…The 'language' element was something I didn't fully understand and hope to explore more in depth in the future." – Teacher 6*

Theme 5 - Teachers mentioned the supports in place to develop their learning

Teachers discussed ways in which their professional learning was supported throughout the term in this theme. This included learning from their peers, drawing from past teaching experiences, seeking advice from lecturers and consulting the literature for their professional learning. Teachers were also aware of taking responsibility for their own learning and identified moments when they felt uncomfortable seeking support.

Learning from their peers was a strong focus of teachers' reflective journals. Teachers discussed their learning from working with peers, engaging in peer assessment tasks and general group discussions during lectures. As noted in previous themes, teachers considered the learner and teacher role when carrying out peer feedback activities to inform their classroom practice. Teachers valued the advice of their peers and found that often this different perspective helped them to overcome difficulties or learn from different teacher experiences, *"During the discussion after each plan there were points brought up that I never would've thought of when planning a lesson." – Teacher 3*

Teachers regularly drew on previous teaching experience to support their professional learning. These experiences identified challenges teachers

encountered in previous school placements and also highlighted approaches that worked well for teachers. The areas discussed varied from classroom management strategies, enhancing student engagement or the sequencing of activities. Mostly teachers evaluated their previous teaching performances in the context of what they were learning in the workshops. For example, one teacher shared their experience of implementing seating plans when it was introduced during the lecture,

> *"We briefly discussed the benefits of assigned seating. I used assigned seating on my last placement as I felt it would be easier to help me learn the students' names and allow me to concentrate more on the lessons and the content involved." - Teacher 6*

Teachers' own learning experiences from school were used to connect concepts within the workshops. Teachers found it helpful to synthesize their past experiences as second-level school students into the experiences of their prospective students. In most cases teachers' memories were so vivid that teachers began developing their philosophy of teaching around them [memories]. It was evident that teachers' past experiences impacted the decisions they made in their teaching now and this in turn had an effect on their lesson planning,

> *"..when I was in school it was one of the last thing that we did in sixth year and at that stage we were burned out and rushed through it. I think if it was done earlier I wouldn't have skipped it in the leaving cert." – Teacher 4*

Support from lecturers and other mentors was also discussed in this theme. Overall teachers reported seeking advice from their lecturer or coordinating teacher about issues such as troublesome students, looking for clarity on subject content or accessing resources for topics they found difficult to teach. Teachers found one-to-one conversations with the lecturer to be helpful as they described finding clarity when they were able to ask questions "on the spot". There were some instances where teachers felt uncomfortable asking for help or receiving constructive criticism, however this teacher describes that when the facilitator could find errors in pre-prepared resources it took the pressure off her to create perfect resources,

"This was refreshing because [the facilitator] could even point out small flaws in the worksheets…so it made me feel a little better about the criticism I get. I feel like a big part of it [feeling overwhelmed] was that I constantly was trying to avoid that criticism or constantly expecting it." – Teacher 5

Theme 6 - Teachers discussed student learning in their reflections of teaching

Student learning was a focus of this theme as teachers described how their experience as a learner gave a student perspective on some of the teaching approaches. Teachers frequently discussed the needs of their students and took into consideration the way that students learn to inform their teaching. Teachers also identified the student role in learning and the necessary skills that students need for their learning.

Teachers' own experiences as learners were most evident in this theme. They explained how their learning during the workshops helped them realise how students may feel interpreting a new approach to learning, difficult topic or confusing instructions from the teacher. They also reported having more of an insight into the challenges the teacher may face implementing the activities as they were able to analyse the lecturers' approach when things didn't always go as planned during the lesson. Teachers outlined that this experience helped them to plan for these setbacks that students may encounter.

"However, while I didn't enjoy the frustration it did remind me of how a student may feel in the classroom at times when they don't understand the teacher's instructions or the exercises they've been given to do." – Teacher 3

Related to the above example, teachers also considered the way in which students learn to inform their teaching approaches. Teachers highlighted the diversity of learning approaches among their students and the multitude of ways in which a student may complete a task. Teachers explored how to promote students' individual and group reflection, how to enhance student autonomy of learning and how to encourage students to "think like a scientist". Teachers highlight activities that may cater more suitably to students who like visual prompts or kinaesthetic prompts. Overall, teachers acknowledged that students

learn in many ways and therefore incorporating different teaching approaches to reflect the different ways of learning was important.

> *"At the end of the class we looked at how other people think and who works well with each other. The class was very divided, and it shows how everyone is different and this would also affect group work." – Teacher 4*

Teachers highlighted the different needs of students in their classes. These needs varied from academic ability to personal experience. Using appropriate resources for students with special learning needs, differentiating resources for mixed-ability classes, and being sensitive to students that may be affected by subject content due to personal experience were all aspects that teachers discussed in their reflections. Teachers reflected critically on an event that occurred during the workshop where another teacher was upset when the class started discussing the physical conditions that may cause a car to crash. Here, teachers considered how they would have dealt with the situation had it occurred in their classroom,

> *"Since thinking about this I don't think I would be comfortable to go into a group of transition years and teach the module I helped create unless I had had the class before. I would have to know that students would look out for each other and advise me on topics to stay away from if there was a topic their classmates might be sensitive to." – Teacher 5*

The student role in learning was also highlighted by teachers. They outlined the importance of the student role in inquiry based teaching. Teachers discussed balancing the teacher and student role so that students were active in their learning and took control of the exploration resulting in deeper engagement with the concepts. Teachers also outlined what they felt were necessary skills to pass onto all students such as reading outside the classroom, communicating science and investigating everyday phenomenon. *"I feel that it is important to start introducing as many inquiry activities as possible into your lessons as it I feel students will learn and benefit from it more as they are the ones who do the work." – Teacher 3*

These themes reflect teachers position at the end of their final year of university. Teachers were largely focussed on planning and implementing new ideas into

the classroom practice for their next school placement. Teachers main source of learning was their analysis of teaching approaches implemented by their lecturer during workshops and their participation as students. There was also evidence to suggest that teachers lacked pedagogical content knowledge in complete a task leading to their lack of confidence teaching that concept in the classroom. However, the professional learning the teachers gained from workshops provided teachers with evaluative skills to work independently on improving this lack of pedagogical knowledge as they gained teaching experience. Teachers highlighted the supports that they felt enhanced their learning experience which included peers, lecturers, literature and past teaching and learning experiences. Finally, teachers considered how students learns, their specific needs and the student role in learning which were all influenced by their own experience as a learner during the module.

Appendix J PLAIN LANGUAGE STATEMENTS AND CONSENT FORMS FOR CASE STUDIES

Plain Language Statement – Case Study A & B

Main Investigators/ Contact: Deirdre O'Neill, CASTeL & School of Physical Sciences, Dublin City University, Dublin 9, Tel: +35317005276, deirdre.oneill68@mail.dcu.ie
Dr. Eilish McLoughlin, CASTeL & School of Physical Sciences, Dublin City University, Dublin 9, Tel: +35317005862, eilish.mcloughlin@dcu.ie

Research has shown that there is an obvious need to enhance the teaching and learning of physics at Junior and Senior Cycle, with only 22% of Irish secondary schools offering physics as a Leaving Certificate subject. This study aims to raise the profile of physics and improve retention of physics teachers at second level by supporting teachers to improve the quality of the teaching and learning of physics and to respond to increasing diversities in classrooms. The study will be carried out as part of the research PhD of Deirdre O'Neill, supervised by Associate Professor Eilish McLoughlin.

You are invited to participate in this study to investigate the impact of participation in research practice partnerships (a group of 7-8 teachers and researcher) on your content knowledge for teaching physics. This research practice partnership will be sustained and ongoing for one year. Teachers will be supported by the researchers and the group will meet twice during school midterm breaks for discussions on progress and next steps which will be decided on by the whole group. You will be asked to volunteer in interviews before becoming part of the research practice partnership. These interviews will establish a baseline for researchers to refer back to in order to measure the impact research practice partnerships on teachers' content knowledge for teaching physics. You will be asked report on any changes you make to your teaching approaches through recording written reflections and individual interviews with the researcher.

The expected benefits of participating in this study is that you will have the opportunity to be supporting in designing, implementing and reflecting on your own classroom practice. The findings of this study will contribute to the field of physics teacher education and raise awareness of the challenges and barriers encountered when teaching physics. Findings of this research will be presented at education conferences, published in journal articles and disseminated though national networks as appropriate. *The research is considered low risk because it involves professionals (teachers) discussing their professional activities. The risk of adverse effect or harm is very low. There is minimal risk of identification as all interviews and teacher reflections will be anonymised and coded to protect your identity.*

GDPR Compliance

- **Data Controller**: DCU, School of Physical Sciences
- **DCU Data Protection Officer** – Mr. Martin Ward (data.protection@dcu.ie Ph: 7005118 / 7008257)
- **Purposes of the processing for which the personal data are intended**: Administration and triangulation of findings.
- **Categories of personal data concerned**: Participants names and email addresses
- **Categories of recipients with whom data is shared**: Principal Investigators
- **Retention period**: 5 years
- **Information on the rights of the data subject**: All data collection will be conducted solely by the PhD researcher Deirdre O'Neill and the names of participants will be anonymized in the reported findings of this study. All data gathered will be kept in electronic format and safely disposed of five years after the completion of the study
- **Information on rights to withdraw consent**: Your participation in this research study is voluntary and you have the right to withdraw from this at any time without penalty.

Participants need to be made aware that confidentiality of information provided cannot always be guaranteed by researchers and can only be protected within the limitations of the law - i.e., it is possible for data to be subject to subpoena, freedom of information claim or mandated reporting by some professions. Depending on the research proposal and academic discipline, you may need to state additional specific limitations.

If participants have concerns about this study and wish to contact an independent person, please contact: The Secretary, Dublin City University Research Ethics Committee, c/o Research and Innovation Support, Dublin City University, Dublin 9. Tel 01-7008000, e-mail rec@dcu.ie

Informed Consent – Case Study A & B

I. Research Study Title: Enhancing novice teacher's content knowledge for teaching physics through participation in research practice partnerships.

Principal investigators:
Ms. Deirdre O'Neill, CASTeL & School of Physical Sciences, Dublin City University.
Dr. Eilish McLoughlin, School of Physical Sciences, Director Centre for the Advancement of STEM Teaching and Learning, Dublin City University.

II. Clarification of the purpose of the research,

This study aims to improve the quality of teaching, learning and assessment in physics and respond to increasing diversities in classrooms and raise the profile of physics and retention of physics teachers at second level. This research will enhance teachers' content knowledge for teaching physics (teaching, learning and assessment approaches) through research practice partnerships (collaboration between teachers and researchers) which will be sustained and ongoing for one year.

III. Confirmation of particular requirements as highlighted in the Plain Language Statement

Participant – please complete the following (Tick Yes or No for each question)

	Yes	No
I have read the Plain Language Statement	☐	☐
I understand the information provided	☐	☐
I have had an opportunity to ask questions and discuss this study	☐	☐
I have received satisfactory answers to all my questions	☐	☐
I give consent for lesson materials and planning to be collected	☐	☐
I give consent for interviews to be audiotaped	☐	☐
I am aware that I may withdraw from the research at any point	☐	☐

IV. Confirmation that involvement in the Research Study is voluntary

I may withdraw from the Research Study at any point without penalty.

V. Advice as to arrangements to be made to protect confidentiality of data, including that confidentiality of information provided is subject to legal limitations

I am aware that myself or my school not be identified in any notes taken or recorded in this research. However, it must be noted that the confidentiality of information provided can only be protected within the limitations of the law. Only myself and the principal investigators (Deirdre O'Neill and Dr Eilish Mc Loughlin) will have access to the data gathered, which will be password protected and safely stored on-site in DCU. All data gathered will be safely disposed of three years after the completion of the research.

VII. Signature:

I have read and understood the information in this form. My questions and concerns have been answered by the researchers, and I have a copy of this consent form. Therefore, I consent to take part in this research project.

Participant's Signature: _____

Name in Block Capitals:

Date:_____

Plain Language Statement – Case Study A

Main Investigator/ Contact:	Deirdre O'Neill Postgraduate Researcher, CASTeL (School of Physical Sciences), Dublin City University Glasnevin, Dublin 9 Tel: +35317005276 deirdre.oneill49@mail.dcu.ie
Other Investigators:	Associate Professor Eilish McLoughlin (Supervisor)

Research has shown that there is an obvious need to enhance the teaching and learning of physics at Junior and Senior Cycle. In raising awareness around unconscious bias this study aims to enhance teachers' knowledge, attitudes, skills and experiences of teaching physics. This study will promote the importance of STEM education in student's lives and, through the project's work with physics teachers, support STEM education itself and will be carried out as part of the research PhD of Deirdre O'Neill, supervised by Associate Professor Eilish McLoughlin.

You are invited to participate in a study to examine second level science teachers' approaches to the teaching and learning of Physics at Junior Cycle and Leaving Certificate. You will be requested to complete a baseline survey to identify pre-service teachers' attitudes towards the teaching and learning of physics. You will be invited to participate in lessons to experience different approaches to teaching physics in the classroom and extend your content knowledge in Physics and careers in Physics/STEM (Science, Technology, Engineering and Maths). You will be asked report on any changes you make to your teaching approaches through recording written reflections and individual interviews with the researcher.

Your participation in this research study is voluntary and you have the right to withdraw from this at any time without penalty. All data collection will be conducted solely by the PhD researcher Deirdre O'Neill and the names of participants will be anonymized in the reported findings of this study. All data gathered will be kept in electronic format and safely disposed of three years after the completion of the study.

The benefits of participating in this research study is that you as a pre-service teacher will have opportunity to participate in research, the findings of which will contribute to the field and your own awareness and understandings of STEM and STEM education will be enhanced. Findings of this research will be presented at education conferences and in journal articles as appropriate.

We thank you for consenting to participate in this study. If participants have concerns about this study and wish to contact an independent person, please contact: The Secretary, Dublin City University Research Ethics Committee, c/o Research and Innovation Support, Dublin City University, Dublin 9. Tel 01-7008000, e-mail rec@dcu.ie

Informed Consent – Case Study A

I. Research Study Title: Enhancing pre-service teachers content knowledge for teaching physics

Principal investigators:
Ms. Deirdre O'Neill, CASTeL/School of Physical Sciences, PhD Researcher
Dr. Eilish McLoughlin, School of Physical Sciences, Director Centre for the Advancement of STEM Teaching and Learning.

II. Clarification of the purpose of the research,

This study will promote the importance of STEM education in student's lives and, through the study's work with pre-service physics teachers, support STEM education itself. The study will enhance PST's pedagogical content knowledge (teaching and learning approaches) through workshops on various physics topics in physics teaching and increase awareness of unconscious bias.

III. Confirmation of particular requirements as highlighted in the Plain Language Statement

Participant – please complete the following (Tick Yes or No for each question)

	Yes	No
I have read the Plain Language Statement	☐	☐
I understand the information provided	☐	☐
I have had an opportunity to ask questions and discuss this study	☐	☐
I have received satisfactory answers to all my questions	☐	☐
I give consent for lesson materials and planning to be collected	☐	☐
I give consent for interviews to be audiotaped	☐	☐
I am aware that I may withdraw from the research at any point	☐	☐

IV. Confirmation that involvement in the Research Study is voluntary

I may withdraw from the Research Study at any point without penalty.

V. Advice as to arrangements to be made to protect confidentiality of data, including that confidentiality of information provided is subject to legal limitations

I am aware that the school or myself will not be identified in any notes taken or in any write up of the research. However, it must be noted that the confidentiality of information provided can only be protected within the limitations of the law. Only myself and the principal investigators (Deirdre O'Neill and Dr Eilish Mc Loughlin) will have access to the data gathered, which will be password protected and safely stored on-site in DCU. All data gathered will be safely disposed of two years after the completion of the project.

VII. Signature:

I have read and understood the information in this form. My questions and concerns have been answered by the researchers, and I have a copy of this consent form. Therefore, I consent to take part in this research project.

Participant's Signature: _____

Name in Block Capitals:

Date:_____

Plain Language Statement – Pilot Case Study

CASTeL, Dublin City University

Main Investigator/ Contact: Deirdre O'Neill
Postgraduate Researcher,
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Dublin City University
Glasnevin,
Dublin 9
Tel: +35317005276
deirdre.oneill49@mail.dcu.ie

Other Investigators: Associate Professor Eilish McLoughlin (Lead supervisor)
Associate Professor Paul van Kampen

This research study "Improving Gender Balance in Ireland" aims to examine the engagement of students, particularly girls, studying physics to Leaving Certificate. This study will be carried out as part of the research PhD of Deirdre O'Neill, supervised by Associate Professor Eilish McLoughlin and Associate Professor Paul van Kampen. This research is conducted in partnership with the Institute of Physics (IOP) Ireland and has received funding support from Science Foundation Ireland (SFI) and endorsement from the National Council of Curriculum and Assessment (NCCA).

You are requested to participate in a study to examine second level science teachers' approaches to the teaching and learning of Physics at Junior Cycle. You will be requested to complete a baseline survey to identify which physics topics are challenging for you and/or your students at Junior Cycle. You will be invited to participate in workshops to experience different approaches to teaching physics in the classroom and extend your content knowledge in Physics and careers in Physics/STEM (Science, Technology, Engineering and Maths). You will be asked report on any changes you make to your teaching approaches in the classroom through collecting student work and completing written reflections and individual interviews with the researcher. All data collection will be conducted solely by the PhD researcher Deirdre O'Neill and the names of participating teachers will be anonymized in the reported findings of this study.

Participants will not be identified in the reported findings of this study, subject to legal limitations of the freedom of information act. All raw data collected from the participants will be coded to ensure confidentiality. Data will be stored in DCU and disposed of by the PI five years after the research project. All raw data collected from the participants will be coded to ensure confidentiality and protected in accordance with national (Data Protection acts 1998 (UK and Ireland) & 2003 (Ireland only)) and international (EU Directive 95/46/EC) legislation. Confidentiality of information provided cannot always be guaranteed by researchers and can only be protected within the limitations of the law, it is possible for data to be subject to subpoena, freedom of information request or mandated reporting by some professions.

Involvement in this research is voluntary and participants may withdraw at any point. This research involves observation as part of normal lessons and participation/non-participation in this study will not affect assessment or grades in any way.

If participants have concerns about this study and wish to contact an independent person, please contact:
The Secretary, Dublin City University Research Ethics Committee, c/o Research and Innovation Support, Dublin City University, Dublin 9. Tel +35317008000 rec@dcu.ie

Informed Consent – Pilot Case Study

CASTeL, Dublin City University

Main Investigator/ Contact: Deirdre O'Neill
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Dublin 9
Tel: +35317005276
deirdre.oneill49@mail.dcu.ie

Other Investigators: Associate Professor Eilish McLoughlin (Lead supervisor)
Associate Professor Paul van Kampen

This research will be led by Deirdre O'Neill as part of a research PhD supervised by Associate Professor Eilish McLoughlin and Associate Professor Paul van Kampen. This research is in partnership with the Institute of Physics (IOP) Ireland and has received funding support from Science Foundation Ireland (SFI) and endorsement from the National Council of Curriculum and Assessment.

For full details of this research please see the Plain Language Statement.

Data will be stored in DCU and disposed of by the principal investigator five years after the research project. All raw data collected from the participants will be coded to ensure confidentiality and protected in accordance with national (Data Protection acts 1998 & 2003) and international (EU Directive 95/46/EC) legislation. Confidentiality of information provided cannot always be guaranteed by researchers and can only be protected within the limitations of the law, it is possible for data to be subject to subpoena, freedom of information request or mandated reporting by some professions.

It is important that you understand that your students/guardians participation is considered voluntary. This means that students/guardians may withdraw from the study at any time, without penalty.

If you have concerns about this study and wish to contact an independent person, please contact:
The Secretary, Dublin City University Research Ethics Committee, c/o Research and Innovation Support, Dublin City University, Dublin 9. Tel +35317008000 rec@dcu.ie

Participant – please complete the following (Circle Yes or No for each question)

I have read the Plain Language Statement	Yes/No
I understand the information provided	Yes/No
I have had an opportunity to ask questions and discuss this study	Yes/No
I have received satisfactory answers to all my questions	Yes/No
I give consent for lesson materials and planning to be collected	Yes/No
I give consent for interviews to be audiotaped	Yes/No
I am aware that I may withdraw from the research at any point	Yes/No

I have read and understood the information in this form. My questions and concerns have been answered by the researchers, and I have a copy of this consent form. Therefore, I consent to take part in this research project

Participants Signature: _____

Name in Block Capitals: _____

Witness: _____

Date: _____