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The Adult Learner: Nature or Nurture?: A Case study of Teacher Educators and Teacher Learners

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THE ADULT LEARNER: NATURE OR NURTURE?

A case study of teacher educators and teacher learners

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Contents

Statement of original authorship

I, Christine Kassis, declare that the work contained in this thesis, submitted in fulfilment of the requirements of the award of Doctor of Philosophy, in the School of Education, University of Notre Dame Australia is wholly my own work. To the best of my knowledge, the thesis contains no material previously published or written by another person except where due reference is made.

Signed

Christine Kassis

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Abstract

Adult learning is very broadly viewed in the literature. The wide-ranging gamut of views, include those that interpret adult learning not dissimilarly to child learning, all the way through to theorists that propose a separate set of considerations for adult learners. When it comes to learning, pedagogy was traditionally associated with child learners and andragogy was born from the need to find a separate niche for the adult learner. As such, pedagogy and andragogy may be positioned opposite to one another—as one pertains to the needs; characteristics; and, behaviours of the child, and the other of the adult learner. These chronological apportionments of pedagogy and andragogy do not properly address the influence of context on the learner. Context is multifaceted, and includes internal elements such as feelings; thoughts; and, behaviours—which are, the learner's very nature. Further to this, context for the adult learner is external, and encompasses elements such as the learning environment; educators; and, work-place pressures and requirements. Understanding the contextual forces on adult learning, calls into question whether all adult learners function within an andragogical framework. A qualitative case study approach was used in the setting of teacher professional learning for primary science education in NSW, Australia, to garner a deeper understanding of adult learning. Participants, both teacher educators and teacher learners, provided insights into their learning journey. This study selected two external influences on the adult learner in this setting; the introduction of the NESA K–6 Science and Technology Syllabus (2012), which was the primary science education curriculum for NSW; and, the technological pedagogical content knowledge (TPACK) framework. In NSW, NESA is the independent statutory authority responsible for curriculum, assessment, teaching standards and school settings. Alongside the two external influences, the internal influence of teacher self-efficacy was used to better understand the adult learner. Teacher participant voice from interview gave rise to findings that illuminated the plasticity of the adult learner, moving between pedagogical and andragogical learner traits at various points in their learning journey, as well as transitioning in expertise. Adult learners were most successful in this study's learning context when there was interplay between their internal learner forces (ILFs), their nature; and, external learner forces (ELFs), the nurture or environment. These findings may have potential for transferability to analogous professional learning contexts of the adult learner.

Key words: *Adult learning; andragogy; pedagogy; teacher professional learning; science curriculum*

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Terminology

External learner force (ELF): A factor exterior to the adult learner that has the potential to influence learning, for example, the introduction of a new curriculum.

Internal learner force (ILF): A factor within the adult learner that has the potential to influence learning, for example, a teacher's self-efficacy.

NESA K–6 Science and Technology Syllabus (2012): The primary science curriculum document for New South Wales (NSW) that in 2015 was the most up-to-date syllabus document.

Novice expert balance (NEB): The balance between functioning as a novice adult learner all the way through to an expert in teacher professional learning for this study.

Pedagogy andragogy balance (PAB): The balance between using pedagogical and andragogical characteristics that is necessary for the interaction between ILFs and ELFs for successful adult learning in the context of this study.

Primary Connections: A primary school science resource that includes units of work that support the Australian Curriculum. Primary Connections does not address all elements of the NESA K–6 Science and Technology Syllabus (2012).

Primary school: An Australian school including the initial grades of child education for children generally aged between 5 and 11 years, beginning in NSW with kindergarten and ending in year 6 (K–6).

Principles of learning continuum (PoLC): A continuum for establishing learner characteristics that includes pedagogical (child learner) and andragogical (adult learner) traits on opposite ends of a spectrum. In this study, the PoLC formed part of the conceptual framework and was utilised as a document-based data source.

Science reference teacher (SRT): A primary teacher from SCS that took on the role of facilitator to transfer knowledge in K–6 Science and Technology they had acquired from professional learning in 2015, to colleague teachers at their school.

Secondary school: An Australian school that follows primary education for children generally aged between 11 and 18 years, beginning in NSW with year 7 and ending in year 12. It may also be referred to as high school.

Stages of learning continuum (SoLC): A continuum for assessing expertise that begins with novice and moves through to expert. In this study, the SoLC formed part of the conceptual framework and was utilised as a document-based data source.

Sydney Catholic Schools (SCS): Catholic systemic schools that belong to the Archdiocese of Sydney, of which there are three regions—the Inner West; the Eastern; and, the Southern. There are (to date) 150 primary and secondary SCS which educate more than 70 000 students.

Teacher educators (TEs): The facilitators of K–6 Science and Technology professional learning, who were teachers in SCS that have taken on the role of education officer in 2015 and also agreed to be participants in this study.

Teacher learners (TLs): SRTs that agreed to be participants in this study.

Technological pedagogical content knowledge (TPACK): A framework that foregrounds how to best teach a learning area with technology, and in reverence of the content that is required to be taught.

Chapter 1: Introduction

"Give me a lever long enough and a fulcrum on which to place it, and I shall move the world"

Archimedes of Syracuse
Pappus of Alexandria, Synagoge, Book VIII, c. AD 340

Introduction

Archimedes of Syracuse is regarded as one of the leading scientists of classical antiquity. From his quote above many meanings may be extracted. When this statement speaks to me, it talks of education, of providing the resources necessary for learners to achieve. If the provision of what is needed comes from the educator, the students may acquire the knowledge. Give me the tools and I will achieve. Students in primary classrooms are capable of achieving in K–6 Science and Technology; they simply wait on the tools—guidance from the teacher in their learning of the core concepts, and a chance to practise the skills of inquiry learning in a contextual and authentic manner. Primary education in Australia concerns the first four to eight grades of schooling for students generally aged between 5 and 11 years. If the teacher in the primary classroom exhibits deficits in what is needed, a further step back must be taken. The teacher, the educator, the instructor, the facilitator of learning must again become the learner. A teacher learning is an adult learning, and for successful learning to take place a sound understanding of the learner is vital. This study is premised on the idea that there is a need to improve science education in Australia, especially in the primary school context. Loughland and Nguyen (2016) summarised:

> There are concerns about the quality of science teaching in Australian primary schools, especially given the change in the national curriculum of primary science in 2014. This requires a greater commitment to the teaching of science concepts in K–6 classrooms in Australia and greater efforts to implement reform in primary science classrooms. The implementation of the Australian Curriculum has brought both opportunities and challenges to teacher educators in Australia as they adjust both pre-service and in-service teacher education courses to match the new skills and content required (p. 498).

As such, the nature of the adult learner in this milieu is in emphasis, as they are positioned to be a significant agent of change.

The current study concerns the nature of the adult learner. Theoretically framed by adult education, it conceptualises learning along a continuum between pedagogical and andragogical traits. Rather than a blanket application of adult learners to andragogy and defining a learner primarily by their chronological age—this study blurs the line between pedagogy as learning for the child and andragogy as learning for the adult. Intersecting with and influencing the learning traits of an adult learner is their expertise in a learning context. As such, the current study also considers adult learners along a continuum, from the most novice learners to the adult experts and how this may interact with an adult's learning characteristics. Overwhelmingly, the literature situates adults as distinctly separate to child learners, learning from a unique adult perspective in line with the views of foundational researchers of andragogy such as Knowles (1968, 1970, 1977, 1980, 1984, 1998) and Savisevic (1985, 1990, 1991, 1999, 2008). The current study challenges the norm of these narratives, applying principles of learning to the learner irrespective of their age, but based on contextual considerations and learner expertise.

The present study calls to question two substantial theoretical notions, that of andragogy for the adult learner and fixed learning styles. A review of the literature presented a strong theoretical base of andragogy for the adult learner, but in praxis, andragogy as learning specific to the adult learner was less robustly demonstrable. Here lays the opening in which to nestle this study. Andragogical traits as presented by foundational researchers would not be applied in a blanket fashion to all adults in this study. Instead, this study ideates that such categorisation is counterproductive when it comes to the practicalities of adults undertaking learning and an understanding of the adult learner. This study's adult learners through participant voice attest to their own learning attributes. What is unique to this study is the consistency in which adult learner traits are established and the ability to show that characteristics of learning, or one's learning style, may not be fixed. Furthermore, the present study validates how these understandings work towards building better science education practices in the primary school arena.

Contextually, this case study research is bound by the K–6 Science and Technology professional learning undertaken across 2015 by primary school teachers working in the Catholic Education Office, Sydney (now, Sydney Catholic Schools). As such, the data from this study is built upon the reality of teacher participants of the professional learning (teacher learners) and the teacher facilitators (teacher educators). This chapter also describes the influence of researcher background on the conceptualisation of the study and the research imperatives that formed as part of this influence. The significance of the current study lays in its ability to better understand the adult learner in order to positively influence learning from adult to adult and so too, adult to child in the context of K–6 Science and Technology. The hope is that the current study edges closer to the goal of improving science education in Australia. Limitations around the nature of this study and its methodology are also put forward.

1.1 Background and context

My life begins without remarkable difference to the next child born in a middle-class suburb in North West Sydney. My parents were born and married in Lebanon and soon after migrated to Australia, seeking a better life for themselves and their now four children. At this time civil war plagued their homeland and conditions of living were difficult by any standard. For the first eight years of my life I was educated at a local Catholic school in Sydney. When I was in Year 3, my parents made the decision to return to Lebanon for the foreseeable future. Two years later, my family would once again be living in Australia. A number of years later, my parents spoke more deeply about the reason they moved. My parents missed their family; their homeland; and, the familiarity of the culture and places they had left behind all those years before. This decision was made with the knowledge that the political climate had calmed considerably, and the move may be undertaken safely. I could not have predicted what this change meant for me and how it would colour the path my education took as a student—and in my adult life as an educator.

I very quickly adapted to life in Lebanon and I recall fondly the natural beauty of the environment; the opportunities for discovery and play; and, the fiercely etched positive memories of this new home. I began my education in a grade equivalent to year 4 at an international school run by catholic brothers. Also, a large percentage of lay teachers taught at the school. The student population included those whose parents were able to keep up with the school fees, and so often included Australian expatriates of Lebanese decent. This description mirrors juxtaposition, but is the clearest means of describing our family context in Lebanon.

The brother responsible for the primary sector of the college ruled with an iron fist. This resulted in classrooms that were bare of colour, sound, and beyond the grades in our end-of-year assessments, bare in evidence of learning. Education in this arena was decidedly different to what I had experienced from kindergarten to year 3 in my Australian primary school. The curriculum manifested in traditional rote learning instructional methods. Theoretically, what is understood about effective curriculum is that it should encompass supports for student learning (cognitive and accommodation supports); teacher supports (procedural and educative); and provide curriculum scope (stand-alone resources versus curriculum sequences) (Roblin, Schunn, & McKenney, 2018). Looking back, there were deficits and inconsistencies in my experience as a learner—and potentially in the experience of my peers, and even my teachers. Much like secondary school in Australia, we had a different teacher for each learning area and moved from class to class each period. So, what were the subjects I studied? There were the usual suspects: Mathematics and English (albeit, American English), history and physical education. Further to this were two new curveballs. The first, the comprehensive study of the Arabic language and the second the study of French to this same standard. Many students found themselves faced with this educational scenario; that had come from Australia, and had never been educated in Arabic and French. We became the students of 'Special Arabic' and 'Special French'. This denoted some differentiation for learners based on language expertise.

These curveballs, to my surprise, became achievements in my two–year education in Lebanon. I was lucky that the educational style of the brother that was heading the primary sector of the college favoured my strengths. Other students that began schooling at the College under the same circumstances were not so fortunate. Again, deficits in curriculum and curriculum implementation could be implicated. One vivid memory draws me back to the end of my first year at the college. The grade results achieved in each of the subjects were recorded. First, second and third place were announced. The student recipients of these grades were called to the front, jubilantly congratulated and presented with a medal for their academic achievement. Then the announcement came for those students who did not pass and receive an overall grade above 50% across their subjects. I recall twin boys, as they almost always fell below this threshold. Not only did they have to repeat an entire year of school, but they were called to the front of the class and given the cane—a form of corporal punishment whereby strikes are administered using a stick.

As an adult, a teacher, a science educator, a mother and upon reflection through these lenses, two important thoughts linger. Firstly, would those twin boys have passed their half yearly and yearly exams had education at the college considered their strengths, as well as, how they learn, their nature and disposition. They were clearly not understood as learners and the intended learning was not reaching them. The knowledge that was designed to flow from teacher to student was being interrupted. The variables responsible are potentially limitless. Perhaps their self-esteem and self-efficacy had been battered (physically and psychologically) and they saw no way out. These thoughts are based on my memory of the situation and the experience of analogy with learners and scenarios I have faced as an educator.

A second lingering thought resinates. In my education up until eleven years of age, encompassing the two years of life in Lebanon and years 5 and 6 upon my return to Australia—I do not recall ever learning science. When I have touched on this subject in conversation with family and friends, a myriad of conclusions were established. The one which solicits the most raucous reaction is the accusation of early senility on my part. I choose to ignore this theory, even though I did question—is my memory faulty? Why is it I recall learning mathematics; about Australian history and Indigenous Australians? That I remember completing art projects and participating in mock parliamentary sessions and in sport once a week? Where is science in all of this? Whether I was taught science or not is not the pivotal point, rather it is the certainty that I had not learnt science in any meaningful, deep or resonating way. Roblin et al. (2018) presented effective curriculum features (supports for student learning, teacher supports and curriculum scope) as being interactional with instructional outcomes of both students and teachers. Therefore, deficits in curriculum features in the context of science education impact teacher beliefs, instructional practices and pedagogical content knowledge—so too student content knowledge, their science practices and understanding of the nature of science (Roblin et al., 2018).

Learning should be meaningful and relevant to the learner. The New South Wales (NSW) Education Standards Authority (NESA) in the development of the K–6 Science and Technology Syllabus (2017, p. 4) highlights that "the syllabus takes into account the diverse needs of all students". An understanding of the learner is bound to learner success. In NSW, NESA is the independent statutory authority responsible for curriculum, assessment, teaching standards and school settings. The Melbourne Declaration on Educational Goals for Young Australians (MCEETYA, 2008) which the NESA Syllabus for K–6 Science and Technology (2017) draws on for influence presents two main goals, the second of which is that "all young Australians become successful learners, confident and creative individuals, and active and informed citizens" (NESA, 2017, p. 4). Arguably, an important and grandiose bar to set for our child learners—our students. Conceivably our adult learners, the primary teachers that are called on to upskill in K–6 Science and Technology through professional learning would benefit from such a bar. They too require the tools for successful learning; that educators understand their nature as a learner; and work to build their confidence—especially in a learning area that is not second nature for many primary school teachers.

1.2 Research questions

The research questions in this study at their core seek to further elucidate the nature of the adult learner. The literature provided a solid platform in which to nestle this qualitative study and establish questions for research. Literature focal points included adult learning; andragogy; pedagogy; what is known about professional learning; teacher self-efficacy; new curriculum implementation; and theoretical models such as technological pedagogical content knowledge (TPACK). Teacher professional learning designed to influence classroom pedagogy often models that pedagogy throughout the professional learning process. Adult professional learning programs are informed by adult education theory (Taylor & Hamdy, 2013). A substantial portion of the literature assumes that adult learners have different learning requirements when compared to younger learners (Savicevic, 2008). This study seeks to validate or call to question this notion, or perhaps align with both notions to some degree.

The main research question for this study is:

> What is the interaction between and influence of factors such as a new curriculum; self-efficacy and technological pedagogical content knowledge (TPACK) on the adult learner in teacher professional learning in K–6 Science and Technology?

The subsidiary research questions are:

- What is the relationship between a new curriculum; teacher self-efficacy; and, technological pedagogical content knowledge (TPACK)?
- How do factors such as a new curriculum; teacher self-efficacy; and, technological pedagogical content knowledge (TPACK) influence the teacher educator and teacher learner?
- What is the influence of the context of K–6 Science and Technology in professional learning?

1.3 Theoretical and conceptual framework

The theoretical and conceptual frameworks work synergistically, to hone in on the current case study and its phenomenon—the nature of the adult learner. Building a solid understanding of adult learning from the literature supported the study in two critical ways. Firstly, it contextualised this case study and foregrounded its uniqueness from previous studies. Secondly, it influenced the creation of concepts to frame this study. The conceptual framework is the brainchild of research from the literature, coupled with researcher experience and influences from practice.

1.3.1 Adult learning

The means by which the adult participants of this study engage with and gain knowledge themselves is of vital importance. If the teacher educators are to be successful in supporting knowledge-building in teacher learners, they must have an awareness of the characteristics of learners that are in their professional learning setting—much like a teacher should have an awareness of the students in their class. This awareness encompasses knowledge of adult learners, which is different from knowledge of child learners. Theoretically, such a process facilitates a movement from a pedagogical framework (when teaching child learners in the classroom) to an andragogical framework (the teaching of adults).

The facilitators may be able to provide significant insight into the processes they, as pedagogical–trained practitioners, incorporated into the professional learning setting to target an adult audience—the teacher learners. This draws on the notion of transition between knowledge of teaching pedagogically, and the practical implications and processes involved in teaching adults. Teacher learners, in the role of knowledge-builders also at some point take on a facilitating lead role in their school. Therefore, it is significant to understand these adult learners in two ways; as adult learners and adult educators.

1.3.2 Conceptual framework

The conceptual framework highlights that andragogical and pedagogical traits exist for all learners—positioning them on a continuum. Intersecting with this continuum is the concept that in any given environment of learning, a learner may be further categorised by their stage of learning. The five identifiable stages of learning are also placed on a continuum from the novice to the expert learner. Teacher educators to an extent like teacher learners are viewed as adult learners in this case study, as they too are practising primary teachers that are not science specialists. Further to this, they are also able to provide insight into the teacher learners as facilitators of the professional learning. The conceptual framework is bound by the case, a study of adult learners in K–6 Science and Technology professional learning. The conceptual framework links with decisions made on the method of data analysis.

A hybrid approach to thematic analysis combining predetermined deductive themes and ground-up inductive themes is used in the current study.

1.4 Methodology

Based on the qualitative nature of the current study and philosophical decisions made, case study methodology made for an authentic choice. The literature presents a variety of forms of case study. For the purposes of this research a case study is the study of a small group of primary teachers based on their connectedness as teacher learners and teacher educators in K–6 Science and Technology professional learning for a new syllabus. In addition, Yin (2009, 2012, 2017) discussed case study as a form of enquiry that explores an existing phenomenon within its real-life context—an exploratory case study. Stake (1995, 2010) spoke to the purpose of case study as adding to the literature, that is, knowledge-building in an area—an instrumental case study. An instrumental case study shifts the emphasis from the individual to the learning that can be gained from the case, the insights it provides and the possibility of generalisation and improved practice in education after the research has been analysed (Rosenberg & Yates, 2007; White, Drew, & Hay, 2009). A melded version of Yin (2009, 2012, 2017) and Stake's (1995, 2010) case study comes closest to defining the current case study. As such, the first aim is to delve further into adult learning to uncover more on the nature of the adult learner. Secondly, this case study aims to add to the knowledge base. There is the intention to inform future analogous studies for comparability and disparities (Pedrosa, Näslund, & Jasmand, 2012). Differences are deemed just as important as comparability. Webster and Mertova (2007) discussed the perils of leveling data to fit preconceived notions. A concerted effort is made in this study to be true to teacher voice and the data that it brings to light.

1.5 Significance

The teacher educators are trained in pedagogy, being practising primary teachers. With this in mind, the extent to which they employ or do not employ andragogical teaching processes, strategies and techniques is important when they teach other teachers in a professional learning setting. This study may illuminate further successful settings for effective adult learning, and foreground similarities and differences between adult learners in this study and how adult learning is theorised in the literature. Is the divide between child and adult learners definitive and binary in nature?

Science has long been neglected in Australian primary classrooms because it is too far removed from everyday life, unpractised and difficult to know (Hume, 2012). More broadly speaking, science education has a poor status in other international settings (Kenny, 2009). Consequently, this study focussed on the subject area of K–6 Science and Technology as a context for adult learning and so will have the added potential significance of informing science professional learning programs. Understanding the elements that influence successful professional learning for the adult learner advances the likelihood of improving student achievement (Scoggins & Sharp, 2017).

The dynamic of limited science interactions in primary classrooms is shifting, and one of the strong initiatives that may leverage this shift is effective professional learning. Professional learning can function to not only strengthen teacher content knowledge, but to propagate pedagogical content knowledge, as well as general pedagogy within education (Schneider & Plasman, 2011). Goodnough and Hung (2009) argued that improving teacher content knowledge can result in better instigation of that subject area in the classroom. Also, that a by-product of effective content presentation in the classroom is a greater variety of student learning needs are more easily catered for (Goodnough & Hung, 2009). This phenomenon has been explained in terms of building teacher confidence which facilitates a strengthening of their knowledge base (Van Duzor, 2012). This is because teachers are not likely to diversify their teaching practice when they are not confident with the information they are presenting or the depth of knowledge they possess.

Science is an integral part of life. It helps us understand our surroundings, the life that inhabits it and the universal energies that control and influence our Earth all the time. It also provides a context and a place to build skills through the investigative processes of observation; measurement; and, the universally important problem-solving—just to name a few. Cognisant of the benefits that would flow from improvement in science education, an understanding of the mechanisms that would enable teachers to be more effective in the classroom delivery of K–6 Science and Technology is important.

This study has the potential to inform science teacher professional learning and andragogy so that it is more effective in achieving intended outcomes. The study findings may also prove useful for professional learning in other subject areas. The insight gained from this case may therefore be useful to facilitators attempting to plan for professional learning that encompasses generic commonalities with this case. Commonalities such as; a professional learning experience that is ongoing, run by multiple facilitators, focused on pedagogical improvement and changing teaching practices, and, with an overall outcome to positively influence student learning.

1.5.1 Significance for the facilitators

The teacher educators in this case prepare and present material for ongoing professional learning and are fundamentally concerned with student gains in K–6 Science and Technology. In order to be impactful, teacher educators are aware that the learning must successfully flow through the teacher learners to their school and its teachers, and finally to students. This is a rich and complex process and one which would benefit from an elucidated understanding of the adult learner; what makes them tick and engage in learning. It is the teacher learner that will take the K–6 Science and Technology knowledge and understanding back to their school for transferal to their teaching peers. If the education in the professional learning setting is impaired for any reason this influences the success at school and classroom level.

A second point of significance for the teacher educators may be the application of learning achieved by this study to future applications with adult audiences. Andragogy, as much as pedagogy, is the knowledge of the art of teaching, theoretically for an adult audience. Therefore, this study may move the teacher educators themselves towards becoming more effective at addressing, teaching and facilitating the transfer of knowledge in adult learning, more adeptly and with more concision.

The present study encompasses the outlook of teacher as researcher. Gould (2008) claimed that effective and influential teacher professional learning that has a positive influence on classroom pedagogical change and improves student learning, needs to be relevant and engaging. Gould (2008) cited the benefit of a “teacher as researcher” framework because “no one knows better than teachers about the challenges they face and the type of support they need" (p. 5). Burns (2010) listed a plethora of arguments for using the teacher as researcher as a framework for research. These include the development of theory from a teacher viewpoint; the enlargement of the role of teachers in the production of knowledge relevant to their craft; and, the professionalisation of teachers. Supporting this view, Holloway and Biley (2011) stated that the power of qualitative research is that it encompasses the involvement of the researcher and their experiences, which they argue is a resource. Christianakis (2010) discussed collaborative teacher research as a means to unify teachers, academics and policy makers; and, allow teachers to directly influence their profession. Although the notion of teacher as researcher does not take the strength of a framework in this study, it certainly was a provocation and useful in establishing predetermined a priori themes for data analysis.

1.5.2 Significance for teachers

An emergent theme from the literature highlighted that teacher self–efficacy is integral to the improvement of student science literacy. Thus, the teacher may gain knowledge which positively influences their confidence in teaching K–6 Science and Technology in a manner that is natural, contextual and engaging for their students. For comparability of understanding teacher self–efficacy will be defined as the ability to plan, teach and facilitate high quality, appropriate teaching and learning for student achievement. In general, primary science teachers have a limited understanding of the concepts and skills required to teach science investigatively (Fraser, 2010). Teaching science investigatively appears in the literature under several pseudonyms such as practical science, experimental science or inquiry science. Inquiry–based teaching was linked with the teaching of open investigations. It is socially demanding, with no prescribed formula and produces unanswered questions. Oliveira (2010) suggested it may make teachers with low self–efficacy in science feel as if they are losing management and control of their classroom. Swackhamer, Koellner, Basile, and Kimbrough (2009) suggested that self–efficacy in science was improved by a focus on content knowledge and pedagogy.

1.5.3 Significance for students

Much of the literature insists that the teacher is the primary influence on student achievement. Hattie (2003, p. 2) claimed that outside the student themselves, "it is what teachers know, do, and care about" that is the single most influential factor on student achievement. With this perception in mind, the link between an improvement of teacher outcomes through professional learning and the potential influence on student achievement is clear. Doppelt, Schunn, Silk, Mehalik, Reynolds, and Ward (2009) in their study about science curriculum reform confirmed "the impact of high quality professional development on teacher practice and student learning" (p. 350).

1.6 Research outcomes

The proposed outcomes of the current study are:

- To elucidate the characteristics of the adult learner in order to better understand the nature of adult learning and what influences success in this arena.
- To foreground andragogical or pedagogical processes, strategies and techniques that evidenced the successful transfer of knowledge from teacher educator to teacher learner.
- Recommendations for the refinement of future professional learning in the area of primary science and technology.

1.7 Limitations

This study is qualitative in nature and as a case study, it is characterised by a specific context at a specific time (Yin, 2009, 2012, 2017). Consequently, this study is limited in its potential to be generalised because the validity of the study findings is not able to be transferred to other contexts and times. That is, they are not able to be directly and simply imposed on other schools and teachers because of local and system variation. The unique contextual elements—a particular professional learning program; specific teachers and their personal views; render the research findings less generalisable to other schools, teachers and learning environments.

As the current study was conducted using data from selected individuals, it is acknowledged that it will run the risk of having a number of variables affect those from which data were obtained. Although most variables that contextualise this study are controlled and minimised as much as possible, they cannot be eliminated. These limiting factors will therefore have an impact on the validity and generalisability of the study. Consequently, the most significant question is: Will the study findings be valid and reliable enough to inform theory?

As a result of these limitations, this study will not change the face of professional learning. However, the findings may be sufficiently valid and reliable to influence similar research, particularly in the area of adult education. This, after all is the purpose of the intended research. As Shen (2009) stated, "the purpose of case study is not to represent the world, but to represent the case" (p. 22).

The potential for bias also needs to be monitored, as the researcher was a co-facilitator in the professional learning for K–6 Science and Technology for Sydney Catholic Schools. This is a necessity constraint of this study, because more meaningful findings will emerge if the interviewer has an in-depth knowledge of the professional learning program and the outcomes the program is designed to achieve.

1.8 Outline of the thesis

Chapter one presents the introduction to the current study. It described the background of the researcher and the educational influences that initiated interest in this study. The research questions were presented and contextualised. This context was then linked with the theoretical framework of adult education and the conceptual framework of the present study. Methodological choices were canvassed, that is, the use of case study and a hybrid approach to thematic analysis. Further to this, the significance of the study was presented in relation to facilitators of professional learning, teachers and students. Finally, research outcomes were outlined and the overall limitations of the present study.

Chapter two presents the literature pertaining to the current study. It showcases significant theoretical constructs such as pedagogy and andragogy. It also includes literature on what is known about teacher professional learning and science education. Furthermore, it reports on literature regarding factors of influence in science education such as the implementation of a new curriculum; teacher confidence and self-efficacy; and the use of the well-established TPACK framework in teacher education.

Chapter three frames the current study theoretically within the realm of adult education. More finitely, it conceptualises six main ideas supported from the broad literature on adult education into a conceptual framework. The conceptual framework presents a greater focus on concepts within the theoretical frame of adult learning that are likely pertinent to the specific context of the present study and its adult learners.

Chapter four canvasses the methodological choices, with explicit detailing of why select choices were made. It discusses the interpretive paradigm and choice of case study and the decision-making that led to this selection. Also, it delves into the hybrid approach to thematic analysis adopted for this study and how this choice champions the theoretical and conceptual frameworks of chapter three.

Chapter five reports on study findings and presents them by subsidiary research question. A sample of the hybrid approach to thematic analysis is included to show the process of data analysis undertaken by the researcher. Summary tables present the nine identified themes of the study, six of which were deductively applied and three inductively born of ground-up analysis.

Chapter six foregrounds the importance of teacher participant voice through a narrative case report. It provides supporting evidence via direct teacher quotes of the nine identified themes in the present study. This chapter, alongside chapter five, provides the building blocks for the in-depth analysis and discussion of chapter seven.

Chapter seven discusses the findings in more detail, bringing to light the interactive nature of adult learning as the theoretical framework in the context of this study. This chapter is organised by subsidiary research question, discussing all themes and their supporting subthemes using the theoretical framework and teacher voice.

Chapter eight presents the major new insights from the present study, which have the potential for transferability. This chapter concludes the study by drawing together the most significant findings in the hope of usefulness in the teacher professional learning setting. Limitations and suggestions for further research are also noted.

Chapter 2: Literature review

Introduction

This chapter presents the literature review that informs the current study. Of central focus is an understanding of pedagogy and andragogy from as broad a view as possible. A review of the literature in primary science and technology education foregrounds some effects of the introduction of a new curriculum. Other central ideas in the literature discuss teacher self-efficacy and theoretical models for teaching primary science and technology such as technological pedagogical content knowledge (TPACK). Past studies inform the scope of this study, and reveal gaps in the literature. According to Bolderston (2008, p. 86), "a literature review can be an informative, critical, and useful synthesis of a particular topic"—it is hoped that chapter two meets these criteria.

2.1 Pedagogy

Pedagogy as a term was derived from the Greek *paidagogos* which composites two words—the Greek *paidos* (child) and *agogos* (leader) ("Pedagogy", 2019). The use of *paidos* in reference to child learners is reflected in the literature by the view of pedagogy as "the art and science of teaching children" (Ozuah, 2005, p. 83). Multiple authors have remained true to this classicist view of pedagogy (Gergely, Egyed, & Király, 2007; Knowles, 1984; Miduli, Kaura, & Quazi, 2018; Miedema, 2017; Ponte & Ax, 2008). This viewpoint is often in contrast to andragogy as referring to adult learning (Knowles, 1980; Merriam, Caffarella, & Baumgartner, 2007; Miduli et al., 2018). Others take a generalised definition and the viewpoint that pedagogy is the art and practice of teaching for all learners (Draper, 1998; Holmes & Abington-Cooper, 2000; Whiteside, 2017). Gehring (2000) referred to pedagogy when he stated, "that somewhere in history the 'children' part of the definition got lost" (p. 157). Savicevic (2008, p. 362) although in disagreement with this school of thought captured the viewpoint that once the philosophy of lifelong learning (that is, learning across an entire lifetime) is accepted "there is no need to emphasise distinctively the learning of children, youth and adults.

It is all the same!" (p. 362). Proponents of this view have used pedagogy as a basis of practice for teaching both adults and children without much differentiation for the past few decades (Chan, 2010). Finally, there is the understanding that pedagogy denotes teacher-oriented education versus andragogy that calls for learner-centred education (Taylor & Kroth, 2009).

Pedagogy is a broadly used term that appears in the literature and has had significant uptake in educational praxis. Irrespective of the thought camp of pedagogy for child learners, or child and adult learners alike, the definition may be further extrapolated by four domains (Inglis & Aers, 2008). These are subject and curriculum knowledge; teaching repertoire of skills and techniques; teaching and learning models; and, conditions for learning (Inglis & Aers, 2008). A similar and more detailed breakdown of pedagogy by Barton (2019) covered the theory and practice of teaching; strategies used for teaching; interplay between teacher and student; educational content utilised; goals of the learner and teacher; and, the manner in which content is presented and delivered to the learner.

2.1.1 Pedagogy for the child learner

Historically, at least, pedagogy as a term had its inception in the notion of children being led in their education by an adult other (Ismail, Sawang, & Zolin, 2018). Historically, as far back as the Stone Age, training was understood to be a skills transfer process from parent to child (Swanson & Holton as cited in Chan, 2010). This form of pedagogy will be referred to as traditional pedagogy in the current study. In the view of Knowles, Holton, and Swanson (1998) pedagogy is based on several assumptions—that learners have a dependent personality; learning is subject-oriented; learners are mainly extrinsically motivated; and, that learners bring little to no relevant experience to learning. These assumptions were influential in relegating pedagogy exclusively to the child learner, as children may be viewed through such a lens (Ismail et al., 2018). Furthermore, adults may be viewed as not fitting these assumptions and therefore require consideration beyond this understanding of pedagogy (Merriam et al., 2007). Settlage and Johnston (2007) asked the question of teachers (the adult others)—"Do we think we are so wise that the manner in which we think and learn differs from that of our students?" (p. 130). They elaborated that there is "little evidence" that the differences between pedagogy and andragogy are real and that "the manner in which people learn is fundamentally the same" (Settlage & Johnston, 2007, p. 131).

2.1.2 Pedagogy and education

Pedagogy is also viewed in the literature as "the art of teaching" ("Pedagogy", 2019, Definition section, para. 1). More than a "synonym for teaching", it "is about the relationship between teaching and learning" (Loughran, 2010, Introduction section, para. 1). The ultimate goal of pedagogy in this context is "to find interesting ways to bring out the possibilities of intelligence and a love of learning" not specific to child or adult learners ("Pedagogy", 2019, The history of pedagogy in education section, para. 1). This opinion situates pedagogy as "an encompassing term concerned with what a teacher does to influence learning in others" (Whiteside, 2017, p. 1); and as "the function or work of teaching: the art or science of teaching, education instructional methods" (Department of Education, Employment and Workplace Relations (DEEWR), 2009, p. 42). Traditionally, students were in a "submissive" role with "obedience to the teacher as instructor" (Samaroo, Cooper, & Green, 2013, p. 78). In the last decade or two, pedagogy used as a general term for teaching and learning encompasses so much more than a linear power relationship between teacher and student.

2.1.2.1 Pedagogy as teacher-centred instruction

Pedagogy as a teaching and learning interaction may also be offered as teacher or subject-based instruction, as opposed to student-centred (Taylor & Kroth, 2009). At times this is the meaning conferred when the term pedagogy is used in the literature. This style of teaching and learning may also be referred to as didactic or instructivist (Ismail et al., 2018). Ismail et al. (2018, p. 170) stated that didactic teaching is "teacher centric", where "educators are seen as transmitters of knowledge" with importance placed on coming up with the "right answer". This educational view is grounded by positivist or empirical conceptions (Akbari & Dadvand, 2011). The link is understandable considering the heightened focus on students being given and getting the right answer. Positivists are anchored by the idea of right and wrong answers and an absolute truth (Boblin, Ireland, Kirkpatrick, & Robertson, 2013).

Arguments for and against the didactic approach abound in the literature, so too arguments for a middle ground. In defence of this approach, a mass of information may be transferred to students very quickly (Barber, 2007). Furthermore, it is an effective means of transferring foundational and theoretical knowledge for a learning area (Ismail et al., 2018). Taber (2011, p. 42) spoke to the place of didactic approaches such as rote learning in the classroom through the example of learning things such as "multiplication tables", "spelling", "the dates of major wars" and "how to say good morning in various foreign languages" and many others. In criticism, the didactic approach is seen as not being very effective in the development of future entrepreneurs who exhibit specific skills, knowledge and behaviour (Yu Cheng, Sei Chan, & Mahmood, 2009). In addition, due to a stunted interaction between teacher and student, students are in a sense given permission to be submissive in their learning (Ismail et al., 2018). This notion of the passive learner is reminiscent of "behaviourism learning because all behaviour is caused by external stimuli (educator)" and "all behaviour can be explained without the need to consider internal mental process or thinking" (Ismail et al., 2018, p. 170).

2.1.2.2 Pedagogy and constructivism

As the educator or adult other shifted from the position of the knower of all knowledge, the teaching role aligned more with that of an educational guide (Murphy, 2007). This was in part due to the influence of the educational theory of constructivism (Bada, 2015). Constructivism "sees the teacher step back to allow a student-directed, discovery-based approach to learning, with the student making decisions, with guidance from their teacher" (Vij, 2015, p. 8). It was through the psychological work of Jean Piaget (1973, 2013) on child development that discovery learning became a focal point in constructivist pedagogy. Piaget surmised (1973) "to understand is to discover, or reconstruct by rediscovery, and such conditions must be complied with if in the future individuals are to be formed who are capable of production and creativity and not simply repetition" (p. 20).

The linear transmission of information (or learning) from instructor to student is challenged by the constructivist paradigm. Assumptions such as a static and controllable learning environment became the suppositions being pushed against by constructivists (Tahir, 2010, p. 8). Instead constructivism in pedagogy operates on other ideologies. Fosnot (1989) made reference to four principles—that learning depends on what we already know; that new ideas emerge as we adapt and change our old ideas; that learning involves developing ideas rather than simply accumulating facts; and, meaningful learning occurs through the challenging and rethinking of our old ideas. From these principles, a multitude of constructivist pedagogies have emerged (Bada, 2015). Honebain (1996) summarised seven goals of the constructivist classroom—that students determine how they will learn; that there is a provision of experience in a multitude of perspectives; that learning is embedded in real-world contexts; that students have opinions and ownership in their learning; that learning is a social experience; that learning utilise a myriad of modes of representation; and finally, that reflection takes place underpinned by an awareness of metacognition in learning.

2.2 Andragogy

The term andragogy has undergone a number of changes to reach its current status as generally describing learning from the adult perspective. The word is derived from the Greek *agogos* meaning leader and the stem *andr-* meaning man, interpreted to adult—thus, leading adults (Loeng, 2018). Andragogy is linked to a German grammar teacher Alexander Kapp (1833) (Loeng, 2018). According to the work of Knowles, Holton, and Swanson (1998), the term was utilised by Kapp (1833) to explain Plato's theory on education. Plato viewed education as the only way to stability in a state; a life-long endeavour that positions truth as a broad and complex structure; and knowledge as an object not directly taught, but brought out in the mind of the learner (Lodge, 2014). In 1921 the term andragogy re-emerged when a social scientist named Eugen Rosenstock, also German, claimed that "adult education required special teachers, special methods, and a special philosophy" (Knowles et al., 1998, p. 59). The country formerly known as Yugoslavia continued discussions of adult education using andragogy. From 1968 onwards upon introduction into the USA, andragogy was utilised by Malcolm Knowles after discussions with Dusan Savicevic (Montague, 2012).

Savicevic (1985, 1990, 1991, 1999, 2008) and his research focused on andragogy as an academic discipline. Savicevic (1999) viewed andragogy as “the subject of which is the study of education and learning of adults in all its forms of expression” (p. 97). Henschke (2011) and Reischmann (2017) concurred with this broad all-encompassing view of andragogy. Henschke (2011) placed the adult on adult teaching and learning relationship as integral to the enhancement and capability of the adult learner. The work of Savicevic (1999) based on the European influence on andragogy provided a breakdown of the scientific discipline into five approaches. First, that andragogy was one of the pedagogical disciplines, with pedagogy as superior (Savicevic, 1999). Second, the conceptualisation of andragogy as a science, which encompassed different established disciplines like sociology and psychology (Savicevic, 1999). Third, the approach of andragogy that centres on the behaviour of teachers and learners in the learning context (Savicevic, 1999). Fourth, an anti-discipline view that rejected the second approach, but positioned andragogy as a field of research belonging to established disciplines like sociology and psychology (Savicevic, 1999). Finally, the approach that places andragogy as a totally independent scientific discipline—different to any other, with its own sub disciplines (Savicevic, 1999). What becomes clear upon further reading of the literature on andragogy is that there is “a long and rich history of development and evolution” (Charungkaittikul & Henschke, 2017, p. 39).

As a term, andragogy was popularised by Knowles (1968) who defined it as how it is that adults learn (Montague, 2012). Knowles (1984) discussed five assumptions present within the andragogical model—that learners are self-directing; that they experience education differently to younger learners; that they present a readiness to learn; that they possess orientation to learning; and finally, that internal motivations for learning exist. Therefore, andragogy by this definition places theories of pedagogy well away from the adult learning environment. That is, adult learners should be contextualised separately to child learners and the art and science of pedagogy. In 1970, Knowles identified a great need to redefine adult theory as separate to pedagogy by “developing a distinctive theory of adult learning” (p. 38). The literature on andragogy advocated that adult learners question what they learn, juxtapose theory and also use personal experience to reconcile their learning—features of learning that are not common in traditional teacher-centric pedagogy (Merriam et al., 2007).

2.2.1 Andragogy for the adult learner

Once popularised, andragogy became a term one and the same with adult learning. Supporters of andragogy for the adult learner alone believe it to have “its own philosophy of facilitating adult learning based on characteristics of adult learners and principles that are essential for the adult learning process” (Terehoff, 2002, p. 66). Savisevic (2008) defended a need for andragogy for the adult learner alone, because of the traditional focus of learning from the child and adolescent perspective only—“the economical, political and scientific resources were also oriented in this direction” (p. 361). Savicevic (2008) does not push for a prominence of adult learning over that of children; but because of the philosophy of lifelong learning and lifelong education and its benefits he feels it is incumbent to fully understand the adult learner. Savicevic (2008) also argued that there are always social and cultural considerations and pressures for an adult that position them differently as a learner; such as their occupation and social positioning and standing in society. Adult learning and the theory and practice that support it should maintain its own position and complexity as “it is and will be interconnected with multiple unsolved social and personal problems” (Savicevic, 2008, p. 362).

2.2.2 Andragogy and education

Bedi (2004) provided specific insights on the influence of andragogy in education. Bedi (2004) claimed that andragogy helped educators understand the behaviour of a learner and their anxieties which are rooted in their learning. Also, learners are encouraged to search for several solutions to a problem and to become self-directed learners (Bedi, 2004). From personal experience as a practitioner, Bedi (2004) remarked:

> An understanding of andragogy has fundamentally changed me as a teacher because it has informed my teaching methods and expanded and harnessed my teaching skills. I would argue that there is a natural bridge between my expanding knowledge of learning styles and the way in which I have matured

> as an andragogical educator. This link, for me, is learning that we as trainers are not responsible for a student’s learning, and that appreciating the learning style of an individual in a given situation helps us to better understand the learner (p. 93).

In a similar vein, Carlson (1979) supported Knowlesian andragogy but extended the understanding. Carlson (1979) contended that societal democracy should extend to education, that is, that learners should take control of their learning and should not be dictated to in what and how they learn. This demonstrated a self-governing, humanistic outlook to andragogy, whereby a respect for the learner’s autonomy was maintained by the teacher (Davenport, 2013). Therefore, beyond a provision of adult learner traits, andragogy may also provide a construct for educators to guide their teaching practice.

2.2.2.1 Andragogy as student-centred instruction

Andragogy in practise, based on the Knowlesian assumptions of the learner, may be positioned as a student-centred approach. In this view, andragogy is “learner focused”, whereby the educator assumes the role of “learning support” (Yoshimoto, Inenaga, & Yamada, 2007, p. 80). Daland and Hidle (2016) presented andragogy as a “mutual responsibility for learning between the students and the teacher” (p. 38). Walsh (2011) provided a further breakdown for the educator when implementing adult learner-centred instruction. The educator or instructor should make clear why specific learning is important; plan for task-oriented active learning; and, also be cognisant of the wide range of backgrounds in the learning setting (Walsh, 2011). In practical terms, such an approach could be too great a financial burden, as well as a drain on staff time (Norrie & Dalby, 2007). Hewitt-Taylor and Gould (2002) in light of data from paediatric nursing students showed that although students accepted the theory behind a student-focused andragogical approach, had a preference for passive, teacher-directed learning. Other studies purported the exact opposite conclusions. For example—Muduli, Abichandani, Bhaduri, and Chaudhuri (2019) in their study on postgraduate Indian business students concluded that “learners prefer andragogy, which can be met only by business education providers shifting to learner-centred teaching and curricula” (p. 168).

2.2.2.2 Andragogy and constructivism

The congruency between an andragogical and constructivist approach becomes increasingly evident upon broad perusal of the literature. Taking into account basic assumptions about "knowledge, students and learning", Bada (2015, pp. 68–69) tabulated the differences between the traditional and constructivist classroom. Table 2.2 presents these divergences.

Table 2.1 A comparison between the traditional and constructivist classroom (from Bada, 2015, pp. 68–69)

Traditional classroom	**Constructivist classroom**
Curriculum begins with the parts of the whole. Emphasises basic skills.	Curriculum emphasises big concepts, beginning with the whole and expanding to include the parts.
Strict adherence to fixed curriculum is highly valued.	Pursuit of student questions and interests is valued.
Materials are primarily textbooks and workbooks.	Materials include primary sources of material and manipulative materials.
Learning is based on repetition.	Learning is interactive, building on what the students already knows.
Teachers disseminate information to students; students are recipients of knowledge.	Teachers have a dialogue with students, helping students construct their own knowledge.
Teacher's role is directive, rooted in authority.	Teacher's role is interactive, rooted in negotiation.
Assessment is through testing, correct answers.	Assessment includes student works, observations, and points of view, as well as tests. Process is as important as product.
Knowledge is seen as inert.	Knowledge is seen as dynamic, ever-changing with our experiences.
Students work primarily alone.	Students work primarily in groups.

In the view of traditional pedagogy, the traditional classroom column is clearly representative. The constructivist classroom column shares multiple links with a Knowlesian andragogical approach. Most notably in reference to the importance of learner interest and experience; the value it is afforded in the classroom and the influence it has on learning. Furthermore, the repositioning of the educator's role as that of a guide for learning is very similar to the role of the andragogical educator. Knowles (1970) noted in emphasis that the "truly artistic teacher conscientiously suppresses what he knows his students ought to learn in favour of helping his students learn for themselves what they want to learn" (p. 51). For the purposes of this study, andragogy will be considered as a set of learner characteristics, applicable to learners of any age and learning contexts. Foundational andragogical researchers such as Knowles (1968, 1970, 1977, 1980, 1984, 1998) and Savisevic (1985, 1990, 1991, 1999, 2008) are critical points of reference in establishing this study's andragogical learner traits.

2.2.3 Criticisms of andragogy

The criticisms of andragogy as the art and practice of teaching adults are broadly based on a lack of empirical evidence. Rachal (2002) discussed the presence of literature that focused on the "philosophical underpinnings of the concept rather than its empirical efficacy" (p. 211). In this view, Knowles' (1977) assumptions of the adult learner have a "weak or non-existent empirical basis" (Loeng, 2018, p. 5). Others (Finger & Asun, 2001; Sandlin, 2005) claimed that Knowles' (1977) andragogy overlooked social, political, economic and historical context—that is the context in which the learner connected with society. By this account Knowles (1977) assumed a primarily individualist, self-realising, independent and self-directed adult (Leong, 2018). Hanson (1996) also argued against age or stage of life andragogy, but positioned a learner's individual characteristics and societal contexts such as culture and power as the main influencers.

Another criticism arises from the lack of translation of andragogy as adult learning theory, to practice. In a critique of Knowles (1970), Rachal (2002) discussed that even Knowles (1970) was not able to practically apply one of his own principles of adult learning, self-concept. Knowles (1970, p. 51) stated that "locus of responsibility for learning" was "in the learner". Yet in a first-year class he offered, Knowles (1970) provided 18 objectives listed on a syllabus for students to select from. According to Rachal (2002, p. 216) and strictly speaking, this moves away from true Knowlesian learner self-concept, not as complete "violation of principle" because students were able to choose which of the objectives "on which to focus as well as how to achieve them", but a transfer from the ideal. Rachal (2002) although highlighting that Knowles (1970) could not practise true self-concept, does not feel the presentation of syllabus objectives to students takes away from their learning, but was contextually appropriate in that particular learning setting.

2.3 Heutagogy

Hase and Kenyon (2000) introduced the heutagogic style of learning (and teaching). Heutagogy was presented as self-determined learning; a form of flexible learning, whereby the teacher provides the resources, but the learner may influence the course itself (Hase & Kenyon, 2000, 2001, 2007). The approach of Hase and Kenyon (2000, 2001, 2007) goes beyond the model of andragogy put forward by Knowles (1968, 1970, 1977, 1980, 1984, 1998) in that a key principle of adult learning is the desire both to have control over the experience and develop expertise whether in reference to the life or work of the adult learner:

> Thus learners might read around critical issues or questions and determine what is of interest and relevance to them and then negotiate further reading and assessment tasks. With respect to the latter, assessment becomes more of a learning experience rather than a means to measure attainment (Hase & Kenyon, 2001, p. 4).

The increase of individual capability appeared to be the distinguishing concept between Knowles' (1968, 1970, 1977, 1980, 1984, 1998) notion of andragogy and heutagogy as presented by Hase and Kenyon (2000, 2001, 2007). Chan (2010) gathered that this increased individual capability that involved the amassing of skills and knowledge was to place the learner at a comparable and competitive level in the 21st century. Burke, Schuck, Aubusson, Kierney and Frischknecht (2018) in their literature review noted that teachers with constructivist teaching and learning views were more likely to influence the effective use of technology in the classroom, a key skillset for the 21st century learner. Therefore, factors outside the self-determination of a learner will continue to influence learning quality—things such as the type of education schools offer; the methods used in the classroom; and, means to involve learners in their knowledge-building, remain pivotal considerations (Chan, 2010).

2.3.1 The PAH continuum

In a 2010 study into heutagogy, Natalie Canning put forward a tiered transitioning of the learner from pedagogy to heutagogy. Figure 2.1 shows the three levels that a learner transitions through in their learning—beginning with pedagogy, into andragogy and finally, heutagogy.

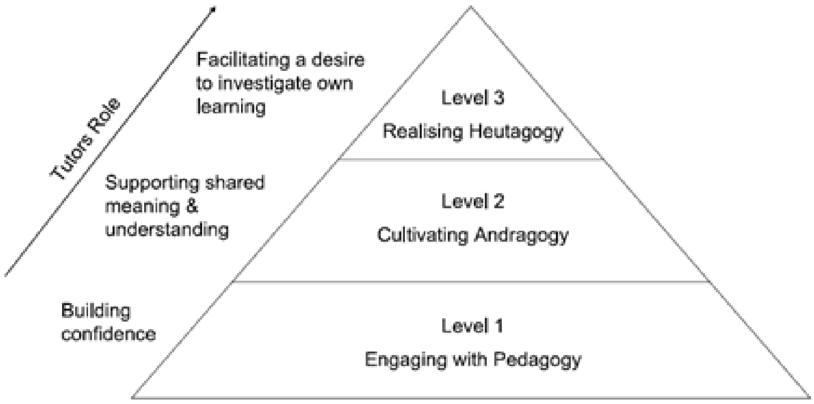


Figure 2.1 A pyramid model of the three levels of learner transition (from Canning, 2010, p. 63)

Here, the educator's role starts with building up the learner in order that they may eventually progress to a realisation of self-determined learning (level three) (Canning, 2010). Canning (2010) noted that in order for a learner to transition from level one, any fears that plagued them had to be "balanced by a desire and motivation to want to attend the programme and succeed" (p. 64). In level two, the learner came to know that their contribution to the learning was valuable and that they could now "begin to co-construct knowledge" (Canning, 2010, p. 64). A heutagogical state was not always reached within the learning journey of the individual, and Canning (2010, p. 66) also made mention of a reversion by some to a "comfort zone" of level one (engaging with pedagogy). This back and forth movement of a learner through the levels evidences a continuum structure rather than a strict stage-by-stage transition that is unidirectional.

Blaschke (2016) built on the work of Canning (2010) in heutagogy. Blaschke (2016) presented four main principles of heutagogy: human agency (learner centeredness); capability; self-reflection and metacognition (double-loop learning); and, non-linear teaching and learning. Hase and Kenyon (2013) contended a heutagogical learner is viewed as the main manager in their own learning resulting from personal experiences. Blaschke and Hase (2015) placed the heutagogical learner at "the centre of the learning process rather than the teacher or curriculum" (p. 27). Blaschke (2016) also showed a relinquishing of instructor control and course structure through the levels, and a building of learner maturity and autonomy from level one through to three, and still maintained the integrity of Canning's (2010) three level pyramid. In outlining the critical differences between the levels, Blaschke (2016, p. 8) acknowledged that "student learning is a persistent goal" of all three. Table 2.2 presents the different approaches used for teaching and learning within each level according to Blaschke (2016).

Table 2.2 Approaches for each of the three levels of learner transition, pedagogy to heutagogy (from Blaschke, 2016, p. 9)

Pedagogy (Teacher-directed)	Andragogy (Self-directed)	Heutagogy (Self-determined)
Some single-loop learning	Stronger emphasis on single-loop learning	Single and double-loop learning
Knowledge transfer and acquisition	Competency development	Capability development
Linear design of courses/curriculum and instructor-directed learning approach	Linear design of courses/curriculum with learner-directed learning approach (e.g., organizing his/her learning)	Non-linear design and learner-determined learning approach
Instructor-directed	Instructor-learner directed	Learner-determined
Getting students to learn (content)	Getting students to learn (content)	Getting students to understand how they learn (process)

This relationship between pedagogy, andragogy and heutagogy was termed the PAH continuum by Fred Garnett in 2013. Garnett (2013) explained in a blog post:

> Start with a known subject, the delivery of which a teacher is confident with (pedagogy), negotiate with the learners how they might study that subject in ways that motivate them (andragogy), and offer creative ways in which they might express what they have learnt (heutagogy) (para. 4).

Garnett (2013) although referring to the relationship between pedagogy, andragogy and heutagogy as the PAH continuum, described an essentially one-way movement from pedagogy to andragogy to heutagogy.

2.4 The teacher professional

The current study focuses on a particular type of adult learner, the teacher professional. As such, a general understanding of what is discussed in the literature regarding the teaching profession is significant. The literature highlighted a contention between the autonomy of the teacher as a professional and their dependence due to pressures such as policy and curriculum. The teacher professional could therefore be reflected upon in light of teacher agency and teacher accountability. What becomes evident in a perusal of the literature is the proverbial tug-of-war between professionalising teaching and producing some level of educational consistency; and, balancing teacher autonomy and agency in their role as frontline educators. Nolan and Molla (2019) recognised this contention and supported an "alignment" of policy and teacher agency in order that "professional learning experiences…be tailored to better support the professionalization of these educators" (p. 126).

2.4.1 Teacher agency

Teacher agency, for some, is the bedrock of the teacher as professional. Teacher agency is not qualified in a single distinct definition, but draws together many theories and notions. Biesta, Priestley, and Robinson (2015) discussed that it "is not something that people have – as a property, capacity or competence – but is something that people do" (p. 626). Thus teacher agency may be seen as the decisions that teacher make, both long and short term in their professional life for the purpose of student learning. Despite not positioning teacher agency as something that people have, Biesta et al. (2015) discussed that it "is highly dependent upon the personal qualities that teachers bring to their work" and "includes professional knowledge and skills" (p. 636). In the introduction to their study on the teaching profession, Özdemir, Demirkol, and Polat (2019) placed the teaching profession at the helm of societal gain. They foregrounded teacher abilities, knowledge, skills (communication and other), devotion and self-sacrifice, to name a few, as critical to the successful decisions teachers make (Özdemir et al., 2019). These notions of teacher personal qualities and teacher agency as the primary influences of student learning speak to a ground-up approach (Wilcox & Lawson, 2018). In other words, learning is best impacted by the day-to-day decisions that teachers make.

Teacher agency has been shown to not only progress student learning, but also to expedite teacher professional development (Hadar & Benish-Weisman, 2019). Hadar and Benish-Weisman (2019) discussed that "attributing importance to promoting the self and being open to new experiences whilst maintaining independent thoughts and actions are positively related to teachers' agentic capacity" (p. 152). When professional development is moved from the responsibility of the teacher to the requirement of policy, conflicts may ensue. Rooney (2015) concluded in his study that teachers that felt compelled to practise in a manner that contradicted their beliefs about effective teaching and learning lost pleasure in their teaching work. Therefore, a purely top-down approach of controlling teacher practice with policy and procedures may elicit its own set of educational issues (Wilcox & Lawson, 2018).

The context of the professional learning in the present study is primary science and technology. Martin (2019) researched primary teachers' professional agency as a means of combatting the reluctance to teach science. Martin (2019) concluded through her study participant Sarah that:

> Professional agency, both personal and collective, is shown to shape her enactment of the science curriculum with her class. Her personal agency is revealed in her commitment to pedagogical decision-making and her collective agency through her commitment to her planning team and institutional requirements and to the success of her school including its reputation in the eyes of the community (p. 1298).

Teacher agency in this view combines the best of personal agency for decision-making in the classroom in preservation of teacher autonomy, and broader policy and procedural decision-making for the greater good of the educational community.

2.4.2 Teacher accountability

Teacher accountability is a complex concept which is defined in the present study as the external impetus to perform, regulate and manage teaching practices and behaviours. This definition is built upon the work of Dubnick (2006) in a paper presented on four orders of accountability. Accountability order one is performative accountability, whereby there is a responsibility on the account giver to be unequivocal in account giving to the account receiver (Dubnick, 2006). The second order of accountability is regulatory accountability, which "does not involve direct and explicit account giving, but is instead manifest in following the guidance, rules and operating standards of the presumptive account giver's task environment" (Dubnick, 2006, p. 3). The third order of accountability is referred to as managerial accountability, in which accountability is used as a motivational tool, more so than a regulatory one to produce deliberate behaviour (Dubnick, 2006). As a result, there is "the extensive use of incentives and sanctions" in the third order of accountability (Dubnick, 2006, p. 5). The fourth and final order of accountability according to Dubnick (2006) is embedded accountability. Dubnick (2006) explained:

> In many respects, fourth order accountability stands as both foundational and aspirational in this scheme. Modern governance – whether public or corporate -- ultimately rests on a foundation of legitimacy and trust, and that legitimacy and trust is rooted in the belief that the governors/managers/administrators operate under the assumption that they are accountable. That is, it is expected that they have or will assume an accountable posture at all times, and that this embedded sense of "being accountable" will guide their behavior without having to resort to performative, regulatory or managerial forms (pp. 5–6).

Teacher accountability has become a significant focus of educational reform and thus there has been a growing concentration on and examination of teachers as the professional frontline of education (Holloway, Sørensen, & Verger, 2017). As a consequence, policy makers (government) are shifting their educational accountability to teachers, in an attempt to address educational problems (Winter, 2017). This exposes the profession of teaching to the influence of governance (Macheridis & Paulsson, 2019). Carnegie and Tuck (2010) defined governance as "the manner in which power and authority is exercised in organisations in the allocation and management of resources" and therefore "involves the enactment of policies and procedures for decision making and control" (pp. 431–432). Winter (2017) qualified that the shift of accountability from government to teachers, does not result in a shift of power to teachers. Rather the opposite appears to be increasingly evident, that complying with policy requirements confers "a violence by assuming control over student and teacher subjectivities" (Winter, 2017, p. 55). In their study of teacher professionalism and performativity, Moore and Clarke (2016) evidenced significant teacher participant voice which highlighted teachers had an issue with the policies being forced upon them, as they were seen as being in opposition to their deeply held beliefs of the purpose of public education.

Teacher accountability as influenced by policy cannot be simply categorised as negatively implicating the teacher professional. This would discount the benefits of consistent educational curricula and practices. A global drive for educational improvement for greater economic efficiency has influenced the overhaul of educational systems via policy in Australia and many other countries (Dargusch & Charteris, 2018). In regions of disproportionately low educational outcomes, this may be a valiant attempt to level the educational playing field. This is evidenced with policy such as the 2002 No Child Left Behind (NCLB) Act in the United States, "which enforced high-stakes testing regimes to improve school performance, thereby challenging established notions of teacher professionalism" (Holloway et al., 2017, p. 5). It could be contended that teacher accountability moves teaching further out of the vocational realm into the professional (Long, Graven, Sayed, & Lampen, 2017).

2.5 Professional development (PD) or professional learning (PL)

PD like many other terms found in the literature, is conceptualised in a number of different ways when used in reference to teacher learning. Traditionally, it may be seen as providing "educators with information, whether it's theories regarding pedagogical practices or updates in subject matter" (Professional development vs professional learning, 2017, Continual professional development section). Scherff (2018, para. 2) concurred, and stated that PD "happens to teachers" and "is often associated with one-time workshops, seminars, or lectures, and is typically a one-size-fits all approach". Archibald, Coggshall, Croft, and Goe (2011) commented on teachers in the context of the United States who were frequently displeased with the PD they were required to partake in. Teachers commented in a survey that PD "leaves something to be desired or is a waste of my time" (Archibald et al., 2011, p. 2). Webster-Wright

(2009) highlighted the scope of the need for effective PD, that no matter the industry there are building pressures concerning "more effective, efficient, and evidence-based practices that deliver improved outcomes for clients whether they be students, patients, or clients" (p. 702). Robinson (2014) spoke specifically of the teaching profession—"A well trained, professional, up-to-date, flexible and responsive teaching force, able to make a real difference to the quality of young people's learning, is regarded as a key to educational reform and economic sustainability" (p. 3). Darling-Hammond, Hyler, Gardner, and Espinoza (2017) discussed the ineffectiveness of PD in reference to changing teacher praxis and positively affecting student outcomes. In accordance with this knowledge of PD inefficiencies, Darling-Hammond et al. (2017) elucidated some features of efficacious PD. They defined successful PD "as structured PL that results in changes to teacher practices and improvements in student learning outcomes" (Darling-Hammond et al., 2017, p. 1).

PL appears to be a term born of the need to integrate teacher learning with lifelong learning or effective ongoing PD. Webster-Wright (2009, p. 703) conceptualised PL as "for the support of professionals as they continue to learn through their professional lives" and "continues over the long term and is best situated within a community that supports learning". Easton (2008) argued:

> It is clearer today than ever that educators need to learn, and that's why 'professional learning' has replaced 'professional development'. Developing is not enough. Educators must be knowledgeable and wise. They must know enough in order to change. They must change in order to get different results. They must become learners (p. 756).

Labone and Long (2016) also specifically addressed the shifting terminology from PD to PL. They saw it as:

> A fundamental shift in focus and responsibility. Development implies a more passive role for the teacher, in which the responsibility is on the developer to improve the teacher . . . learning implies a more internal focus or constructivist approach in which the teacher becomes an active participant who is responsible

> for his or her own learning, and is instrumental in constructing his or her change within their context (Labone & Long, 2016, p. 5).

The current study assumes Easton's (2008) and Labone and Long's (2016) understanding of PL, because of its all-encompassing view of teachers as learners who are looking to build their professional capacity for student benefit as part of their lifelong learning.

2.5.1 Effective professional learning environments

The literature put forward essentially two formations of teaching, that of ability and the other a more malleable notion involving a process of career-long learning (Kenny, 2009). The first encompassed the mastery of particular skills that were definable and able to be demonstrated and practised in real settings. The latter focused on the "reflective practitioner" that developed work by understanding their practice and accordingly reforming ineffective conceptions (Kenny, 2009, p. 5). In the area of primary science and technology education, Harland and Kinder (as cited in Davies, 2010) developed a hierarchy of nine possible outcomes from in-service training, with the ultimate goal of change in practice. Davies (2010, pp. 513–514) spoke to seven goals. Firstly, to broaden teachers' repertoire of creative teaching and learning approaches in primary science and technology (Davies, 2010). The next goals are to improve teachers' enthusiasm in teaching primary science and technology; and, improve teachers' subject knowledge and understanding of science and technology (Davies, 2010). Another goal is to develop opportunities for primary science and technology educators to reflect on their practice and provide opportunities to discuss best practice with colleagues from other schools (Davies, 2010). Furthermore the goal to improve the leadership of teachers with decision-making powers that impact upon primary science and technology education; promote creative activities that will be motivating and interesting for students; and, improve students' attainment in primary science and technology (Davies, 2010). Differences between the criteria presented by Harland and Kinder (1997) and that of Davies (2010) centred on the addition of student attainment in that of Davies.

From a meta-analysis of 35 studies "that have demonstrated a positive link between teacher PD, teaching practices, and student outcomes" Darling-Hammond et al. (2017, pp. 1–2) settled on seven features of effective PL. They are that PL is content focused; incorporates active learning utilising adult learning theory; supports collaboration, typically in job-embedded contexts; uses models and modelling of effective practice; provides coaching and expert support; offers opportunities for feedback and reflection; and is of sustained duration (Darling-Hammond et al., 2017). These features inform the review of literature in relation to professional learning for the current study.

2.5.1.1 Content focus

Darling-Hammond et al. (2017) claimed that PL that brought together explicit content from the curriculum and teaching and learning strategies that aligned well with that content resulted in effective teacher learning. One such example is from the *science teachers learning from lesson analysis program* (STeLLA)—a video-based analysis of a PL program which focused on science content through story and student thinking, content (Darling-Hammond et al., 2017). The STeLLA program was found to have "significantly improved teachers' science content knowledge and their ability to analyse science teaching" evidenced by "higher average gains in student learning" (Roth, Garnier, Chen, Lemmens, Schwille, & Wickler, 2011, p. 117). A supplementary randomised study of STeLLA was confirmatory and claimed, "that students whose teachers experienced content deepening integrated with analysis-of-practice . . . reached higher levels of science achievement than students who received content deepening alone" (Taylor, Roth, Wilson, Stuhlsatz, & Tipton, 2017, pp. 262–263).

PL can function to not only strengthen teacher content knowledge (CK), but to propagate pedagogical content knowledge (PCK), as well as general pedagogy within education (Schneider & Plasman, 2011). Goodnough and Hung (2009) argued that improving teacher CK can result in better instigation of that subject area in the classroom. Also, that a by-product of effective content presentation in the classroom is that a greater variety of student learning needs are more easily catered for (Goodnough & Hung, 2009). This phenomenon has been explained in terms of building teacher confidence which facilitates a strengthening of their knowledge base (Van Duzor, 2012). As such, teachers are not likely to diversify their teaching practice when they are not confident with the information they are presenting or the depth of knowledge they possess.

2.5.1.2 Active learning

Active learning in the perspective of teacher PL refers to "hands-on experience designing and practising new teaching strategies" (Darling-Hammond et al., 2017, p. 2). Darling-Hammond et al. (2017) cited that PL undertaken with active learning in mind often involved teachers learning in the same style that is intended for their students. In a randomised study by Greenleaf, Litman, Hanson, Rosen, Boscardin, Herman, Schneider, Madden, and Jones (2011) that utilised active learning, a conclusion was reached that "literacy teaching in an academic content area, such as science, can substantially impact teachers' classroom practices and the resulting opportunities students experience to learn to read and reason with complex science materials and texts" (p. 706). Student gains in this study were based "on state standardised assessments in English language arts, reading comprehension, and biology" (Greenleaf et al., 2011, p. 647).

The study of Zeegers, Paige, Lloyd, and Roetman (2012) based on a practical mode of science engagement centred on PL that utilised the inquiry-based approach to teaching. This was achieved through the incorporation of "science, environmental education and connecting students to the natural world" via a citizen project named *operation magpie* (Zeegers et al., 2012, p. 27). This approach focused on active learning and the development of the skills such as posing questions, planning investigations and critical thinking (Zeegers et al., 2012). Engagement was evidenced in this study in the enlisting of teachers to participate and collaborate with each other and the community; and, in the development of the program itself to engage students in their science learning (Zeegers et al., 2012). The engagement strategy used by Zeegers et al. (2012) to "engage students in the real life collection and analysis of scientific data in the schoolyard and in their local community" was citizen science (p. 29). Citizen science referred to a bilateral exchange between the non-professional scientists, that is, the teachers and students (even parents and friends) of operation magpie, and scientists in the field (Zeegers et al., 2012). Public engagement is maintained through this process as data collected is analysed and then disseminated back to the non-professionals, giving ownership to them of contributions made (Zeegers et al., 2012). Engagement science is supported by the Australian Curriculum, Assessment and Reporting Authority (ACARA, 2011) and the goals of the NESA Syllabus for K–6 Science and Technology (2012). Engagement science promotes connectivity for teachers and students to the natural world; and moves K–6 Science and Technology beyond the four walls of the classroom, to allow for authentic investigative experiences in the local environment (Zeegers et al., 2012). Conceptually science shifts from “a static, de-personalised, disconnected and largely unattainable body of knowledge to a collection of best explanations and engaging stories embedded in an ever-changing real-world social context” (Fitzgerald & Smith, 2016, p. 70). For teachers in PL, looking at primary science and technology through this lens may elucidate what is of paramount importance (Fitzgerald & Smith, 2016).

2.5.1.3 Collaboration

Collaboration in the milieu of effective PL “creates space for teachers to share ideas and collaborate in their learning, often in job-embedded contexts” (Darling-Hammond et al., 2017). Lave and Wenger’s (1991) notion of *community of practice* (CoP) considered a different form of engagement within the framework of collaborating teachers—that is, engagement in conversation of the people, their ideas and practices. Forbes and Skamp (2019) extended the CoP notion to include students too. They championed the benefits of a CoP in the learning process through their *MyScience* initiative that brought together primary teachers, primary students and scientist mentors. Some authors such as Lieberman (1995) believed that conversations alone were not effective and a more substantive framework within cooperating teachers’ PL needed to be considered. Having said this, in the study outcomes of Nielson, Triggs, Clarke, and Collins (2010) it was noted that teachers that were engaged in the collaboration termed *the conversation* developed their collegiality and self-organisation skills. It was these teachers that could project beyond what practice was current, prompting the aim towards “what could be?” (Nielson et al., 2010, pp. 849–850). These study results supported the idea that the relationship of teaching and learning demanded greater internal engagement and not, as is often advocated, an external intervention (Nielson et al., 2010).

The literature favoured the use of learning communities and collaborative PL over short-term contexts. Akerson, Cullen, and Hanson (2009) pointed out that fostering a CoP didn't guarantee change, but improved on its likelihood. A CoP allowed teachers to situate their learning in their own contexts; interact with other teachers; and, learn individually and as a group (Akerson et al., 2009). Ebert and Crippen (2010) in their cognitive-affective model of conceptual change (CAMCC) stated that time and opportunity for practise of the reform message is a necessity to counteract the fact that there were many avenues for the reform message to be lost. Schneider and Plasman (2011) specifically discussed the science teacher and stated that support is essential to the teacher as they forged ahead in creating an effective science learning setting for their students. Schweinle, Reisetter, and Stokes (2009) spoke of the cohesion that a collaborative group setting can provide. Engle (2006) noted that wider knowledge gains were more likely if the reform was discussed and practised in different contexts in a learning community. This phenomenon was termed *transfer of learning* or *generative learning*. Nielson et al. (2010) indicated that collaboration is critical to reducing hierarchical structures among teachers that may hinder the effectiveness of PL. Desimone, Porter, Garet, Yoon, and Birman (2002) added that collaborative PL can be improved when learning communities involve the same school, department or grade.

2.5.1.4 Use of models and modelling

The use of models and modelling may provide another effective tool for teacher learning. Darling-Hammond et al. (2017) claimed that the power of this tool is in the provision of "a clear vision of what best practices look like" (p. 3). A skilled teacher in the area of learning provides guidance via teaching materials such as lesson and unit plans for the PL of others (Darling-Hammond et al., 2017). Loughran (2006) remarked that modelling "means teaching about two things simultaneously; the content under consideration and the teaching employed to convey that content… to actively make the tacit explicit" (p. 42). Jarvis, Dickerson, Thomas, and Graham (2014) in their work on teacher education noted three significant pedagogical approaches, the third of which was modelling. Jarvis et al. (2014) concurred with Loughran's (2006) representation of modelling as referring to teacher theory and praxis coming together. Seidel and Stürmer (2014) in their study on professional vision used "authentic video sequences of classroom situations" whereby "a myriad of teaching and learning acts occur" for modelling (p. 742).

In a review of the literature on cooperating teachers and their interaction with student teachers, several categories of importance abounded from the meta-analysis—two relevant categories were cooperating teachers as modellers of practice and advocates of the practical (Clarke, Triggs, & Nielson, 2014). Modelling practice provides visuals of teaching that are practical, contextual, replicable, and a sound starting place for a less experienced teacher to build and adapt their practice (Clarke et al., 2014). Clarke et al. (2014, p. 178) commented on the need for cooperating teachers to move from modelling practice for student teachers to mirror to more "reflective and independent ways of engaging"—a move from mimicry to promoting autonomous teacher practice. Perchance this is the prime position for pedagogical modelling in teacher PL; that is, at the beginning of a teacher learner's journey when inexperience and significant gaps in knowledge and confidence exist.

2.5.1.5 Coaching and expert support

Generalist science teachers, such as primary teachers of science and technology, may require specific forms of PL and support when compared to specialist teachers of science that teach in a high school setting. Mulholland and Wallace (2003) advocated a definite difference in needs between these two types of teachers. A focus for the former group centred on building confidence and motivation for teaching primary science and technology, whereas the latter encompassed curriculum training for the specialist and imparting more reflective practice to solicit improvement in science education (Mulholland & Wallace, 2003). Primary teachers of science and technology are called upon "to openly acknowledge the dilemmas and tensions they face when teaching science as an opportunity to re-imagine their role as a teacher of science" (Fitzgerald & Smith, 2016, p. 70). Darling-Hammond et al. (2017) contend that expert knowledge may be shared in an individualised interaction in the classroom; by facilitators of group sessions; or by mentors remotely with the aid of technology. Therefore, this type of support fits well with many different forms of PL.

2.5.1.6 Feedback and reflection

The effectiveness and conversely ineffectiveness of PL undertakings are vital considerations so as to highlight what works and doesn't in a real-life teaching context. In order to assess effectiveness, time must be afforded for feedback and reflection. Darling-Hammond et al. (2017) stated that "high-quality PL frequently provides built-in time for teachers to think about, receive input on, and make changes through their practice" (p. 4). Darling-Hammond and Richardson (2009) deemed the most effective PL activities are student-centred and involved active teaching; assessment; observation and reflection, rather than theoretical discussions and short-term out of context learning. Clarke et al. (2014) also highlighted feedback and reflection as key categories of teacher learning in the context of student teacher education. Feedback and reflection are linked as useful, and praxis influencing feedback should promote "deep and substantive reflection" (Clarke et al., 2014, p. 175). A change in praxis that is meaningful and sustainable may be achieved when reflection as "the ability to frame and reframe practice in light of past experience or new knowledge" is accomplished (Clarke et al., 2014, p. 178).

2.5.1.7 Sustained duration

Almost unanimously, the literature advocated lengthier PL contexts over the "drive by" notion as mentioned by Darling-Hammond and Richardson (2009). They promoted the positives of collaboration and collegiality. So too, Meister (2010) who stated that ongoing teacher support was crucial to success. Teachers require "adequate time to learn, practice, implement, and reflect upon new strategies that facilitate changes in their practice" (Darling-Hammond et al., 2017, p. 4). Dursken, Klassen, and Daniels (2017) in their study on teacher professional learning concluded that the most important reason for PL is "time and space to think" (p. 53). Darling-Hammond and Richardson (2009) gathered that PL of a sustained duration could even extend across years. Length alone may not guarantee advantageous change in teacher praxis, but alongside other considerations, time represents an often finite but potentially very useful resource.

2.5.2 Challenges for professional learning

The importance of the identification of influential variables in PL to enable its success it well substantiated. Wang, Odell, Klecka, Spalding, and Lin (2010) surmised that teacher education is a major factor in improving teacher quality. Furthermore, higher quality teachers influence learning (Daugherty & Custer, 2012). Policymakers and educators, according to Klein and Riordan (2009), are focused on the link between PL and student learning and the reflection this has on teacher practice. Klein and Riordan (2009) also conceded the difficulty in evaluating the context and quality of the implementation associated with PL.

Despite a furore for lengthier PL experiences, some negative possibilities were highlighted. Maloney and Konza (2011) indicated a drop in motivation in PL as time passed. They discussed the realities that even when part of collaborative PL environments, teachers still tended to work in isolation (Maloney & Konza, 2011). Opfer and Pedder (2011) furthered this and discussed the balance of collaboration—"Too much collaboration and learning are stifling, too little collaboration and teacher isolation inhibit growth, just enough collaboration and teachers receive the stimulation and support from colleagues necessary for change" (p. 386).

Even with the selection and instigation of effective PL activities there are many barriers that can inhibit reform or change in the classroom. Johnson (2006) highlighted the difficulty of teachers choosing to abandon safe and familiar teaching practice; the technical dimension of lacking content, pedagogy and technology knowledge; political barriers in a lack of support and finally the most difficult to shift, the cultural dimension that encompasses the existing beliefs and values of the teacher. Opfer and Pedder (2012) commented that even when teachers changed their beliefs because of PL they didn't necessarily change their practice. Some teachers changed their practice, but not their beliefs and also change in practice may not affect the learning outcomes of their students (Opfer & Pedder, 2012). Sahlberg (2015) spoke to the general purpose and reflexive undertakings of PL, such as workshops and mentoring sessions—which negatively affected teachers' undertaking of more authentic professional collaboration.

2.6 Learning

Learning is an all-encompassing term that has been in use in the field of psychology for more than a century (De Houwer, Barnes-Holmes, & Moors, 2013). Traditionally, literature often defined learning practically as a change in behaviour resultant from experience or systematically as a change in the learner resultant from experience (Lachman, 1997). Both types of definitions are underpinned by causation, that is, a cause and effect relationship. Learning then becomes experience shifting behaviour or experience shifting the learner. De Houwer et al. (2013) utilise a longer-term reference point to define learning as "changes in behaviour of an organism that are the result of regularities in the environment of that organism" (p. 633). Their definition acknowledges that not every change in behaviour is learning, and for learning to be evidenced consistency in the environment across time is the driving force. Learning in this study as influenced by former definitions is seen as changes in the learner or their behaviour that are perceptible across different contexts and are resultant from experience.

There are many factors and variables that influence learning and the translation of primary science and technology content to learners. They are embedded in and contextualised by PL and classroom environments. Figure 2.2 positions the PL setting much like a second classroom, with its own environment and interactions and its own influence on effective science and technology teaching and learning.

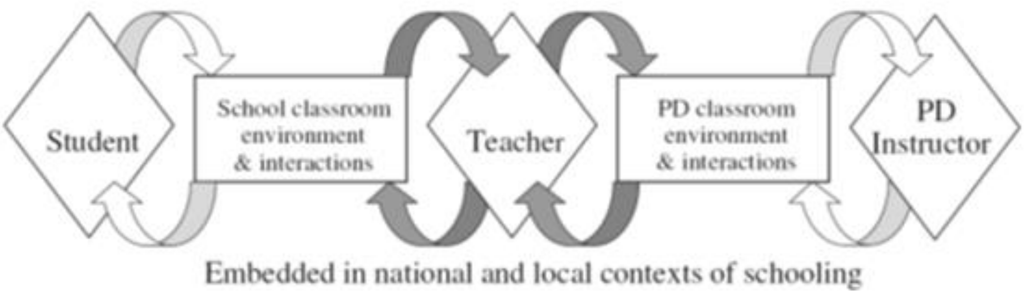


Figure 2.2 *Framework for learning interactions within the structure of professional development (from Van Duzor, 2012, p. 486)*

Among the myriad of factors that influence a learner in any environment engaged with, this literature review foregrounds motivation and engagement as critical to learner success in any setting.

2.6.1 Motivation

Motivation is a broadly addressed term in the literature. Ryan and Deci (2000, p. 54) claimed that "to be motivated is to be moved to do something". According to Glynn, Aultman, and Owens (2005) "motivation is an internal state that arouses, directs, and sustains human behaviour" and has "a fundamental role in learning" (p. 150). In the view of Eccles and Wigfield (2002), all motivational theories in the literature may be attributed to one of four categories—expectancy; reasons for engagement; integrating expectancy and value constructs; and, integrating motivation and cognition. Another breakdown by Seifert (2004) from an educational psychology viewpoint canvassed four prominent theories—self-efficacy theory; attribution theory; self-worth theory; and, achievement goal theory. Seifert (2004) claimed that the four individual theories "are more tightly entangled than the literature suggests" and "in considering these entanglements and arguing each theory in light of the others, it is possible to weave them together" (p. 137). Seifert (2004) argued that motivation, specifically student motivation, is derived from beliefs and emotions. The present study maintains Seifert's (2004) breakdown of motivation theories, with a particular focus on self-efficacy because of its connection in the literature to teachers and adult learners.

Self-efficacy is a concept often discussed interchangeably with confidence. According to Seifert (2004) self-efficacy concerns "a person's judgement about his/her capability to perform a task at a specified level of performance" (p. 137). Bandura (1977, 1986, 1993, 2006) connected self-efficacy with the behaviours required for learning success—such as cognitive processing, motivation and performance, a sense of self-worth and the choices made regarding teaching and learning activities. Learners that demonstrate high self-efficacy are more likely to face challenging tasks and to effectively control their anxieties during such learning challenges (Bandura, 1993). Conversely, a learner with diminished self-efficacy will be less adaptable, tactical and metacognitive (Seifert, 2004).

Contemporary understanding of motivation was in part swayed by self-determination theory (SDT) (Deci & Ryan, 2008). SDT is a theory of "human motivation, focus, and wellness" which emphasises the types of motivation over the amount (Deci & Ryan, 2008, p. 182). SDT highlights the importance of competence, autonomy and relatedness as contributing to motivated choices (Brown, McCord, Matusovich, & Kajfez, 2015). Brown et al. (2015) explained that "need for competence is a desire for mastery . . . need for autonomy is a desire to be in control of one's actions" and relatedness is evident when there "is a desire to fit with others or to be part of a group" (p. 188). Deci and Ryan (2008) theorised a continuum of motivation from amotivation (an absence of motivation) to extrinsic motivation (motivation from the external) to intrinsic motivation (motivation from the internal). Essentially what is theorised are dualistic motivation types—the intrinsic and extrinsic.

When regarding adult learners, Merriam et al. (2007) believed that intrinsic motivation was the primary form. According to Rothes, Lemos, and Gonçalves (2017), intrinsic motivation is the execution of an activity for its own internal rewards, such as learning about ancient Egypt because it is considered by the learner to be interesting. Rothes et al. (2017, p. 4) related extrinsic motivation "to the performance of an activity for the consequences or rewards that come out of it" such as higher grades and honours "and/or to avoid negative outcomes" such as punishment or criticism. Intrinsic motivation related to more affirmative educational approaches and outcomes than extrinsic motivation (Reeve, Deci, & Ryan, 2004). However, extrinsic motivation did not always denote negative outcomes (Reeve et al., 2004). This suggested that extrinsic motivation existed in many forms, and because of this, resulted in different effects (Rothes et al., 2017). In line with SDT, some negatively positioned extrinsic motivation leads to resentment, resistance and a lack of interest—whereas the positives of extrinsic motivation afford an acceptance of the task because of its inherent value (Deci & Ryan, 2008). Yoo and Huang (2013) spoke to jobs and family responsibilities as influencing the adult learner extrinsically. Inan and Yukselturk (2006) referred to the extrinsic expectations of employers on employees to learn and upskill for career progression. Glynn et al. (2005, p. 154) conferred that when intrinsic and extrinsic motivation were under discussion, constructs "that refer to students' traits and states, such as activity level, interest and curiosity" are the predominant focal points.

Psychologists generally position student motivation as an individual process (Munns & Martin, 2005). This is because thinking is assumed to occur within an individual and so motivation becomes cognitive in nature (Munns & Martin, 2005). The field of psychology also confers that thinking occurs before action and in accordance motivation as a thought comes before the action of engagement (Martin & Dowson, 2009). This notion is typified by Martin (2003) in the development of the *student motivation and engagement wheel* (Munns & Martin, 2005, p. 2), as shown in Figure 2.3. Barkley (2010) discussed that when motivation and active learning were in interplay, engagement was resultant—again supporting the notion of motivation preceding engagement.

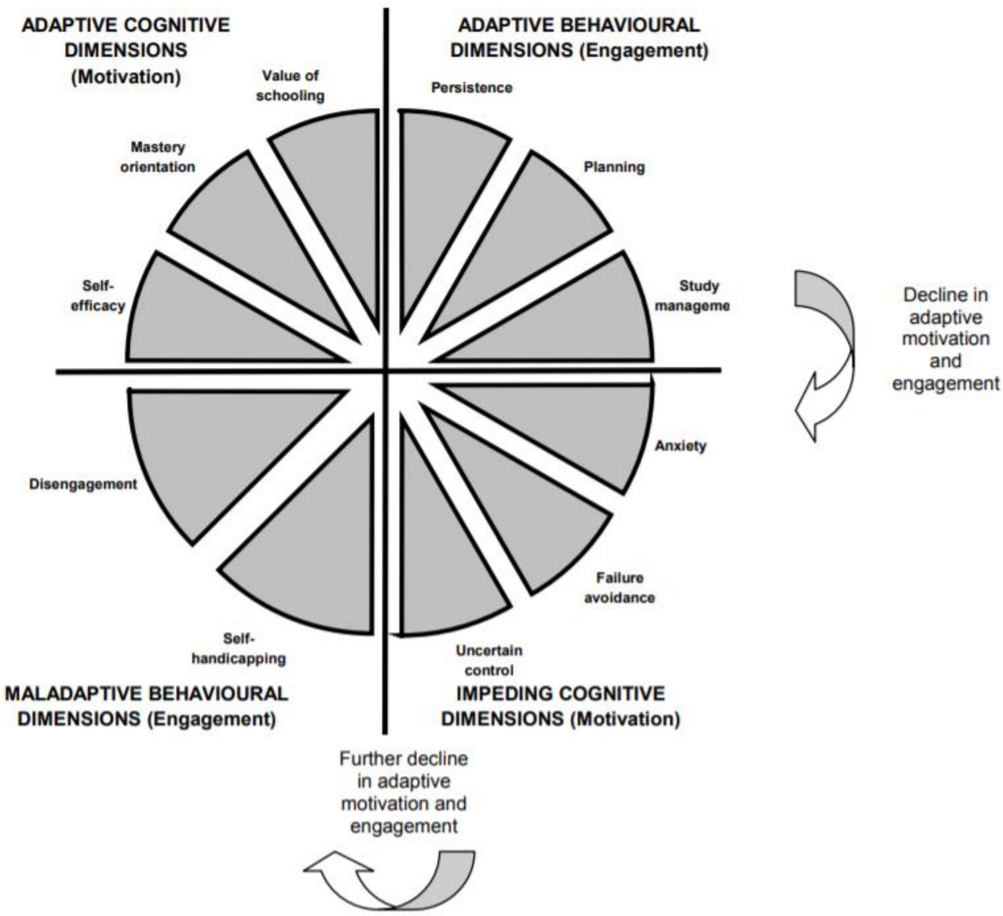


Figure 2.3 *Student motivation and engagement wheel (from Munns & Martin, 2005, p. 2)*

2.6.2 Engagement

Christenson, Reschly, and Wylie (2012) in their work on student engagement noted that engaged learners find learning meaningful and interesting and give value to the influence of learning on their future. Christenson et al. (2012) defined engagement as:

> A multidimensional construct that consists of behavioral, cognitive, and affective subtypes. Student engagement drives learning; requires energy and effort; is affected by multiple contextual influences; and can be achieved for all learners (pp. 816–817).

There appears to be agreement between authors on the notion of engagement as a "multidimensional construct that is highly influenced by context" (Schmidt, Rosenberg, & Beymer, 2018, p. 20). Variances in the understanding of engagement occur because of the theoretical perspective of the researcher and the grain size of the context (Sinatra, Heddy, & Lombardi, 2015). In this circumstance grain size regards the breadth of the engagement (Schmidt et al., 2018). For example, a learner's general engagement with their schooling; engagement with a specific learning area; or a more finite engagement with a specific teaching and learning activity (Schmidt et al., 2018). Grain size ranges from the "microlevel (such as an individual's engagement in a moment, task or learning activity) to macrolevel (such as a group of learners in a class, course, school or community)" (Sinatra et al., 2015, p. 2). Perhaps a sustained and building number of microlevel engagements may stimulate macrolevel engagement.

Engagement has long been used as a means for strengthening pedagogical practice and student interaction to improve learning outcomes (Schweinle et al., 2009). Engagement has been associated with achievement because it encourages "learning, retention, and recruitment" (Schweinle et al., 2009, p. 1). Wayne, Yoon, Zhu, Cronen, and Garet (2008) aligned with this view and suggested that engagement of learners is much more effective than traditional memorisation or rote learning methods. Although the literature often report on child or adolescent learner engagement, the learning of adult participants may be similarly influenced by engagement.

Fredricks, Blumenfeld, and Paris (2004) discussed three forms of engagement—behavioural; emotional; and, cognitive. Other authors supported this social construct of learning engagement (Buelow, Barry, & Rich, 2018; Hew, 2016; Wang, 2008; Woo & Reeves, 2007) which are used to inform this review of literature. Behavioural engagement evidenced positive behaviour and a lack of negative behaviour (Fredricks et al., 2004). Emotional engagement solicited tangible emotion reactions such as happiness, sadness and anxiety from the engaged (Fredricks, 2011). Finally, the cognitively engaged are identified because of a clear investment they have placed in their learning (Fredricks, 2011). Cognitive engagement is related to motivation in the literature (Martin, 2006). This is because the cognitively engaged show an intrinsic motivation to learn and reach goals, and a willingness to invest the effort required for attainment (Martin, 2006).

Shernoff, Csikszentmihalyi, Schneider, and Shernoff (2003) described an almost pure form of engagement they termed *flow theory*, whereby concentration; interest; and, enjoyment must be experienced simultaneously in order for authentic learning to ensue. Fredricks et al. (2004) also discussed the varying degrees of engagement and identified potential ambiguity when scrutinising and analysing engagement. They suggested that the learner may appear to be on-task, but are not engaged in the task at hand. Schweinle et al. (2009) in addition to the understanding of degrees of engagement separated learners into the binary of the engaged and disengaged. These considerations place importance on circumstances and context that may influence the engagement of the teacher learners during professional learning in the current study.

Oliver and Coyte (2011) suggested the use of *social learning theory* (SLT) for engagement of learners with novel and unversed material. SLT encompasses four categories beginning with gaining attention at the sensory and emotional levels (Oliver & Coyte, 2011). The second category requires coding modelled behaviour into words, labels or images to achieve better retention than simply observing (Oliver & Coyte, 2011). Followed by engendering engagement through self-observation of reproduction with feedback; and finally, providing various kinds of motivation to accomplish learning (Oliver & Coyte, 2011).

The literature on engagement qualified that alongside the learning task, the instructor was a key influence. Blumenfeld and Meece (1988) acknowledged both task and teacher influenced engagement. They specified that higher cognitive engagement was achieved by complex hands-on tasks, over the more traditional pedagogical methods where teachers provided instructional support and pressed for answers (Blumenfeld & Meece, 1988). Wayne et al. (2008) suggested that there is a gap in the literature about how this influences the effectiveness of PL. There is comparability to *variation theory* as presented by Pang and Ling (2012), who suggested that two teachers may experience PL sessions differently, take different knowledge from them and be engaged by different tasks and facilitators. Therefore, in the context of the current study facilitators and their methods and approaches may be judged in a myriad of ways by different teacher learners.

Engagement is malleable, even in reference to one person. That is, not all teachers and students are engaged or engaged equally or remain fully engaged during learning. The behaviours of engagement are well documented in the literature, what is lacking are the practical means to engage learners and teachers that actively involve both parties (Pittaway, 2012). Herein lays a challenge because of the difficulty in controlling and predicting the variables that influence engagement.

Pittaway (2012) developed an *engagement framework* that encompassed five generic elements. These are personal engagement; academic engagement; intellectual engagement; professional engagement; and, social engagement (Pittaway, 2012). All engagement elements cannot be separated from the environment and context in which they exist, and thus an influence from environment is exerted (Johnson, Morwane, Dada, Pretorius, & Lotriet, 2018). Pittaway (2012, p. 39) acknowledged that “a safe, respectful and supportive environment” fortified engagement in teaching and learning. Rabourn, BrckaLorenz, and Shoup (2018) in their study on adult learners (higher education students over the age of 24) found them to be more academically engaged then their younger tertiary counterparts. The engagement framework was designed to support the faculty of education for a regional Australian university—therefore for adult staff members and their adult higher education students. Pittaway’s (2012, p. 2) holistic framework embedded in an adult learning context may "be applied to any discipline, year, level or course" and also:

> can be used by unit coordinators when designing and developing a unit, by tutors when considering the teaching practices they might employ to engage students in on-campus and/or online tutorials, by students in taking responsibility for their own learning and making decisions about what, when and how they will engage in their studies, and by professional staff in the design of materials to support marketing, recruitment, orientation, induction, transition and student support initiatives whereby environment and context of learning was undoubtedly the underpinning connection between all facets of engagement (p. 2).

Johnson et al. (2018) added another element to the engagement framework they termed *other*. The other could include but was not limited to difficulties of finance and access to appropriate resources (Johnson et al., 2018). The broad applicability in an adult learning context of the engagement framework renders it a pertinent consideration for the adult learning setting of the present study. For example, adult learners may exhibit strength in one or all forms of the engagement framework which could influence their nature as a learner and the gains they make in their learning journey. Equally, low engagement may result in other effects on the adult learner and their learning successes.

2.6.3 Learning in science and technology

Hands-on activities may for many be tantamount to high quality science and technology learning. Goodrum, Hackling, and Rennie (as cited in Kenny & Colvill, 2008) discussed that the little science and technology in primary schools that was done focused on hands-on activities. This, on the surface, appears to fit the brief of the beneficial focus on student-centred approaches; however, there is no praxis on the "level of student learning associated with this type of activity" (Kenny & Colvill, 2008, p. 35). The suggestion is that student-centred learning does not simply imply the use of hands-on activities, rather it is taking hands-on science from a "fun and filler" association to an engaging "hands-on and minds on" approach which allows student thinking to be stimulated on a scientific level (Kenny & Colvill, 2008, p. 35). Therefore, where hands-on activities are used, the main consideration is that student-centred activities must be geared for the improvement of scientific skills, knowledge and understanding.

2.6.3.1 Scientific literacy

Science is an integral part of life; it provides a context and a place to build skills through the investigative processes of observation; measurement and the universally important problem-solving, just to name a few. Gluckman (2012) placed the highest importance upon a scientifically literate society:

> There is no challenge that we will face over coming decades that will not depend on science . . . science is not just a collection of facts—rather it is a particular way of observing the natural and built world so as to gain a better understanding of it . . . science, both formal and informal, remains the only process we have to gather reliable information about our world on any scale and from any perspective (pp. 2–3).

The science education context has and will continue to receive focus because of the aforementioned reasons. There is also evidence of falling enrolments in science courses and predictions of detrimental repercussions for Australia's economic prosperity and prowess in the long-term (Kenny, 2009). As a part of a flourishing Asian economic market it is essential that Australia continues to improve in science and technology because of the influence on the production of high-skilled jobs for Australians and new technologies for export. Labov (2011) discussed the American context and the significance of science, technology, engineering and mathematics (STEM) "to the continued health, infrastructure, and prosperity of the nation" and that "both research and STEM education are not meeting future or even current needs" (p. 173).

International tests for science allow, at a minimum, a rudimentary comparison of science achievement between Australia and other countries. According to the latest results from the Programme for International Student Assessment (PISA) in 2015, Australia is trailing many of its Asian counterparts in the area of science. Australia is ranking behind Singapore, Japan, Chinese Taipei, Viet Nam, China and Korea. Results from the Trends in International Mathematics and Science Study (TIMSS) in 2015 at a fourth grade and eighth grade level showed that Australia did not rank in the top 10 countries, rather it was well behind its developed world English-speaking counterparts, and its Asian counterparts (Thomson, Wernert, O'Grady, & Rodrigues, 2016). The previous results from PISA (2009) show a downward trajectory for Australia's science mean score. Although the results from TIMSS (2015) for both fourth and eighth grade evidence a slight improvement in score, Australia's country ranking has dropped in both grades (Thomson et al., 2016). Across a twenty year period in TIMSS (1995–2015), Australia stagnated in its overall science achievement (Thomson et al., 2016). There are criticisms made regarding this type of outcome measurement—specifically a questioning of the validity of results in reflecting the true nature of what is occurring in the educational setting (Biesta, 2012). Notwithstanding, as qualitative in nature, the current study is not concerned with the numbers and figures presented in this data, rather what it may represent descriptively—that is, potential inefficiencies and inconsistencies in science and technology education in Australian classrooms and PL environments.

In the Australian context a concern about science education resulted in the commissioning of a report by the Australian Council for Educational Research (ACER) in 2007. In response to results on the need for improvement, as highlighted by this ACER report, the Australian Curriculum, Assessment and Reporting Authority (ACARA) through the Australian Government bolstered teaching and learning in science, and developed the Australian Curriculum (AC) from 2008. The AC is the foundational curriculum upon which the NESA Syllabuses for K–6 Science and Technology (2012, 2017) are forged.

Goodrum et al. (2001) in the work of Kenny and Colvill (2008) put primary schools and the science and technology education they impart as the key towards a shift to a more scientifically literate society. It is at the pre-service level that changes appeared to be needed. Kenny (2009) stated that because little time was dedicated to primary science and technology by supervising teachers this resulted in a lack of good teaching being modelled to pre-service teachers. Such realisations highlight the cyclic nature of the lack of science and technology in the primary classroom, as those pre-service teachers that were neglected in the realm of science education go on to inadvertently neglect the pre-service teachers they take on in the future. Fitzgerald and Smith (2016) provided hope that “with support, primary teachers may begin to think differently not only about their role as science teachers but also the type of learning they value for their students” (p. 74).

Barriers to the improvement of scientific literacy have been well established in this study’s review of the literature and encompass such aspects as teacher self-efficacy in science and technology, and a lack of knowledge of pedagogical approaches. Other practical limitations were shown by Kenny and Colvill (2008). These include a substantial split between the theoretical time allocated to science and technology in the primary classroom versus the actual time spent (Kenny & Colvill, 2008). This may stem from the importance placed on doing science and technology in comparison to other learning areas that may gain more teaching and learning time. Other barriers highlighted were policy and support issues, which impacted on resource allocation for science and technology (Kenny & Colvill, 2008). Goodrum et al. (2001) through Kenny (2009) purported the need of primary school teachers “to be supported by professional development and curriculum resources to build up their confidence and competence to teach science” (p. 172).

It is not a waning interest in primary science and technology that is the root cause of science educational measures not being met. The missing link according to Labov (2011) was highlighted during a science and technology exhibition by a little girl that was provided with a scientific puzzle to solve at one of the stands. She commented on how much she enjoyed the puzzle and thinking like a scientist, even stating that was something that never happens in her class at school. Therefore, Labov (2011) concluded it is not the interest that was lacking, rather a strengthening of pedagogy for students. Labov (2011) discussed the holistic nature of science education—which individual scientists could contribute as well with presentations, interviews, open-house laboratory or field days; breaking down misconceptions, as well as improving community education in science. From a teaching perspective, Labov (2011) advocated engagement as the primary means of using imagination to show students that science and technology are all around them.

2.6.3.2 Science communication

In the literature science communication appears to exert influence on the science education field. Lewenstein (2011) described science communication as a "web of interactions among different actors and formats" (p. 819). This aligns with previously presented literature that errs against traditional rote learning or memorisation of professional learning methods, which are by nature monological. Horst (2011) also discussed the traditional means of communicating science and its monological nature. Horst (2011) presented the dialogical means as preferential for learning, because of its potential to positively influence engagement, as it allows the non-expert to engage in dialogue on their own terms as part of a knowledge production that is unique to them. Belohlawek, Keogh, and Naylor (2010) summarised the literature on the well-documented nature of talk in children's learning and how it allows for clarification and the development of thinking and reason. This is of importance in primary science and technology, as the ability to grasp conceptual ideas and to reason, edges a student ever-closer to the goal of scientific literacy.

There is a link with teacher confidence and the use of efficacious dialogical talk. Belohlawek et al. (2010) highlighted low teacher confidence is the primary reason for absence of this strategy in science and technology lessons. The *puppets project* used puppets as stimulus tool for teachers and students to engage in more productive science dialogue (Belohlawek et al., 2010). The data demonstrated that teachers using puppets are more likely to steer away from questions that only require rote-learning of science by students, and rather delved into questioning related to reasoning (Belohlawek et al., 2010). A documented shift in professional practice appeared to be achieved in what was an extremely short period of time, a matter of hours (Belohlawek et al., 2010). Whether this change was maintained warrants further discussion.

The support for dialogical talk in the science classroom is rife in the literature, as it advocates use to guide student understanding whilst actively involving students in the process. However, a similar issue arose with teachers adopting reflective practice, that is, that the concept and its use may not be properly understood (Mercer, Dawes, & Staarman, 2009). There was a distinguishing between classroom talk that encompassed closed questions followed by short student responses; and, open dialogue conducive to exploration and explanation that used talk to strengthen teaching and learning (Mercer et al., 2009). The former evidenced relatively low-level influence towards quality dialogue between teacher and student (Mercer et al., 2009). Dialogical talk required the use of "active, influential and substantiated" participation of students for best educational results (Alexander, 2000 as cited in Mercer et al., 2009, p. 354). A teacher that understands and practises the dialogic method may in turn influence students to better understand the process, and its involvement in the learning of scientific professionals. Of the teachers involved in the study of Mercer et al. (2009), it was noted that no teacher actually engendered talk that was interactive in nature as is evident in dialogic talk—that there was a clear absence of students speaking for extended periods, teachers selecting relevant points to build upon the discussion and give it new direction (Mercer et al., 2009). This expounds the difficult nature of incorporating such a technique in science communication, and potentially draws into focus teacher knowledge and confidence.

As with any lack of knowledge and experience in the realm of education, strategies and practise, play a large role in affecting praxis. A method for stimulating dialogic talk as presented in Mercer et al. (2009) was the *talking points* resource. Basically, it is a list of statements which is either factually accurate, arguable or undeniably wrong (Mercer et al., 2009). These gear discussion by providing a myriad of ideas for student consideration and talk. By assessing the accuracy of the provided statements students are not only using their prior knowledge and beliefs, but have an open forum to confirm and cement notions or challenge misconceptions in a non-threatening environment (Mercer et al., 2009). The teacher stands to gain a lot from furthering such discussions, with the potential for informally assessing student understanding. In science, formative classroom-based assessment is gaining more ground because of the significant gains in learning and achievement and for improving student outcomes (Andrade & Brookhart, 2019). Formative assessment is geared more closely with the student-centred approach to teaching science (Andrade & Brookhart, 2019). In general terms, the literature acknowledges that "learning occurs through talking with others; ideas are created, shaped and refined through conversation" (Hackling, Smith, & Murcia, 2011, p. 18).

Hand-in-hand with the benefits of talk is listening. In listening, a student may hear different explanations; reconcile preconceived ideas and form the new, all with a sense of those ideas being connected to meaning (Hackling et al., 2011). Hackling et al. (2011, p. 19) argued that the level of discussion must match the "phase of inquiry" to build in a constructivist manner and therefore produce a discourse that supports inquiry. Freebody and Luke (as cited in Hackling et al., 2011, p. 19) specified that the discourse must be of "high intellectual quality", because without this standard, students' academic and intellectual work will not move forward beyond what is a basic skill level. Therefore, appropriate, intellectual and geared whole class discussion involving talking as well as listening appears to be at the core of effective student-centred inquiry-based science.

2.6.3.3 Constructivism and science education

Constructivism as a world view lends itself to the learning area of science and has had significant uptake (Julyan & Duckworth, 2005; Krahenbuh, 2016). Traditionally, science courses were reputed to be "hard", incomprehensible, perplexing and potentially unrelated to students and their interests (Kruckeberg, 2006, p. 1). These and other challenges have the potential to develop into science anxiety, which is incapacitating fearful negative emotions and thoughts when engaging in science learning (Bryant, Kastrup, Udo, Hislop, Shefner, & Mallow, 2013). This presents a challenge for the science educator—to engage students in the learning area in a personally meaningful manner (Novak, 1977). For the science educator to address such a challenge it would mean closing the gap between science as a "body of public knowledge that is designed to minimise personal, subjective interest" and "a student's desire for personal meaning" (Kruckeberg, 2006, p. 1).

Dewey (1902, 1916) presented the dichotomy of child versus curriculum, without deciding on one extreme over the other. Rather, he argued against both as they fell short of socialising the student—one via apathy and the other through personal indulgence (Dewey, 1902, 1916). According to Kruckeberg (2006) Dewey put concrete arguments forward towards teaching that built upon the experience that a student brings to the classroom. This has the potential to be interpreted as supporting the constructivist approach, whereby the acquisition of knowledge is heavily influenced by previous experience and understanding held by the learner (Kruckeberg, 2006). Constructivism as it pertains to science education, also builds upon the experiences, knowledge and understanding a student brings with them into the classroom (Julyan & Duckworth, 2005). Bryant et al. (2013) viewed *interactive engagement* (IE) as "the most common manifestation of constructivism in science education"—as the "substantial departure from lecture mode to student-teacher and student-student interaction" (p. 434).

Perhaps the strongest of modern viewpoints against constructivism in education comes from the work of Kirschner, Sweller and Clark (2006). They argued that beginner learners should be provided with an instructional framework for the "concepts and procedures required by a particular discipline" and not left to their own devices of discovery (Kirschner et al., 2006, p. 75). This movement towards discovery learning is sometimes referred to in the literature as minimally guided instruction (Bakker, 2018). Kirschner et al. (2006) claimed that this form of instruction is "likely to be ineffective" as the vast majority of research from the last fifty years supports the efficacy of guided instruction "to support the cognitive processing necessary for learning" (p. 76).

Taber (2011) provided greater equilibrium in interpretation of the dichotomy of guided versus minimally-guided instruction. Taber (2011) spoke to the research-supported benefits of guided or direct instruction, but also to the misunderstanding regarding minimally guided instruction—often used as a holistic term for consciously not teaching all content directly. For comparative consideration, if a learner is required to know the two animal phyla, in a direct instruction lesson the teacher may impart the information that there are vertebrates (backbone animals) and invertebrates (without backbone animals). A minimally guided approach may mean the teacher lets the student know that they need to be aware of the animal phyla. Taber (2011) said on the surface that students will gain the information they need accurately if the teacher directly provides it to them. However, what could be lost may be far more important. That is, an opportunity for developing "higher level educational aims" such as self-directed learning and metacognitive skills (Taber, 2011, p. 54).

Constructivism in science education influenced the development of the NESA Syllabus for K–6 Science and Technology (2012). This is apparent from the general student-centred approach to learning; in the continuum of outcomes for both knowledge and understanding and skills; and, in acknowledgements made in the rationale of student voice in learning, that learning is "relevant to personal, social and environmental issues in their lives" (NESA, 2012, p. 12). Dewey (1902) emphasised that student experience was a key building block to student knowledge. Julyan and Duckworth (2005) concurred and commented that many experience-based science curricula are built upon this perception and that even scientists use experience for meaning making. Arguably one of the most famous scientists, Einstein (1938), posited that science moved well beyond a collection of learnable facts and laws into a construction of human cognition. The NESA Syllabus for K–6 Science and Technology (2012) aligns with a more balanced view of constructivism in science education, as it sets out explicit outcomes that students need to meet across a stage of learning, so too the freedom to meet those outcomes in the best manner for learner context. This may represent the middle ground between direct-instruction (set outcomes) versus minimally guided instruction (ability to meet the outcomes in a myriad of ways). Synonymously, a middle-ground approach may prove contextual to the adult learning that is in focus in the current study.

2.7 A new curriculum

Undoubtedly, a strong motivation for the introduction of the NESA Syllabus for K–6 Science and Technology (2012) was to strengthen and support science education. Improving the quality of curriculum is well established as a strategy for shifting science education practices (DeBarger, Penuel, Moorthy, Beauvineau, Kennedy, & Boscardin, 2017). Success in the form of improvement in student achievement has been evidenced in several countries upon the implementation of refreshed curricula. One such example is China, whereby 30 years of curriculum innovation have influenced China's achievement in science education (Yao & Guo, 2018). This is evident from the PISA results of Shanghai in the last decade (PISA, 2015). Roblin et al. (2018) spoke to the positives of new curriculum materials when used by both teachers and students alike. Further to this, when curriculum materials are "intentionally designed to simultaneously support teacher and student learning" this provides "teachers with authentic opportunities to incorporate new skills and practices into their instruction" (Marco-Bujosa, McNeill, González-Howard, & Loper, 2017, p. 141). Based upon these points, a new curriculum could be a significant agent of change and influence. The introduction of the NESA Syllabus for K–6 Science and Technology (2012) could potentially be a useful factor of influence to gain insight into the adult learner in the context of this study.

2.7.1 The NESA Syllabus for K–6 Science and Technology (2012)

In the early stages of the present study, the NESA Syllabus for K–6 Science and Technology (2012) was the current curriculum. Built upon the backbone of the overarching Australian Curriculum (AC), it was syllabus developed in context of the state of New South Wales (NSW). Like other curriculum innovations, the NESA Syllabus for K–6 Science and Technology (2012) was intended to support teachers and students alike. Figure 2.5 shows the organisation of content of the NESA Syllabus for K–6 Science and Technology (2012), which foregrounded the skills of working scientifically and working technologically to support and strengthen knowledge and understanding in the learning area. Continuity of learning, according to this syllabus document, is made possible by "relevant and relatable contexts" (NESA Syllabus, 2012, pp. 27–28). The importance of context is verified by its inclusion front and centre in the organisation of content diagram.

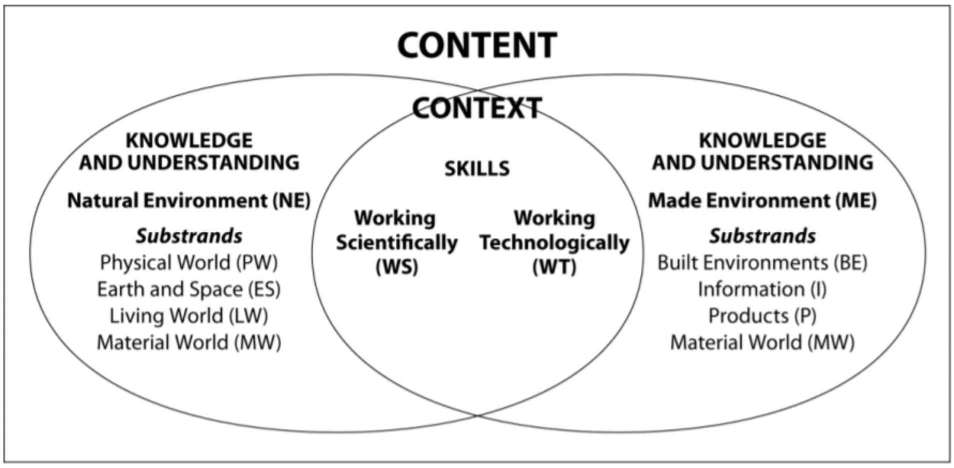


Figure 2.4 The organisation of content diagram for the NESA Syllabus for K–6 Science and Technology (2012)

2.7.2 *The NESA Syllabus for K–6 Science and Technology (2017)*

In the midst of the present study a more current syllabus for K–6 Science and Technology was developed and released for NSW in 2017. Figure 2.6 shows the organisation of content diagram for this latest syllabus. The diagram combines the content of Science 7–10 and Technology alongside K–6 Science and Technology. One obvious difference is the omission of context in the diagram. Another is the representation of the knowledge and understanding of the technology portion of the syllabus via a single strand—digital technologies. In common with the NESA Syllabus for K–6 Science and Technology (2012) is the placement and foregrounding of the two main skills of the syllabus—working scientifically and working technologically (now referred to as *design and production*). There is a clear skills focus as the NESA Syllabus for K–6 Science and Technology (2017) acknowledges in a breakdown of the organisation of content.

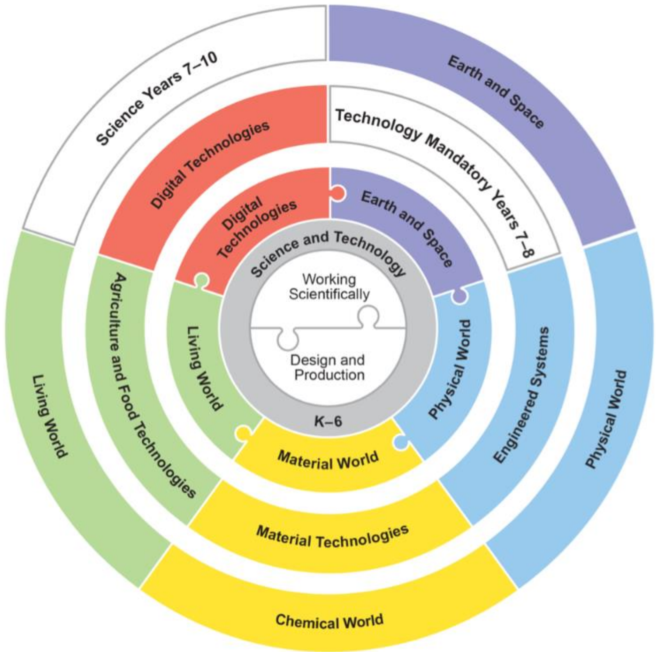


Figure 2.5 The organisation of content diagram for the NESA Syllabus for K–6 Science and Technology (2017)

2.8 The TPACK framework

Collectively, technological pedagogical content knowledge (TPACK) has in the last decade of so gained traction as a theoretical framework for teacher education.

TPACK focuses on three main knowledge constructs—technology, pedagogy and content (Ocak & Baran, 2019). TPACK has been utilised to determine "whether a teacher can effectively design and conduct technology-enhanced instruction" (Lin, Tsai, Chai, & Lee, 2013, p. 325). The current study assumes the version of TPACK introduced by Mishra and Koehler in 2006 and defined in Koehler, Mishra, and Cain (2013), represented by the interplay of seven factors in Figure 2.6:

> Underlying truly meaningful and deeply skilled teaching with technology, TPACK is different from knowledge of all three concepts individually. Instead, TPACK is the basis of effective teaching with technology, requiring an understanding of the representation of concepts using technologies, pedagogical techniques that use technologies in constructive ways to teach content, knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face, knowledge of students' prior knowledge and theories of epistemology, and knowledge of how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones (p. 16).

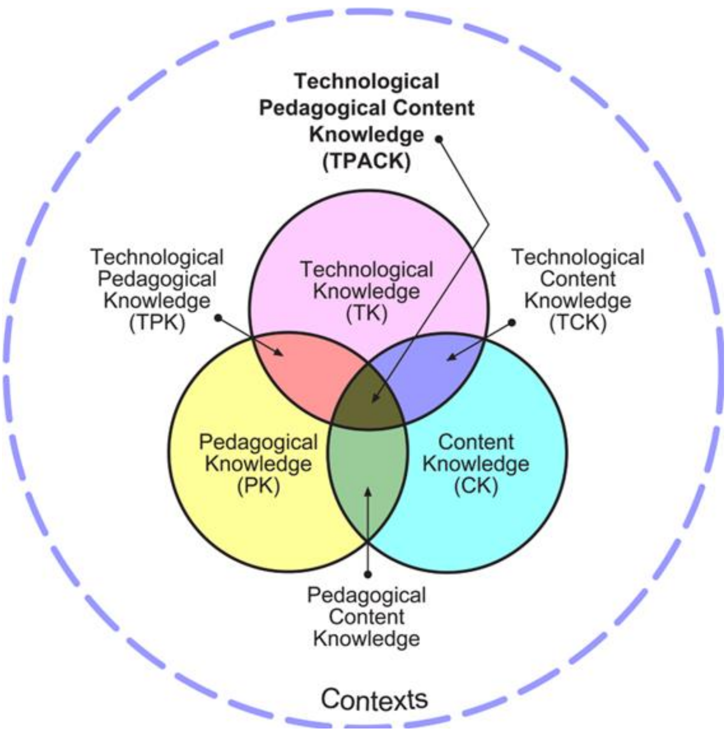


Figure 2.6 The TPACK framework (from http://tpack.org/)

Surrounding the three forms of knowledge and seven interplaying factors is context. Koehler and Mishra (2006) added context to the framework in 2008. Kafyulilo, Fisser, Pieters, and Voogt (2015) noted that context is significantly influential on the way technology may be used for teaching and learning practice. Many studies ignore the application of context to the framework (Koh, Chai, & Tsai, 2013). Context renders the framework useable in a multitude of settings (Kafyulilo et al., 2015). The current study foregrounds a science and technology context of learning and assumes a version of the framework that understands the knowledge constructs will be unique to this context.

2.8.1 Content knowledge (CK)

CK is perhaps the most traditional domain of knowledge in the TPACK framework. CK has been defined as "teachers' knowledge about the subject matter to be learned or taught" (Koehler at al., 2013, p. 14). The content that is therefore covered in primary history is different to the content covered in a first year biology undergraduate course. Shulman (1986) in his conception of CK included concepts, theories, ideas, organisational frameworks, evidence and proof, in addition to established practices and approaches that assist in its development. It is critical that teachers have a sound understanding of the nuanced knowledge that underpins each discipline they teach. In a meta-analysis of professional learning (PL) for student achievement, Blank (2013) identified several characteristics of effective programs. Blank (2013, p. 52) noted that content focus was the "primary goal" to "improve and increase the content knowledge of teachers". This designates significance to CK in the PL arena. Knowledge of K–6 Science and Technology would include knowledge of facts and theories, the scientific method and evidence-based reasoning (Koehler et al., 2013).

In Bate and Maor's (2010) three-year study of new teachers when asked about what knowledge is required for effective teaching an overwhelming majority of participants placed pedagogical knowledge (PK) in primary position. There could be a danger in such thinking; in that it may impact a teacher's impetus to consistently broaden and improve their CK. Koehler et al. (2013) discussed limited CK as being "prohibitive" (p. 15). For example, students may receive inaccurate information that manifests misconceptions, which can be notoriously difficult to shift from a student's thinking once formed. It is also worth noting that one teacher's conception of CK may be another teacher's misconception. For instance, CK on the theory of evolution may be presented very differently depending on teacher and school context. This showcases a weakness in this knowledge domain, as "issues relating to curriculum content can be areas of significant contention and disagreement" (Koehler et al., 2013, p. 15).

CK has influences on the use and uptake of other areas of TPACK. A study by Crawford (2007) on pre-service teachers showed that those teachers that lacked in subject-matter knowledge (a part of CK) faced greater challenges when attempting to teach inquiry strategies (a part of PK or PCK). However, in a balanced view it is important to note that "content knowledge alone does not appear to guarantee the implementation of inquiry-based lessons" (Smit, Rietz, & Kreis, 2018, p. 622). From the point of view of teacher educators, Foltos (2013) noted that CK was not necessarily required in the making of a successful coach.

2.8.2 Pedagogical knowledge (PK)

PK is knowledge of the nuance of teaching a specific learning area, in this case, K–6 Science and Technology. It is a weighty knowledge regarding "the processes and practices or methods of teaching and learning" (Koehler et al., 2013, p. 15). Lin et al. (2013) saw it to include "instructional principles, psychology of students, classroom management, and teaching strategies" (p. 327). As such PK encompasses the preparation of teaching materials, administration and supervision, and assessment (Aquino, 2015). Therefore, in the teaching of science and technology an educator with sound PK would understand the nuances for example of planning, resourcing, managing, and assessing risk as well as learning during a practically based investigation lesson. This example denotes a level of experience by the educator in the learning area and an understanding of how teaching primary science and technology differs from other learning areas.

PK is evident in the structure of the NESA Syllabus for K–6 Science and Technology (2012). It could be argued that this represents a significance or importance of PK to K–6 Science and Technology. Koehler et al. (2013) stated that PK designated a learning area rationale and a representation of values and aims. The NESA Syllabus for

K–6 Science and Technology (2012) laid out a rationale; an aim; and, objectives in line with the version of PK by Koehler et al. (2013). This sets a strong context for the importance of learning about K–6 Science and Technology and how as a learning area it may enrich the life of the learner and their community. PK therefore speaks to goal 2 of the Melbourne Declaration on Educational Goals for Young Australians (MCEETYA, 2008) to foster "active and informed citizens" (p. 8).

2.8.3 Technological Knowledge (TK)

Of all three forms of core knowledge, TK is known to demonstrate considerable changeability. Such changeability results in a difficulty defining TK, as attempts to do so are rendered outdated as technologies advance (Koehler et al., 2013). Koehler et al. (2013) discussed that there are still certain ways of thinking about and working with TK. For the purposes of understanding TK, analogies may be drawn with the *fluency of information technology* (FITness) framework:

> FITness goes beyond traditional notions of computer literacy to require that persons understand information technology broadly enough to apply it productively at work and in their everyday lives, to recognize when information technology can assist or impede the achievement of a goal, and to continually adapt to changes in information technology. FITness, therefore, requires a deeper, more essential understanding and mastery of information technology for information processing, communication, and problem solving than does the traditional definition of computer literacy (Koehler et al., 2013, p. 15).

With FITness in mind, the fluidity of TK is more apparent. There is no final step in a linear process in order to master TK—it is an ever-evolving consideration. Mastery comes from an understanding that leads a person to "a lifetime of generative, open-ended interaction with technology" (Koehler et al., 2013, p. 15).

Technology, as a learning area, encompasses almost half of the outcomes of the NESA Syllabus for K–6 Science and Technology (2012). Technology is included in three manifestations:

1. Science and technology: The learning area that focuses on technological concepts. This includes materials, data, systems, components, tools and equipment used to create solutions for identified needs and opportunities, and the knowledge, understanding and skills used by people involved in the selection and use of these.

2. Information and communication technology (ICT): The capability to use technology effectively and appropriately to access; create; and, communicate information and ideas; solve problems; and, work collaboratively.

3. Working technologically: The skills and processes of applying scientific knowledge and creative processes to use tools, resources and systems to solve problems and meet human needs and wants.

In general terms, TK appears to cover all three manifestations of technology in the NESA Syllabus for K–6 Science and Technology (2012).

2.8.4 Technological content knowledge (TCK)

Technology and its developments are continually changing what is required and expected of teachers in the classroom. The primary classroom is no exception. Uerz, Volman, and Kral (2018) acknowledged that expectations are not being met in this arena. Chai, Koh, and Teo (2019) spoke to the entire framework when they stated "that the emergence of TPACK has not transformed the state of technology integration in classrooms" (p. 361). Uçar, Volman, and Kral (2014) elucidated the high self-confidence of preservice science and physics teachers in relation to technology integration as determined by a TPACK confidence scale.

Overwhelmingly, the literature appears to acknowledge a gap between the theory of technology integration and success in praxis. This gap endorses focus on an understanding of what TCK is how it may be effectively used in the classroom. Therefore, "teachers need to understand which specific technologies are best suited for addressing subject-matter learning in their domains and how the content dictates or perhaps even changes the technology—or vice versa" (Koehler et al., 2013, p. 16). TCK as defined by Cheah, Chai, and Toh (2019, p. 166) is how technology is used to "represent/research" and "create the content in different way" and not in consideration of teaching (that is, the pedagogical portion of the TPACK model). So for example, addressing the concept of night and day from the NESA Syllabus for K–6 Science and Technology (2012) may be rendered more effective with the use of an app that models the movement of the Earth in relation to the Sun.

2.8.5 Technological pedagogical knowledge (TPK)

As with the other factors of the TPACK model, this literature review is informed mainly by the definitions put forward by Koehler et al. (2013). As such, TPK requires "understanding of how teaching and learning can change when particular technologies are used in particular ways" (Koehler et al., 2013, p. 16). Cheah et al. (2019) surmised that at a base level this means knowing what technologies are out there and their specifications that make them useful for teaching (or pedagogy). Therefore, in reference to primary science and technology and its pedagogies, the NESA Syllabus for K–6 Science and Technology (2012) is a key starting point. The *rationale* states that science and technology should be learned through "trialling, testing and refining ideas" to augment "skills in inquiry and manipulating tools and materials to produce solutions" (NESA, 2012, p. 12). In light of this, TPK may be seen as the 'how to' of technology integration to support the pedagogical approaches presented in the rationale of the NESA Syllabus for K–6 Science and Technology (2012).

2.8.6 Pedagogical content knowledge (PCK)

Van Driel and Berry (2012) understood PCK to encompass not only how students learn specific subject matter (such as science), but also what hindered learning in the area. Thus PCK is not rigid in its transferral or use, but allows for flexibility of approach to cater to student needs—that it is "highly topic, person and situation specific" (Van Driel & Berry, 2012, p. 26). PCK therefore "covers the core business of teaching, learning, curriculum, assessment and reporting, such as the conditions that promote learning and the links among curriculum, assessment, and pedagogy" (Koehler et al., 2013, p. 15). The intention of PCK is to render content, a topic or a particular learning area in general better understood by the learner (Chai et al., 2013).

PCK, presented by Lee (2011) included the aforementioned five components of the TPACK framework less the integration of technology. Lee (2011) and Goodnough and Hung (2009) spoke to the importance of PCK as they noted that teachers will continue to feel ill-prepared and equipped to teach K–6 Science and Technology using scientific inquiry or other interactive and innovative approaches until their own experience with content and these pedagogical approaches are strengthened. In a literature review, Kenny (2009) discussed that teacher training at a pre-service level should encompass a combination of science CK and PCK to affect change in the earliest possible time in a teacher's career. Therefore, a view may be taken that before technology is even considered in the primary classroom or in the PL environment, PCK required a well-oiled integration. Further to this, teachers should have a sound conceptual and practical understanding of PCK.

The fluidity of PCK requires the teacher to demonstrate expertise in changeability also. For example, even in one school, a teacher may experience that an effective way to teach the concept of energy with year 5 on a Monday morning may not receive the same success if used in a kindergarten classroom on a Friday afternoon. A teacher well-armed in the area of PCK use is sensitive to these shifts in classroom dynamic and can accordingly alter approach. PCK therefore encompasses knowledge of augmenting student learning in a myriad of ways (Van Driel & Berry, 2012). Conceivably this skill of augmentation and PCK expertise in K–6 Science and Technology are a result of repeatedly teaching the same topic (Van Driel & Berry, 2012). Koehler et al. (2013) elaborated on the strength in this flexibility provided by "exploring alternative ways of looking at the same idea or problem" (p. 15).

2.8.7 Technological pedagogical content knowledge (TPACK)

Knowledge in the present study shares a relationship with technology, pedagogy and content. It is represented through the interplay of the three forming the basis of a teacher knowledge framework in the literature known as technological pedagogical content knowledge (TPACK). TK is the latest addition to the framework. This builds on Lee Shulman's (1986, 1987) concept of PCK. Koehler et al. (2013, p. 13) maintained that the interplay between these forms of knowledge, in theory and practice, result in "flexible knowledge". Furthermore, such flexible knowledge is viewed as a necessity in order to successfully integrate technology use into teaching (Koehler et al., 2013).

Multiple researchers (Goudnough & Hung, 2012; Lee, 2011; Schneider & Plasman, 2011) advocated a combination of these forms of knowledge specifically in science education reform. This has come from "the proliferation of the technology tools used to support teaching and learning" which have in turn created a need to "use technology effectively to support learners in innovative practices" (deNoyelles, Cobb, & Lowe, 2012, p. 85). In the context of science education Bilici, Yamak, Kavak, and Guzey (2013) spoke to five components within the TPACK model:

- Orientations: Knowledge and beliefs about the purposes of teaching science with technology.
- Knowledge of science curricula: Knowledge with regards to the goals and objectives for teaching science and knowledge about the programs and materials, including the educational technology tools to teach science.
- Knowledge of students' understanding of science: Knowledge about variations in student learning, prior knowledge, misconceptions, and topics that are difficult for students to learn, and technology tools that may represent those.
- Knowledge of assessment: Knowledge about student learning that needs to be assessed and methods to assess specific aspects of student learning using technologies.
- Knowledge of instructional strategies: Knowledge of science-specific and topic-specific strategies (activities and representations) that include educational technologies (p. 41).

The multiple forms of knowledge as represented by the TPACK model inform this literature review, as it is deemed contextual to K–6 Science and Technology professional learning (PL).

The TPACK framework has been reworked several times to suit PL for different subject areas, and science is no exception. In a review of the literature, Voogt, Fisser, Pareja Roblin, Tondeur, and van Braak (2013) noted only seven subject-specific studies on the development of the TPACK concept and asserted that feasibly the most tangible was that of Jimoyiannis (2010). Jimoyiannis (2010) presented a manifestation known as TPASK—technological pedagogical science knowledge, for science teachers' professional development. TPASK focused on an ICT-based integration of technology into science. This study arose from the need to further theoretically conceptualise TPACK in science, in an attempt to understand the interplay of the three components of knowledge (pedagogy, content, and technology) and how they may be taught to and made practically useful for the science teacher. Jimoyiannis (2010, p. 1261) highlighted that "science education was a privileged subject matter when considering ICT integration" because of the great variety of tools and environments that adhere seamlessly to science (for e.g. simulations and modelling tools, web resources and environments, spreadsheets and databases, apps, etc.). The depth in which Jimoyiannis (2010) addressed TPACK in science is beyond the scope of this study. The current study focuses primarily on the nature of the learner, with TPACK being considered as a potential factor of influence on the learner.

2.9 Teacher self-efficacy

Self-efficacy for any individual has the potential to influence feelings, thoughts, motivation and behaviour (Parajes, 1997). Individuals choose to participate in certain activities because of an internal understanding that they are able to achieve in the task—making self-efficacy a critical facilitator for all manner of behaviour (Senler, 2016). Therefore, self-efficacy as a humanistic trait is common to all, not just teachers in the profession. As such it featured as a core construct in *social cognitive theory* (SCT) whereby it is seen as "people's judgments of their capabilities to organise and execute courses of action required to attain designed types of performances" (Bandura, 1986, p. 391). SCT posits that learning occurs in a social context—with multidimensional interaction between an individual, the environment, and behaviour (Bandura, 1986). Self-efficacy was linked earlier in chapter two with a learner's motivation when unpacking the literature on learning. Next self-efficacy will be foregrounded from the point of view of the teacher as an adult in the profession.

Teacher self-efficacy has been defined a number of times in the literature. Tschannen-Moran, Woolfolk-Hoy, and Hoy (1998) saw teacher self-efficacy as "a teacher's belief in his or her own capability to organise and execute courses of action required to successfully accomplish a specific teaching task in a particular context" (p. 233). Swackhamer et al. (2009) defined it as a "teacher's belief in his/her skills and abilities to positively influence student achievement" (p. 66). The current study amalgamates the aforementioned understandings and defines it as a teacher's belief in their capacity to plan, teach and facilitate high quality, contextual teaching and learning geared towards student achievement.

Links with teacher motivation and success, and self-efficacy were evident from perusal of the literature. Ham, Duyar, and Gumus (2015) contextualised the importance of studying teacher self-efficacy—"both educational researchers and practitioners agree that teachers are one of the most important school factors, perhaps the most important one, affecting student learning" (p. 228). Therefore, when determining what constitutes an impactful and successful teacher, self-efficacy should be considered. A teacher's effectiveness has been shown to be influenced in the same manner by their self-efficacy (Caprara, Barbaranelli, Steca, & Malone, 2006). Self-efficacy appears to be a self-fulfilling prophecy in that an individual with high levels of self-efficacy generates greater exertion in and perseverance of task—feeding the positive perceptions of their capabilities (Pajares, 1997).

Teacher self-efficacy has been connected with teacher action and achievement in several areas. Holzberger, Philipp, and Kunter (2013) determined an association between high teacher self-efficacy and quality instructional strategies and a stronger "reverse effect of instructional quality on teachers' self-efficacy" (p. 774). This highlights the influence of a highly efficacious teacher, but more so the impact of quality instruction on a teacher developing their self-efficacy. As a consequence, PL has a role to play in providing a template of what high quality teaching and learning looks like—and in the context of this study what constitutes quality instruction in primary science and technology.

An emergent theme from the literature highlighted that teacher self-efficacy is integral to the improvement of scientific literacy in students. Science has long been neglected in primary classrooms because they are too far removed from everyday life, unpractised and difficult to know (Hume, 2012). More specifically, teachers of science and technology in the primary school setting often have a limited understanding of the concepts and skills required to teach science investigatively (Fraser, 2010). Inquiry-based teaching is linked with the teaching of open investigations. It is socially demanding, with no prescribed formula and produces unanswered questions—it may make teachers with low self-efficacy in science feel as if they are losing management and control of their classroom (Oliveira, 2010). Swackhamer et al. (2009) suggested that self-efficacy in science be improved by a focus on content knowledge and pedagogy.

In the study of Kenny and Colvill (2008) teachers overwhelming viewed *enactive mastery* as the primary means of combatting poor self-efficacy. This was defined as gaining the confidence by actually doing the task—a practise makes perfect notion (Kenny & Colvill, 2008). A study which involved pre-service teachers indicated that cognitive pedagogical mastery was the key to alleviating poor self-efficacy in teaching science (Palmer, 2006). This refers to knowing how to teach science effectively, that is, PCK. Dursken et al. (2017) linked teachers' motivational beliefs and PL as positively related. Furthermore, they elaborated that "teachers' sense of self-efficacy is one of the key motivation beliefs influencing teachers' professional behaviours" and that "successful teachers are likely to possess a strong sense of their own self-efficacy" (Dursken et al., 2017, p. 55). Teacher self-efficacy has been shown to affect teacher diligence, passion, job fulfilment, efficacious teaching and learning behaviours, with some influence too on student achievement (Dursken et al., 2017).

2.9.1 Teacher confidence

Self-efficacy is closely related to confidence (Norton, 2019). Fennema and Sherman (1976) defined confidence as how certain an individual is that they will perform well on a specific task or activity. As established, confidence is connected with content knowledge and pedagogical content knowledge; as well as, to a sense of authority and control in the classroom (Bandura, 2006). In terms of classroom management and mutual respect between educator and learner, confidence is often expected by the latter. Security and assurance in the classroom is more likely resultant when a teacher is confident–conversely, if a teacher is unsure and apprehensive, students are likely to push boundaries and undermine authority (McBer, 2001). Confidence is noted as one of four core professional characteristics of an outstanding teacher–alongside challenge and support; creating trust; and respect for others (McBer, 2001). In their study on early childhood teachers, Nolan and Molla (2019) determined that teacher confidence is "aligned with expansions in professional capital encompassing the acquisition of knowledge and skills (human capital), participation in networks of collaborative learning communities (social capital), and the ability to exercise professional agency (decisional capital)" (p. 10). In their view, a confident teacher is one focused on the improvement of their knowledge base; networks professionally and collaborates; and, exhibits autonomy in teaching and learning decisions (Nolan & Molla, 2019).

Martin (2006) suggested there is a strong relationship between teacher enjoyment and confidence in teaching and effective pedagogy. Teachers who enjoy their teaching and are confident in the classroom are more likely to become emotionally engaged in the overall teaching process (Munns & Martin, 2005). To paraphrase, they are more likely to use effective pedagogy and engage students in learning. Arguably, the same dimensions of engagement could be experienced by the teacher educator as the student engagement identified by Munns and Martin (2005). This draws on an idea in the present study of the engagement of the facilitators (the teacher educators) and what impact, if any, this had on the engagement of the adult learners (the teachers learners).

Teacher confidence is evidenced in a number of ways, such as teacher voice. Use of a clear and effective teacher voice is important when delivering instructions (Zwozdiak-Myers & Capel, 2016). Teacher voice "is like a musical instrument, and if you play it well, then your pupils will be an appreciative and responsive audience" (Zwozdiak-Myers & Capel, 2016, p. 142). Dierking and Fox (2012, p. 135) claimed "voice closely links to autonomy and confidence—the involvement, focus, and energy that teachers might bring to classrooms". Alongside voice, a confident teacher exhibits the "*lighthouse effect*–being fully aware of everything that is going on in the classroom and having 360° vision" (McBer, 2001, p. 200).

Teacher confidence and enjoyment in teaching is strongly influenced by perceptions of student motivation and engagement (Martin, 2006). Martin (2006) proposed a strong relationship between teacher enjoyment and confidence in teaching and effective pedagogy. Confident teachers are more likely to engage in pedagogy that promotes positive and solution-oriented classroom results (McBer, 2001). Teacher enjoyment of and confidence in teaching also influences their emotional engagement with students and promotes student motivation and engagement (Martin, 2006). The DEST (2003) main report linked dislike to lack of knowledge, and stated in "initial training, primary teachers do not specialise in science and mathematics. As a result, many primary teachers who teach mathematics and science lack the necessary expertise and confidence; and may even actively dislike mathematics and science" (p. 56).

Adopting a student-centred approach to teaching primary science and technology is seen to be impacted by teacher confidence. Fraser (2010) claimed that confidence of science subject knowledge and concepts, and an ability to answer student questions or gear students along an appropriate avenue to seek answers were the critical skills needed by the teacher to centre learning on students. Teachers with waning confidence in the study of Fraser (2010) demonstrated very rapid pedagogical shifts from student-centred to a classroom management approach:

> Changes in pedagogy required changes in the tools employed to mediate effective teaching of science, for example from model-making equipment to photocopied worksheets. Similarly, the rules which permitted, and even encouraged, discursive collaborative group work changed to allow silent, independent and solitary work. The division of labour within the classroom also changed as teachers adopted the roles of managers rather than leaders of the learning community (p. 101).

This further illuminates the interwoven nature of subject knowledge, confidence, motivation and enthusiasm for teaching science and technology. The all-encompassing goal of reaching scientific literacy through investigative, student-centred approaches therefore extends beyond a lack of subject knowledge. Fraser (2010) discussed that some teachers professed limited science knowledge, yet still appeared to incorporate educationally enriching investigations that engaged and motivated students—whilst in turn developing their conceptual understanding of science.

2.9.2 Teacher development

For successful professional learning (PL) experiences to supervene, and shifts in knowledge and practice to take place, the literature suggested a focus on what is known about teacher development. That is, that development is individual for each teacher; it is bound by the context of their own classroom and teaching situation, and by the formal and informal communities to which they belong (Akerson, Cullen, & Hanson, 2009). Many authors (Archibald et al., 2011; Darling-Hammond et al., 2017; Meister, 2010; Robinson, 2014; Webster-Wright, 2009) advocated that professional development will become a rudimentary element of the professional lives of teachers only when schools become places where teachers undergo both formal and informal learning on a daily basis. Also when teacher development promotes self-understanding and risk-taking is no longer viewed as a negative contribution, but rather is promoted (Meister, 2010).

Lengthier PL interactions which are advocated as an impetus for change must coincide with a myriad of other impacting variables for teacher development. According to Fraser (2010) teacher development is undeniably controlled by teacher attitudes—that is, that there must be ability for reflection on practice, a welcoming of dialogue about their development process; and, support-based work ethic that encompassing strong collegiality. Fraser (2010) additionally discussed teacher perceptions and vocabulary as barriers to teacher development—as continual professional development (CPD) is thought of as just attending courses. The reality of CPD in the area of science and technology should encompass the development of curricular expertise, which in turn encompasses an improvement in content knowledge, pedagogy and PCK for attainment of this goal.

Reflective practice is often noted in the literature as impetus for change in science education reform, yet many teachers may not grasp on a practical sense what is needed for the fulfilment of this goal. Pedro (2005) cited that the term *reflective practice* is not automatically understood. Furthermore, Russell (2005) argued that the reflective process needs to be explicitly taught to pre-service teachers with the hope that it is integrated as part of their basic role as a teacher. Kenny (2009) provided a three-way framework for imparting reflective practice. The framework encompassed a personal (first person reflection) level; a collaborative level with their colleague teachers and peers (second person reflection); and, an educational theory (third person reflection) that may or may not involve action research (Kenny, 2009).

Prytula (2012, p. 112) furthered the point in discussion of metacognition, and defined it as "thinking about thinking, or the monitoring and regulation of thinking". Prytula (2012) stated that to ascertain whether teachers were thinking metacognitively about their practice, or whether they were able to, evidence that they were teaching their students how to think so would be apparent. The reality dictated that a teacher can only teach and utilise what they know, therefore with the knowledge and practice of metacognition reflective practice remains a term verbalised, yet not accomplished (Prytula, 2012). Through PL teachers are encouraged to undergo a modification in understanding that learning does not move from the outside-in, but from the inside-out (Georghiades, 2004). Teachers must be willing to accept change before PL is fruitful, the process of talking at teachers in PL environments on what changes should be instigated is deemed useless without attitudinal metacognitive shifts by the teacher (Meerah, Halim, Rahman, Abdullah, Harun, Hassan, & Ismail, 2010).

Metacognition as discussed in the literature elucidated some issues that may ascend from the use of this process. New knowledge does not arise independently and in isolation, with a simple transfer of knowledge in teaching, but is more likely to ensue upon teacher collaboration and collective problem solving (Prytula, 2012). The idea that a teacher's knowledge, beliefs, understandings and experience will impact upon this process sympathises with a social constructivist view of teaching and learning (Driscoll, 2000). Therefore, this draws back to previously discussed benefits of working collaboratively and even in triads for the purposes of effective PL and meaningful knowledge shifts in teacher thinking and practice.

According to the study compiled by Hackling et al. (2011) intervention in the methods teachers utilised in the science classroom affected change. This seconds the idea of the need for appropriate PL scenarios that guide and support teacher reform. Intervention also impacted confidence, as more teachers were comfortable categorising themselves as effective teachers of primary science and technology (Hackling et al., 2011). From this study teacher evolution was noted to be gradual, over several PL days (Hackling et al., 2011).

It stands to reason that the ultimate goal in any teacher development is the edification of great teachers—arguably the strongest tool for promoting quality education. Therefore, "well-trained, highly motivated, dedicated and professionally competent teachers are essential players" towards this goal (Meerah et al., 2010, p. 27). Scheerens (1992) claimed that a quality teacher will ensure the effective use of time in putting forward a variety of cognitively complex activities whilst utilising an empathic and active teaching style. Furthermore, a teacher should enjoy teaching, inspire curiosity and enthusiasm for the topic at hand, ensure the relatability of the content, prompt and encourage participation and provide students with frequent feedback (Sorcinelli, 2006). Teachers evolved an enthusiasm for change once they were armed with the effective tools, that is, there was a keenness to instigate and continue their journey of change (Sorcinelli, 2006). This supports some key elements of the five assumptions of andragogy as presented by Knowles (1984), most especially with reference to the idea that learners are self-directing and that they present a readiness to learn. In the pedagogical field students may not exhibit this readiness for learning, and so engagement becomes integral to draw students into learning.

2.10 Summary

Chapter two presented core ideas and theories in the literature that pertain to the present study. Several areas of literature feature in the overarching research question of this study and thus required contextualising. These areas are a new curriculum; teacher self-efficacy; the TPACK framework; and, professional learning, all of which were deliberated on in the context of science education. Centrally, the diverse understandings of pedagogy and andragogy were shown, to differentiate what is understood about these terms in the literature and how they could manifest in the present study. This study views pedagogy and andragogy as learner traits or characteristics. Chapter three, informed by specific viewpoints within the literature, posits a theoretical frame of adult education which is further postulated into a conceptual framework for this study.

Chapter 3: Theoretical and conceptual framework

Introduction

Chapter three presents the theoretical and conceptual frameworks of the current study. The theoretical framework is bound by what is known about adult education in the literature. Due to the broadness of theory on adult education, a contextual focus on pedagogy and andragogy was most appropriate for this study. From the theoretical framework and a broad review of the literature in the area of syllabus implementation and science and technology teacher professional learning derived the development of the conceptual framework. Six major concepts contribute to the overall conceptual framework and they are extrapolated by what is known about professional learning within an adult education theoretical framework.

3.1 Adult education

Adult education is a broad and all-encompassing theoretical frame. Adult learning theory is an ever-changing and active area of research and also theory building (Merriam & Bierema, 2014). Gouthro (2019) claimed that “a deeper understanding of theory helps ground teaching and research” (p. 60). This is a resonating thought in lieu of the present study, because it concerns a deepening of understanding of adult learning with the flow-on effect of potentially improving teacher practice. In its broadness, adult education concerns the development of the adult as an individual, and for purposes of work and in their role as an active citizen. As such, adult education is influenced conceptually by “employability, the knowledge society, globalisation and lifelong learning” and how students are influenced by adult education (Sandberg, 2016, p. 266). Bjursell (2016) further elaborated that educational policies and market forces have had significant influence on adult education and lifelong learning as a result of policy transformations instigated by agencies such as the World Bank; United Nations Educational, Scientific and Cultural Organization

(UNESCO); the World Trade Organisation (WTO); the Organisation for Economic Co-operation and Development (OECD); and, the European Union (EU).

Rashid (2017), in a study of surgical education, focused on adult learning principles to engage with the field of adult education. Rashid (2017, p. 3) spoke to:

- Adult learning characteristics (differences between adult and child learners)
- Adult’s life situation (where individuals are in the variable stages of life)
- Changes in consciousness (ability to reflect upon experiences and environment).

Adult learning characteristics includes theories such as that proposed by Knowles (1968) and all subsequent supporters of the Knowlesian andragogical approach. An adult’s life situation includes Knox’s (1980) proficiency theory. Knox (1980) explained:

> Proficiency is the capability to perform given the opportunity. An interest in enhanced proficiency encourages adults to engage and persist in learning activities. Effective adult learning is transactional and developmental, with periodic assessment of discrepancies between current and desired proficiency to assess needs, set objective, organize learning activities, and evaluate progress. Experience, learning effectiveness, sense of proficiency, and commitment to enhance proficiency affect the adult's search for meaning which entails acquisition of new learnings and reorganization of old. Effective teaching-learning transactions encourage adult learners to assume major responsibility for objectives and pacing, combine an overview of content with emphasis on important aspects, and contain a sequence of activities that encourages persistence in learning activities and use of new learnings (p. 378).

Changes in consciousness are concerned with prominent theories such as that of Mezirow (1981, 2000) on critical reflection. Mezirow’s (1981) framework consisted of seven levels of reflection as shown in Figure 3.1. Lungdren and Poell (2016) delved deeply into Mezirow’s (1981) critical reflection theory and commented that “although Mezirow draws from different intellectual traditions, his focus has been on the individual and how the individual learns through experience and reflection" (p. 8). The present study, within the realm of adult education is primarily concerned with adult learning characteristics; but acknowledges an adult's life situation and changes to consciousness. It draws on each of the three adult learning principles outlined, and each have an influence on the six concepts featured within this study's conceptual framework. As Rashid (2017) recognised, "no single theory can be applied universally" (p. 3).

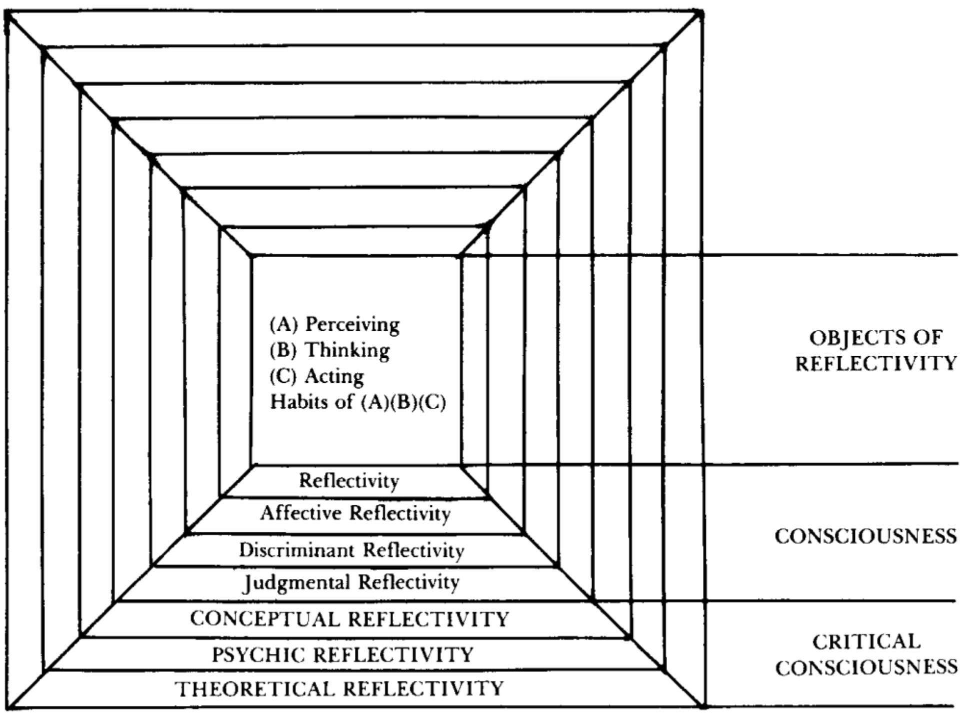


Figure 3.1 Mezirow's (1981) levels of reflectivity (from Mezirow, 1981, p. 12)

The literature on adult learning characteristics includes an approach to pedagogy and andragogy that extends beyond fixed notions of child and adult learners. Among them, White (2000) suggested a "composite and interactive teaching approach . . . that integrate and supplement both" (p. 70). White (2000) claimed that andragogy was born from the limitations that traditional pedagogy placed on the actions of teachers and students. White (2000) in turn argued that self-direction should not be presumed as limited to the adult learner, and that for many reasons some adult learners are intrinsically motivated and not interested in self-directed learning—when "the andragogical approach is taken to the extreme" (p. 72). White's (2000) interactive model is ageless; with mutually created motivation by teacher and student that could be either intrinsic or extrinsic at different points in learning; has collaborative learning goals; and, the primary goal for learning is to resolve problems or issues. Knowles (1980) too accepted that andragogy may not always be best fit for adults and that pedagogy could be relevant still, and so too andragogy for children. Perhaps there is no dichotomy between andragogy and pedagogy; and learning is a morphing concept “for learners of all ages, at different times and in different contexts” (Kerka, 2002, p. 2).

3.1.1 Pedagogy versus andragogy

There are assumed characteristics of pedagogical and andragogical learners as outlined by Knowles (1977). Since the work of Knowles, the literature has extended the pedagogical and andragogical understanding of the learner (*about the learner*) and their *orientation to learning*. In a table produced by Knowles in 1976 titled “Assumptions and processes of teacher-directed (pedagogical) learning and self-directed (andragogical) learning” featured as an appendix to Knowles (1977), he himself asked his audience to “please read (pedagogy and andragogy) as poles on a spectrum, not as black-and-white differences” (p. 211). Table 3.1 contrasts the differences between, and assumptions of, the pedagogical and andragogical approaches. Perhaps even the conception of Knowles’ (1976) separation of pedagogical and andragogical learner traits within Table 3.1 could be median traits on a continuum. This would position pedagogy and andragogy as more complexly related. For example, a point nestled within *about the learner* such as *self-directed learning* may be very strong in one learner and less pronounced in another—both of whom could still be seen as overall andragogically geared in their learning.

Table 3.1 Table based on Knowles (1977) separation of pedagogical and andragogical learners

	Pedagogical	**Andragogical**
About the learner	Teacher-directed learning Teacher-evaluated learning Teacher responsible for what is taught and how	Self-directed learning Self-evaluated learning Learner responsible for their own learning
Concept of the learner	Dependent learner	Self-directed learner

Role of learner's experience	To be built on, more than used Little experience Teacher experience very influential	A rich resource for learning A greater amount and variety of experience The influence of teacher's experience is negligible
Readiness to learn	Varies with levels of maturation Learner directed by teacher in order to advance to the next level of education / mastery	Develops from life tasks and problems and a need to perform more effectively Learner able to analyse gaps in learning
Orientation to learning	Subject-centred A process of acquiring prescribed subject matter and its sequenced content	Task or problem-centred Learning is organised around a need which arises from life (including work situations)
Motivation	External rewards and pressures, punishment, competition for grades and consequences of failure Extrinsically motivated	Internal incentives (e.g. curiosity, self-esteem, recognition, improved quality of life, self-efficacy, self-confidence) Intrinsically motivated

3.1.2 *Pedagogy beyond the child learner*

Acceptance of Knowles' (1998) assumptions of pedagogy does not automatically sequester it to child learners alone (traditional pedagogy). Gehring (2000) discussed in the context of education in correctional facilities that the majority of immature, low achieving adult inmates were educated much like children and contrariwise mature or skilled child inmates were taught like adults. Although this is a context-specific description, it speaks to the notion of blurred lines in the education of adults and children. Schapiro (2003) stated that adult learners could have self-direction in "disposition" but not the "knowledge and skill needed to design, manage, and direct their own learning" (p. 155). These viewpoints push pedagogy beyond learning for the child, and into the realm of assumed child-like traits. As such, a learner, depending on their personal position, understanding and experience may or may not nestle within the realm of traditional pedagogy no matter their age. Even in literature on adult education, there are references to "the pedagogy of adult education, without any apparent discomfort over the contradiction in terms" (Gehring, 2000, p. 157).

For some researchers, it is self-direction that can move a learner beyond the realms of pedagogy (Merriam et al., 2007). Grow (1991) established the *staged self-directed learning model* (SSDL) based on Hersey and Blanchard's (1988) *situational leadership theory* (SLT). To preface, SLT argued that management is situational and should therefore correspond with an employee's readiness (Hersey & Blanchard, 1988). Some employees are willing and not able, others are able but not willing and some may be both willing and able. SLT dictates that successful management takes this notion of readiness into strong account (Grow, 1991). In building on SLT, Grow (1991) took management to qualify as an extension for teaching and developed a model to deal with learners of varying readiness and self-direction. Table 3.2 presents the four stages of the SSDL as shown in Grow (1991).

Table 3.2 Grow's (1991) staged self-directed learning model (SSDL) (from Grow, 1991, p. 129)

The teacher's purpose is to match the learner's stage of self-direction and prepare the learner to advance to higher stages.

Stage	Student	Teacher	Examples
Stage 1	Dependent	Authority Coach	Coaching with immediate feedback. Drill. Informational lecture. Overcoming deficiencies and resistence.
Stage 2	Interested	Motivator, guide	Inspiring lecture plus guided discussion. Goal-setting and learning strategies.
Stage 3	Involved	Facilitator	Discussion facilitated by teacher who participates as equal. Seminar. Group projects.
Stage 4	Self-directed	Consultant, delegator	Internship, dissertation, individual work or self-directed study-group.

The SSDL proposed that learners have a situational readiness to learn and self-direction that could fall within any of the four stages. The four stages were not limited to or based on age; thus, adults were not automatically assumed to fall within greater stages of self-direction such as stage three and four. This sheds light on a curious notion that the self-direction hierarchy represented in Table 3.2 relied on other contextual understandings about the nature and experience of the learner rather than their chronological age. Similar to this, the current study came to view pedagogy as a set of learning principles that are matched to a learner based on their nature and experience and not simply because they are a child learner. Therefore, pedagogy which has been traditionally aligned with child learners may have the potential to represent adult learners. Conversely, and utilising the same logic of argument, andragogy which if taken as a set of learning principles, may also represent learners of a younger chronological age.

3.1.3 Andragogy beyond the adult learner

Andragogy is also mentioned in some areas of the literature as a set of learner traits, which although adult-like by assumption, may be applied more broadly (Chan, 2010). Knowles (1970) is acknowledged by the current study and many others, to have popularised andragogy as a synonym for adult learning. Nevertheless, Knowles (1970) articulated that andragogy is "simply another model of assumptions about learners to be used alongside the pedagogical model of assumptions" (p. 91). From this perspective, not all adults will fall into the theoretical category of andragogy, simply by the age allocation of adulthood. Zmeyov (1998) supported the importance of andragogical principles and commented that they "are widely needed now, and not only in adult education. Practically all sectors of educational services need these principles" (p. 107). Zmeyov (1998) suggested that success in the application of andragogical principles occurred when learners have a good amount of practical and social experience; are aware of a life goal and of the applicability of their knowledge and skills; have adequate background of the selected field of study; and, are trying to attain short-term educational goals. As this study posits, if andragogy is viewed as a set of assumptions about a learner, then context of the learner (irrespective of age) becomes an overriding consideration.

Knowles (1980) suggested that there were levels of *andragogy-ness* which could imply an influence of learner context. In the higher education environment, undergraduate students with little to no experience should be taught differently from those adult learners "with a high level of knowledge in their field" in order to "prevent frustration and poor learning outcome" (Daland & Hidle, 2016, p. 37). Rachal (2002) spoke to these context influences, as "situational variables", which could include a learner's "degree of voluntariness, learner's experience of and prior knowledge of the content, the need for quality control for assessing learner's outcomes, the presence or absence of institutional or professional constraints, and general course goals" (p. 224).

This study, in line with acknowledging pedagogy as a set of learner assumptions, views andragogy as the same—a set of principles of the learner that apply based on context and not age.

3.1.4 Pedagogy and andragogy

Most teaching is likely to encompass a melding of pedagogical and andragogical processes no matter the age, experience and background of the learner. In this way, both are important and play a role in teaching and learning. In the context of science education, the manner in which a child builds understanding of how concepts work is not unlike that of an adult (Julyan & Duckworth, 2005). This suggests commonalities in learning that are not age influenced. Taylor and Kroth (2009, p. 42) commented that among the myriad of instruction techniques, "there is usually some of each" of pedagogy as teacher-focused and andragogy as learner-focused—it is "the amount of what type of technique" that changes. In this view the andragogical characteristics as outlined in Table 3.1 are viewed as being learner-focused, conversely the pedagogical characteristics teacher-focused. The current study does not align with these strict allocations; but acknowledges the wisdom that comes from a best-fit mix of teacher-centric and student-centric techniques. Samaroo et al. (2013) in their literature review discussed the polarising of pedagogy and andragogy as "in essence pointless since the literature in support of one model against the other is unclear and cannot be relied on as a secure platform" (p. 79). Instead, Samaroo et al. (2013) put forward a new model they named *pedandragogy* which brings together the teaching and learning positions of pedagogy and andragogy. Pedandragogy is learner centred, focuses on effective and appropriate learning environments, promotes self-engaged learning and it does distinguish between the child and adult learner "but does not treat each as unlike" (Samaroo et al., 2013, p. 85). The current study views the balance between the child and adult learner in the pedandrous model (Samaroo et al., 2013) as compelling as it seeks to build a clearer picture of the adult learner.

3.1.5 Heutagogy

The context of learning in this study works against the complete realisation of heutagogy as an independent practice of learning from andragogy. Both andragogy and heutagogy call on the teacher to provide assistance and learning aids for the learner, but heutagogy for those that advocate its separatism, requires that the teacher "fully relinquishes ownership of the learning path and process to the learner" (Blaschke, 2012, p. 59). In this study, teachers were called on to upskill in the NESA Syllabus for K–6 Science and Technology (2012). This required that teacher educators direct learning to cover core requirements of the syllabus. Without this guidance, teacher learners would potentially struggle to grasp all they were required to prior to having to use the syllabus document to teach in the classroom. In a manner, this context constrains the learner, but an argument could be made that there is still room for some manifestation of self-determined learning in the uptake of the basic knowledge and core requirements. In contrast to this standing, heutagogy purists argue "there is no such thing as a standard learning outcome, despite the widespread determination among politicians and education policy makers to make it so" (Hase, 2016, p. 2).

At its core, the current study juxtaposes pedagogy and andragogy as learner traits on a continuum—the significance of which is bolstered by decades-long literature of pedagogical and andragogical learning theories. Heutagogy, as a considerably novel learning theory concerns independent and pure autonomous learning that does not align with the experience primary teachers undertook in the professional learning in this study. As such, extending the conceptual framework into heutagogy would be redundant as the vast majority of teacher participants were novice in their K–6 Science and Technology expertise and were operating as learners outside of the realms of heutagogy. They were adults, but still learners that required considerable facilitator support and the provision of structure in their learning. Furthermore, compliance to the teaching of the NESA Syllabus for K–6 Science and Technology (2012) meant that very specific syllabus requirements were necessary to cover in professional learning, again moving away from heutagogical notions of learners deciding what they learn, when and how.

3.2 The conceptual framework

Adult learning theories, like other theories in the literature, may be formal or informal (Gouthro, 2019). Taylor (2006) described formal theories as "theories that have been well established in the literature" (p. 20). Lange (2015) spoke to the importance of classical theories because they track a continuity of sociological thinking within adult education. For the current study this speaks to an importance of investigating and binding research to a theoretical frame that is robust—that of adult education. Conversely to formal theories, informal theories encompass personal experiences and the influence of social context. Sommer and Strong (2016) claimed that it is the influence of a myriad of experiences as a lens for interpreting new experiences that informs useful theory. In the context of teaching and learning, informal theories "are the premises that we come up with that shape our understanding of how to do things"—they "shape beliefs . . . which may then affect actions and behaviors" (Gouthro, 2019, p. 61). Roessger (2017) commented that historically speaking, a theory to practice translation has been of import in the realm of adult education. Thus, the present study acknowledges understanding and insights from previous literature and in part the experience, observations and social context of the researcher and how all elements may influence practice. These elements are not viewed as mutually exclusive; but are each strengthened by their connection to the other. The theoretical framework grounds the understanding of adult education from which a conceptual framework may be nestled. The current study espouses six main concepts within the overarching field of adult education in its conceptual framework. These concepts are visually represented in the image of the conceptual framework in Figure 3.2.

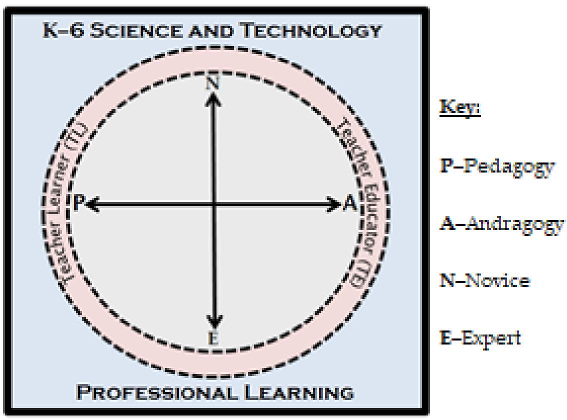


Figure 3.2 *A visual representation of the conceptual framework of the current study*

3.2.1 The new curriculum effect

The new curriculum effect concept aligns with the notion that an adult's life situation has influence on their learning. That is, that the context of learning, such as the introduction of a revitalised curriculum document may evidence a renewed impetus for learning. This has potential to draw on what is understood about engagement and motivation in the adult learning arena. Therefore, where there is a contextual cause, that is, the introduction of the NESA Syllabus for K–6 Science and Technology (2012), it stands to reason that there will be an effect.

The NESA Syllabus for K–6 Science and Technology (2012) embodied significant changes to the previous curriculum document. It foregrounded a combination of knowledge and understanding and skills within science education—as shown in the organisation of content diagram in Figure 2.4. It articulated a clear vision about how content and skills may be interwoven through context for a rich learning experience. In science, curriculum needs to extend beyond the memorisation of facts within each scientific discipline to include resources that support direct interaction with scientific phenomena in order to promote learning (Harris, Penuel, D'Angelo, DeBarger, Gallagher, Kennedy, Cheng, & Krajcik, 2015; Ko & Krist, 2019). This style of teaching and learning engagement science "requires that students develop both explanatory science ideas and practical forms of the epistemologies undergirding science practices" (Ko & Krist, 2019, p. 980). Patchen and Smithenry (2013) found that curriculum that supported student inquiry resulted in learners that were better able to work collaboratively; communicate to engage all stakeholders in the inquiry; and, undertake work that meets the requirements of sound scientific inquiry. Therefore, the NESA Syllabus for K–6 Science and Technology (2012) includes features that are viewed in the literature as enriching science education through effective curricula.

Where there is cause, an effect or several invariably follow. Therefore, the introduction, implementation and use of a new curriculum will no doubt solicit effects on teacher learning, student learning, or both. A new curriculum has the potential to ignite a refreshed impetus for learning—especially when teachers are "actively engaged in their own learning while adapting the curriculum to their context" (Marco-Bujosa et al., 2017). Bayram-Jacobs, Henze, Evagorou, Shwartz, Aschim, Alcaraz-

Dominguez, Barajas, and Dagan (2019) noted that *socioscientific issues* (SSI) in curriculum were paramount to teacher development of PCK, whereby students fostered skills of "discourse, argumentation, decision-making, and assessing the validity of sources of information" (p. 1208). Equally, it is acknowledged that curriculum changes may be a source of stress, challenge and greater demand on teachers—especially if encompassing significant change to teacher content knowledge or pedagogical content knowledge (Leal, Pereira, & Morais, 2013). Roblin et al. (2018) set out to determine the critical features of science curriculum materials that impact student and teacher outcomes. They concluded with several positively impacting features— "that teacher supports, rather than student supports, had positive impacts on both student and teacher outcomes, and that materials with a larger scope had positive impacts on student outcomes" (Roblin et al., 2018, p. 279). Roblin et al. (2018) discussed that the larger the scope of the curriculum material that included comprehensive and well sequenced curricula—the greater the gains for both teacher and student. DeBarger et al. (2017) concurred that quality curriculum is a crucial undertaking when strategising for changes to science education praxis. In line with this idea, one of the strengths of the NESA Syllabus for K–6 Science and Technology (2012) could be the clear building of knowledge, understanding and skills from K–6 evidenced through comprehensive continuums of learning.

Success stories in science curriculum introduction are noted across several studies. Yao and Guo (2018) discussed China's successes and put it down to three main considerations—a top-down translation and interpretation of changes; an authentic use of science researchers, scientists, educators and teaching-researchers in the implementation and use of curriculum; and, the increasing support for science education research, especially for comparative and quantitative studies. Pringle, Mesa, and Hayes (2017) showed that extensive, comprehensive, and ongoing professional learning is the key to successful curriculum reform and that a new curriculum results in positive changes when this is the context. Harrison (2018, p. 55), in reference to secondary stage 6 science, indicated that a new curriculum deserved "to be accompanied by a new approach" and that a technology-dense blended or flipped learning approach was best-fit. Curriculum has the ability to shift scientific attitudes, and when this occurs there is a notable improvement in academic performance (Lacap, 2015).

Pitfalls or negative impacts of curriculum implementation are also recognised in the literature. Koopman, Le Grange, and de Mink (2016, p. 149) in their phenomenological study of a physical science teacher in South Africa, reported on a teacher who viewed himself as “incompetent” and ill-equipped for implementation. Furthermore, the teacher in the study was ill-supported by the “Department of Education and his head of department” (Koopman et al., 2016). Gilbert (2013, p. 143) argued against a “pragmatic and theoretical approach” and “curriculum policy changes with broader social and economic trends”; but rather for the “deeper learnings available in the discourses and concepts of knowledge fields” to enrich “students’ lives as autonomous citizens in a democratic and just community”. This study contends that flow-on effects from the introduction of the NESA Syllabus for K–6 Science and Technology (2012) are significant enough to influence the adult learner and garner focus within the conceptual framework.

3.2.2 Learner plasticity

The strong basis for the development of this concept is that an adult learner is not fixed in their learning style. This idea nestles within adult learning characteristics, which evidence malleability depending on the learning situation. There are several proponents of this viewpoint in the literature (Cook, Thompson, Thomas, & Thomas, 2009; Husmann & O’Loughlin, 2019; Knoll, Otani, Skeel, & Van Horn, 2017; Lafferty & Burley, 2011; Massa & Mayer, 2006; Newton & Miah, 2017; Pashler, McDaniel, Rohrer, & Bjork, 2009; Ragowsky, Calhoun, & Tallal, 2015; Riener & Willingham, 2010). This counters the notion of fixed learning styles for learners. Learning styles may be defined as “different ways that people process and retain information” (Berry & Settle, 2011, p. 1). Several authors spoke to the idea of learners ascribing to a set learning style (Clarke, Lesh, Trocchio, & Wolman, 2010; Deniz, 2013; Felder & Silverman, 1988; Gregorc, 1984; Jepsen, Varhegyi, & Teo, 2015; Koçakoğlu, 2010; Kolb, 1984; McCarthy, 1987; Mozaffari, Janatolmakan, Sharifi, Ghandinejad, Andayeshgar, & Khatony, 2020; Myers & Myers, 1995; Nielson, 2008; Pitts, 2009; Sims & Sims, 1995).

There are so many conceptions of learning style in the literature, that not all may be covered. A particular focus is placed on Sarasin's (2006) learning styles of auditory, visual, or tactile/kinaesthetic as being preferred by and fixed within a learner. Auditory learners require information to be orally presented; visual learners require graphic aids, such as drawings, charts, tables and sometimes mental images; the tactile/kinaesthetic learners assimilate new information by physical activity and using their bodies (Sarasin, 2006). Table 3.3 presents a summary of some commonly referred to learning style perspectives from the literature. What is congruent between all theories is "the assumption that learning style is a stable and predictable characteristic" (Salter, Evans, & Forney, 2006, p. 173). The present study argues against a fixed notion of learning style and alternatively supports arguments for plasticity in the learner as influenced by context.

Table 3.3 Prominent learning style theories presented in the literature, alphabetically by author

Author(s) and model	**Learning style perspective**	**Further publications**
Felder and Silverman (1988) Felder-Silverman learning style model (FSLSM)	Learners are sensing, intuitive, visual, verbal, active, reflective, sequential, and global.	Felder (2010) Felder and Brent (2005) Felder and Brent (2016) Felder and Spurlin (2005) Litzinger, Lee, Wise, and Felder (2007)
Gregorc (1984) Mind styles model	Learners are concrete, abstract, sequential, and random.	Gregorc (1989) Gregorc (1998) Ginsburg (2001) Toktarova and Panturova (2015)
Kolb (1984)	Learners are concrete, abstract, active and reflective.	Kolb, Boyatzis, and Mainemelis (2001) Kolb and Kolb (2005) Kolb and Kolb (2013) Kolb, Kolb, Passarelli, and Sharma (2014)
McCarthy (1987) The 4MAT model	Learners are imaginative, analytic, common sensical and dynamic.	McCarthy (2001) McCarthy (2012) McCarthy and McCarthy (2006)

		Rothman and McCarthy (2012)
Myers and Myers (1995) Myers-Briggs Type Indicator (MBTI)	Learners are extraverted, introverted, sensing, intuitive, thinking, feeling, judging and perceiving.	Myers (2000) The Myer-Briggs Company (2018) The Myer-Briggs Company (2019)
Sims and Sims (1995)	Learners are cognitive, perceptual, behavioural or affective.	Sims (2002) Pitts (2009) Zapalska and Brozik (2006) Zhang, Sternberg, and Rayner (2012)

For supporters of learning styles, they are seen as crucial to best understand the learner. It is thought that "individuals approach learning differently due to differences in their learning style" (Csapo & Hayen, 2006, p. 129). As such to understand learning style is to understand the learner—a critical part of successful teaching (Csapo & Hayden, 2006). Because of this view, learning styles have garnered much attention within the domain of education. The result, a snowball effect of a robust industry developing for learning styles, evidenced by the publishing of books and learning styles tests for educators and the professional learning offered by organisations (Pashler et al., 2009).

Advocates of learning styles used the myriad of perspectives available in the literature to suit their research intentions. Deniz (2013) linked learning styles to self-efficacy, but rather tenuously, as the research mainly focused on self-efficacy and its positive impact on pre-service teachers. Clarke et al. (2010) also looked at preservice teachers in their study—they argued that thinking and learning styles influence how preservice teachers assimilate information for the purposes of transferral to their students. Pitts (2009) proposed that teaching and learning styles match so that "teachers can design more appropriate learning strategies for the benefit of each student" (p. 225). Jepsen et al. (2015) studied four learning styles (*pragmatist*; *activist*; *reflector*; and, *theorist*), and linked the reflector and activist as having an influence on the perception of teacher quality. Nielson (2008) noted an improvement in teacher instruction differentiation upon a two-day workshop on teaching and learning styles maintained for a year after the original workshop. Perhaps there were a myriad of reasons the professional learning influenced change in teacher practice and it may not be linked with an understanding of fixed learning styles. Koçakoğlu (2010) tested Turkish teacher's learning style using Kolb's (1984) *experiential learning style cycle*, noting the dominant learning style as *converger*. By Koçakoğlu's (2010) own account, his results were different from several other researchers who determined that Turkish teachers are predominantly *assimilators* in Kolb's (1984) learning styles. This calls to question—if learning styles are fixed, how can results on the determination of learning styles be so inconsistent? Salter et al. (2006, p. 173), supporters of learning styles, noted that "demonstrating stability over time would seem to be of critical importance to the utility of trait-based learning style measures in educational practice" and simultaneously a paucity of longitudinal studies for this purpose.

There are several compelling reasons to counter the idea of fixed learning styles. Amongst the popularised ideas of learning styles comes the *meshing hypothesis*. The meshing hypothesis accords that teaching strategies should be appropriated to the learning style penchants of the learner, that a tactile/kinaesthetic learner must be physical and using their body in all their learning (Pashler et al., 2009). Pashler et al. (2009) found that several studies "flatly contradict the popular meshing hypothesis" (p. 105). A study by Ragowsky et al. (2015) came to the same conclusion and claimed no statistical support for the meshing hypothesis for both verbal comprehension aptitude and mode of instruction. Knoll et al. (2017) concurred that "although learning style has garnered widespread acceptance in the educational community, there is a distinct lack of empirical support for the meshing hypothesis" (p. 545). They argued that the popularity of learning styles in education was down to an entrenched and subjective belief that if learning is presented in a way to suit a student's learning style then performance improved (Knoll et al., 2017). In the context of higher education, Newton and Miah (2017) conducted a study to ascertain student beliefs regarding learning styles. They reported that very few respondents actively used learning styles theory, even though a majority believed in it (Newton & Miah, 2017). This highlights a disparity between learning style theory, and praxis—an appealing set of theoretical assumptions that still lack evidence-based approaches.

Lafferty and Burley (2011) presented arguments that position learning styles as a myth or at the minimum as an unscrupulous idea. They mythologised learning styles because they are subject-dependent, that is, "a visual subject has to be taught visually" and because learning styles do not always support what we know about "how the brain works" (Lafferty & Burley, 2011, p. 17). Lafferty and Burley (2011) elaborate on their points:

> Learning styles are subject dependent, they are teacher dependent, they are temperature dependent, they are emotion dependent etc. In fact they are dependent on so many things, that they are on a continuum and therefore, not measureable, and do not exist . . . . We cannot rule out a learning style being associated with many neurotransmitters, and then the way we learn is based on how the brain works. But what is more likely is learning is more to do with memory, which is to do with forming more dendrites/neurons to hold more facts, which are held in circuits of neurons, and forming associations or indexes. The more indexes we have, the more deeply we have thought about a subject (pp. 18–19).

In reference to how the brain works, research abounds in the literature on neuroplasticity. Neuroplasticity denotes the brain's ability to change its networks, essentially rewiring itself (Banks, 2016). It is understood that "the brain is a hugely complex, highly recurrent, and non-linear neural network" which is "surprisingly plastic and sustains our amazing capability for learning from experience and adapting to new situations" (Denève, Alemi, & Bourdoukan, 2017, p. 969). Research into the brain has evidenced arrangements of experience-dependent modification, otherwise known as plasticity, that happen in the brain during learning (Chein & Schneider, 2012). Therefore, in the midst of learning the brain evidences change and malleability. This notion works against two of the presuppositions of learning styles—that they are fairly stable across time; and fixed across task, problem or situation (Lafferty & Burley, 2011). Gurunandan, Carreiras, and Paz-Alonso (2019) showed that adult language learners had functional brain differences depending on their level of expertise. They compared intermediate and advanced adult language learners and found greater functional plasticity in the advanced learners that adopted an "ongoing practice of skills" (Gurunandan et al., 2019, p. 8). An understanding of the learner is perhaps better garnered through building a picture of how the brain works, rather than a fixed application of learning styles to the learner. Carrasco, Serrano, and García (2015) in their study on the relatedness between neuroscience and education concluded "that the concept of plasticity contributes to enlarging our understanding of the educational diversity of learners in their experiential contexts, combined with special attention to human agency and the capacity to making choices and effect changes" (p. 152). Demir-Lira, Aktan-Erciyes, and Göksun (2019) reviewed literature on children with early focal brain injury, and highlighted that even in extremes the brain possesses extraordinary plasticity that allow the learner to make gains.

There are moderate points of view in the learning styles literature that take what is useful and supported by evidence into account no matter the position of argument. Reiner and Willingham (2010) noted that several claims of learning style theorists are very useful in the educational arena. These were acknowledged as the equivalent of universal truths. Firstly that "learners are different from each other . . . understanding these differences and applying that understanding in the classroom can improve everyone's education"; second that learners have different interests; third that learners have different background knowledge and that has an influence on learning; and finally, that some learners have "specific learning disabilities, and that these affect their learning in specific ways" (Reiner & Willingham, 2010, p. 33). They concluded nonetheless that learning styles are not evidence supported, and that the value of a learning tool (e.g. a visual one) is not in how it suits a supposedly visual learner, but in how well it is matched to the content the students are called upon to learn (Reiner & Willingham, 2010). This statement echoes a familiarity with the notion of pedagogical content knowledge, which is, adopting a pedagogical approach that is best suited to the learning area or specific content knowledge.

Moderate proponents of learning styles took on a more fluid view. Hou (2015, p. 1) spoke to the multitude of learning styles and that "understanding that no one learning style is better, nor no one teaching style fits all, and trying to expand their style repertoires for more effective teaching and learning" was the most useful uptake of learning style theory by educators. Beck (2007) in a study on preservice teachers concluded that case method pedagogy (i.e. the use of case studies for learning) was impactful for science teaching irrespective of learning style. Berry and Settle (2011) although supporting learning style theory argued that learning styles can be influenced by the educational experience of the learner and can alter based on those experiences and circumstances of the learner. Mozaffari et al. (2020) tested the VARK (visual, aural, reading/writing, and kinaesthetic) questionnaire developed by Fleming and Mills (1992) and concluded that learning styles were not correlated with academic achievement. Rogiers, Merchie, and Van Keer (2019) studied three contextual differences of learners—gender; reading ability; and home language. Rogiers et al. (2019) noted that no matter the learner's profile or characteristics—gender; reading ability; and, the number of strategies used for learning had the most significant influence on performance. These researchers appear to acknowledge the influence of context, to some extent, as influencing the nature of the learner—a significant presupposition of the current study.

3.2.3 Learner self-awareness

The essence of this concept focuses is in the idea of learner metacognition. This encompasses adult learning characteristics, and also changes in consciousness. Metacognition in its early inception was described by psychologist John Flavell as "knowledge and cognition about cognitive phenomena" which includes "memory, comprehension, and other cognitive enterprises" (Flavell, 1979, p. 906). Flavell's (1979) model of metacognition encompassed four different cognitive phenomena—metacognitive knowledge (for e.g. a learner's belief that they excel at writing versus solving algebraic equations); metacognitive experiences (for e.g. a learner's understanding that they struggled to fully comprehend algebra equation solving when it was demonstrated by their teacher); goals or tasks (for e.g. a learner decides to work harder to improve their skills in algebraic problem solving); and, actions or strategies (for e.g. a learner allocates the majority of their homework time to practising algebraic equation solving and solicits the help of their teacher and friends) (Flavell, 1979). Since Flavell (1979), metacognition has been described and represented in many different ways. Combining the understanding of Schellenberg, Negishi, and Eggen (2011) and Gonullu and Atar (2014); Steuber, Janzen, Walton, and Nisly (2017) defined metacognition as "a higher-order mental process used to plan, monitor, and evaluate one's awareness of information processing and performance, and denotes critical self-recognition of thinking, learning, and doing" (p. 20). When examining learners in a pharmaceutical course, Steuber et al. (2017) concluded that self-awareness was a must for the learner—an indispensable skill, that if practised over long periods may improve learner mindfulness for learning improvement.

Learner self-awareness is considered as pertaining to metacognition. Karaali (2015) in a study on mathematics learners linked motivation and self-awareness. Karaali (2015) noted that weekly metacognitive and self-reflective undertakings aided in student focus on deep learning; and the demonstration of consistent engagement and motivation throughout the semester. This means that a learner thinking about thinking, that is, metacognition, is of benefit to learning in, and of, itself.

Self-awareness is a necessity for effective self-assessment of the learner. In a study by de Blacam, O'Keefe, Nugent, Doherty, and Traynor (2012) they concluded that a higher year of training—that is, the more experienced surgical residents were more accurate in their self-assessment and self-prediction as compared with their demonstrable skills. Furthermore, older age and non-European nationality were further predictors of self-assessment accuracy (de Blacam et al., 2012). Perhaps metacognitive skills such as self-awareness are strengthened over time, with learner age and experience. Siegesmund (2017) argued that conversely it is self-assessment that grows learner metacognition, which in turn positively influences learning and self-regulation in a college student context. Siegesmund (2017) claimed that "self-regulated learners have agency over their learning before, during and after learning experiences" (p. 1).

For younger learners, self-assessment may still be useful, but not without constraints. Butler (2018, p. 242) demonstrated a limitation of self-assessment with primary school aged learners in that "they primarily focused on the just-completed tasks and perceived task requirements" in their self-assessments, rather than a generic self-assessment of their overall gains in language learning. These studies draw attention to a potentially significant difference between the child pedagogical learner and the adult andragogical learner.

3.2.4 *Context comfortability*

A familiarity, or on the other hand, a lack of familiarity with a learning setting is the foundational idea of this concept. A familiar learning context may influence an adult learner's characteristics in a particular way, so too an unfamiliar learning arena. Context comfortability draws into an adult learner's life situation and changes in consciousness as it considers their prior learning and experiences and how these influence their current position as an adult learner of K–6 Science and Technology.

An adult learner considered to be a novice in a particular learning area presents differently to another considered an expert. Several studies from the literature focus on the influence of expertise on learning within adult education. One such example discusses *cognitive load theory* (CLT). CLT maintains that:

> When advanced learners who already have sufficient knowledge to process information are provided with detailed instructional guidance designed for less experienced learners, the excessive guidance may become redundant, resulting in an excessive cognitive load because cognitive resources will be used to integrate the redundant instructions with the learner's available knowledge structures, thus diverting cognitive resources from productive higher order activities. In contrast, less knowledgeable learners may need the additional information (Bokosmaty et al., 2015, pp. 328–329).

Blayney, Kalyuga, and Sweller (2010) in an accountancy study concluded that novice adult learners evidenced improvements in their learning when they were tasked with new learning in a sequential manner. They discussed that "novice learners benefited from studying isolated elements because this instructional format allowed a reduction of learner cognitive load by having learners perform complex tasks in a sequential, cumulative manner" (Blayney et al., 2010, p. 285). In contrast, expert adult learners benefitted from interactive elements whereby they could assimilate and utilise their own knowledge base (Blayney et al., 2010). Blayney et al. (2010) also noted that expert learners required negligible guidance during task completion. Bokosmaty et al. (2015) found that novice learners saw great benefit in using worked examples for mathematics learning, whereas expert learners excelled in the area of open-ended problem solving.

Some of the teacher learners in the present study may be considered novice learners in reference to K–6 Science and Technology. A study by Butcher, Clarke, Wood, McPherson, and Fowle (2019) looked at higher education entry-level science, technology, engineering and mathematics (STEM) students. Butcher et al. (2019) linked STEM learner success to self-confidence and self-efficacy. For the novice STEM learners findings were strong and based on the viewpoints of students and tutors, that studying a STEM access module had improved preparedness for future study in science (Butcher et al., 2019). There is an argument for correlating to the studies on CLT discussed previously, in that novice learners excel with sequential and background-building learning when attempting to improve their expertise in a learning area. In other words, the extra support that may be stifling to the learning of an expert is essential for the novice.

An adult learner could exhibit different levels of comfort in a learning area depending on their background and experience. Çetinkaya-Aydın and Çakıroğlu (2017) looked at a myriad of learner characteristics and the association with a pre-service science teacher's understanding of the nature of science. Previous studies have addressed similar issues regarding the nature of science (Akerson & Donnelly, 2008). Pre-service teachers that "had high personal science teaching efficacy beliefs and moderate levels of science teaching outcome expectancies, possessed high levels of metacognitive awareness, and were committed to flexible faith and had respect to other belief systems" had the better understanding regarding the nature of science (Çetinkaya-Aydın & Çakıroğlu, 2017, p. 942). Perhaps these pre-service teachers had a stronger science and technology background and experience. Furthermore, they commented that a learner's engagement with activities on the nature of science, with explicit and reflective learning, evidenced learner improvement (Çetinkaya-Aydın & Çakıroğlu, 2017). This again draws importance to a building blocks approach, that is, a sequential and step-by-step approach for novice learners or similarly learners in the early stages of engagement in a learning area.

Pre-service teachers are a significant talking point, because in the ideal scenario they bring fresh ideas and up-to-date knowledge and understanding to the teaching profession. Bleicher (2009) reported on pre-service teachers that undertook an elementary science-methods course and categorised them in one of four categories: *Fearful*; *disinterested*; *successful*; or, *enthusiastic* science learners. Bleicher (2009) based the analysis on differences in science backgrounds and interest in science. This aligns with the concept of context comfortability in that a teacher learner's background and experience influence how they present as a learner of K–6 Science and Technology. Bleicher (2009) found that all categories of pre-service teachers improved their science content knowledge, understanding of the learning cycle, self-efficacy in teaching science, and confidence to learn science. Furthermore, fearful learners demonstrated the least increase in science content knowledge and understanding of the learning cycle and were the least confident of all four categories (Bleicher, 2009). The disinterested category of pre-service teachers made "fewer gains in science content knowledge than Enthusiastic science learners" (Bleicher, 2009, p. 293). Norris, Morris, and Lummis (2018) used Bleicher's (2009) science learner typologies in a statistical analysis that showed that learner type influenced *science teaching self-efficacy* (STSE). Table 3.4 shows how Norris et al. (2018) characterised each of the four science learner typologies. In addition, Norris et al. (2018) identified "a new type of learner (*not clearly identifiable*, n = 68), located in the middle of the other four categories, where individuals' attitudes and beliefs towards science had changed due to life experiences between secondary school and their Australian Graduate Diploma of Education Primary (GDEP) program" (p. 292).

Table 3.4 The characteristics of the types of science learners (from Norris et al., 2018, p. 2298)

Type of science learner	Characteristics
Enthusiastic	Strong statements expressing their high interest in science; enjoyed science classes they had at secondary school; attended extra-curricular science *type* of activities or hobbies; not necessarily achieving highest grades in classes other than science and commented that they are looking forward to teaching science.
Successful	High achievers in the area of science academic classes along with other learning areas; didn't comment on specific science hobbies or specific interest outside of school science; felt confident to learn and understand science concepts.
Disinterested	Stated they had a dislike or disinterest for science during their secondary education. They reported feeling bored, not engaged during class and described having to rote learn or memorise large amount of information in order to pass an assessment. They did not mention that they were worried or afraid of science learning and often did well in class despite the disinterest in the subject.
Fearful	Mentioned that they were afraid or had apprehension towards science. They did not enjoy science activities and often mentioned that the subject content felt *foreign* and did not make sense. They mentioned struggling to pass the subject and did not feel confident about teaching science even at the commencement of the unit due to their lack of conceptual understanding.

The concept of context comfortability may be seen in literature regarding student teaching and learning in science and technology. Such literature should not be disregarded because it studies child learners, as there may be wisdom applicable to the adult learner context. Ifenthaler and Gosper (2014) suggested the use of a MAPLET (matching aims, processes, learner expertise and technologies) framework, a six step process that aligns phases of acquisition (early, intermediate and late) to learner expertise and elements of the curriculum. This speaks to the notion of foregrounding learner expertise in the process of moving learning from basic tenets to more complex late phase tasks. Schneider, Krajcik, Lavonen, Salmela-Aro, Broda, Spicer, Bruner, Moeller, Linnansaari, Juuti, and Viljaranta (2016) reported on optimal learning from U.S and Finnish science classes. They showed when "students experience more times of optimal learning in their science classes they are more likely to report that they perceive science as important to them and their futures" (Schneider et al., p. 400). *Optimal learning* encompassed fostering an interest in science; foregrounding the importance of skills; and, undertaking challenges—"the motivation within a person to improve his or her abilities beyond what has been previously mastered" (Schneider et al., 2016, p. 403). Optimal learning may be a means of taking the novice to more expert levels of science and technology knowledge and understanding, and influencing context comfortability.

A myriad of literature highlights to-dos on the list of what is efficacious for the adult learner. In order to positively influence context comfortability perhaps a multilevel approach is needed. Pyhältö, Pietarinen, and Soini (2015) studied teacher learning and teacher professional agency. They found that skills, efficacy beliefs, and motivational factors, "which entail transforming one's teaching practices, experiencing collective efficacy, constructing positive interdependency, the appreciation of mutual agreements, and using active strategies of help-seeking" were of critical importance (Pyhältö et al., 2015, p. 811). Newton (2018) highlighted the impact of strong academic vocabulary to academic achievement. When teachers improved their metalinguistic awareness, they evidenced changes from teacher-centred to student-centred teaching and learning approaches (Newton, 2018). This places significance to the jargon of science and its metalinguistic roots. Peeters, De Backer, Buffel, Kindekens, Struyven, Zhu, and Lombaerts (2014) highlighted the benefits of informal learning that supports formal professional learning. Informal learning included things such as "self-directed learning projects, daily conversations and experiences…and inform and hidden curriculum" (Peeters et al., 2014, p. 181). Gu (2016) spoke to the benefits of informal learning to workplace learners demonstrated by use of an app, whereby self-direction and motivation were significant influencers of success. Context comfortability may be influenced by strong informal learning as well as formal educational experiences for adults. An interaction of informal learning may potentially keep formal learning experiences such as professional learning sessions alive in the memory and praxis of teachers.

3.2.5 Perceptions on teacher learner

This concept is firmly grounded in an understanding of adult learner characteristics. It extends beyond the viewpoint of the adult learner themselves to the viewpoint of the adult educator and their perceptions on the teachers undertaking learning. It draws on what teacher educators consider to be the main learner characteristics of the teacher learners they encountered, coached, facilitated and educated. It also links these perceptions with expectations of achievement in learning for the teacher learners.

A learner may be viewed in a multitude of ways, especially by their teacher or facilitator. In a study of English as a second language (ESL) learners, twenty one teacher responses were solicited based on fake student records—which highlighted the influence of student ethnicity or ESL status over academic achievement of the student (Riley, 2015). Riley (2015) showed "that even when teachers are asked to base their recommendations only on academic achievement, some teachers still attend to arbitrary factors such as a learner's group membership" (p. 659). This speaks to something in the human condition, of the natural propensity for stereotyping and applying biases. Conversely, without some arbitrary grouping or classification in the educational setting perhaps teaching and learning could not be properly differentiated to suit each learner. There may be a fine line between the two.

As teacher learners in the present study are likely to be non-specialists in science education, there may be a propensity for teacher educators to perceive them in a particular way. For example, a primary teacher with a negligible level of science in their background may be novice in their science and technology knowledge and understanding. Because of this, the teacher educator's perception may be that this learner, although an adult, could exhibit child-like learner traits—or traditional pedagogical learner traits. This concept also links with the construct in the literature of the *teacher-learner*, an adult learner, yet still a student "both learning science and learning to teach science simultaneously" (Knaggs & Sondergeld, 2015, p. 117). In general, the literature shows that primary teachers have "weak science content backgrounds and had poor/negative experiences as students of science, resulting in a lack of confidence regarding teaching science" (Knaggs & Sondergeld, 2015, p. 117). And so the fine line appears again. The perception of the teacher learner as child-like in their learning characteristics may negatively influence self-efficacy or limit expectations of achievement—yet, not recognising a novice learner, floundering in a learning environment, may result in the insufficient provision of support. Therefore, perceptions are useful, until they negatively influence learning progress.

In a narrative perspective of the adult learner, Barnett (2013), a higher education teacher, discussed some complexities of perceptions. Barnett (2013) evidenced a growing rate of mature age students over 35 in her Bachelor of Education (BEd) classes and many were seeking greater than usual support and reported emotional distress. Barnett (2013) could not attribute gender, marital or parenting status, level of success in the BEd program, professional employment, race, religion, sexuality, background experience or first language as correlated to this need in support. The only commonalties remaining were being 35 years or older and being enrolled in the BEd program (Barnett, 2013). Barnett (2013, p. 67) stated, "I became conscious of the need to comprehend the experiences of the adult learner enrolled in a one-year intensive programme in order to better meet their needs". Adult learner needs is a broad consideration. Mezirow (1981) advocated that the business of the adult educator is to "respond to the learner's educational need in a way which will improve the quality of his or her self-directedness as a learner" (p. 135). Barnett (2013) then undertook the experience of becoming a mature age learner herself. She noted that mature age students experienced insecurity, and self-doubt which leads to apprehension, and as a result require affirmation (Barnett, 2013). Perhaps Mezirow's (1981, 2000) notion of building self-direction in adult learners would address Barnett's (2013) identified learner uncertainties.

Beyond the experience of the teacher learner in K–6 Science and Technology the teacher educator may perceive different levels of motivation from the adult learners they encounter. In a study regarding the perspectives of Chilean English teachers, Glas (2016) explored learner motivation, and the difficulties teachers have in motivating students. It was teacher agency that was deemed most impactful to learner motivation:

> Teachers need to develop a sound sense of agency to identify 'spaces to manoeuvre' between external constraints, such as curricular policies or lack of parental support, and possible internal constraints, such as paralysing beliefs about their own competence or a limited cultural repertoire to draw on in order to make English lessons motivating and meaningful for their students (Glas, 2016, p. 442)

An interesting juxtaposition arises in light of the current study. The teacher educators may perceive the teacher learners in a particular manner, but so too themselves, because they are also non-specialist science educators that come from a primary teaching background taking on the role of teacher educator. Therefore, an understanding of the teacher learner is at the heart of learning, integrated with an understanding of the teacher educator and the learning journey they undertake in their role as facilitator.

Perception-making is a two-way street, the teacher educators hold their own and potentially so too teacher learners, and each may evidence a provocation on the learning environment. Ferguson and Brownlee (2018) highlighted specific beliefs preservice teachers hold and the need of teacher educators to address these. Beliefs regarded "the ways knowledge and practice will change, reasons for change, and the rate of change in teaching knowledge" (Ferguson & Brownlee, 2018, p. 94). Dargusch and Charteris (2018) outlined the tension of expectations on the teacher learner and teacher educator in the context of assessment practices, as they discussed teacher accountability and learner agency and the balance between. These studies again speak to an equilibrium that is necessary between what is expected of the educator and the learner and how these expectations may be balanced in a real-life context.

3.2.6 Professional learning setting

The final concept concerning the professional learning setting once again draws to attention the influence of context in the present study. In this circumstance it regards professional learning in K–6 Science and Technology, undertaken by adult learners that are predominantly non science specialists. These particular learners are likely to garner the highest benefit from a suitable professional learning setting. Analogous professional learning contexts from the literature were shown to have influence on adult learning characteristics.

An effective professional learning environment is critical to teacher learner attainment, with an influence on the classroom setting and student achievement. In a thorough review of teacher effectiveness and professional learning literature, Muijs, Kyriakides, van der Werf, Creemers, Timperley, and Earl (2014) argued one step further for the use of what is known about student attainment for teacher attainment. They claimed, "making connections, developing metacognitive awareness, and taking control of one's own learning through self-regulation are important to promoting learning of both students and those who teach them" (Muijs et al., 2014, p. 246). Muijs et al. (2014) spoke to a *teacher enquiry and knowledge building cycle* that also promotes outcomes for students simultaneously and used the *dynamic model* shown in Table 3.5 to build their argument.

Table 3.5 The dynamic model and the main elements of each effectiveness factor (from Muijs et al., 2014, p. 244)

Factors	Main elements
(1) Orientation	(a) Providing the objectives for which a specific task/lesson/series of lessons take(s) place (b) Challenging students to identify the reason why an activity is taking place in the lesson.
(2) Structuring	(a) Beginning with overviews and/or review of objectives (b) Outlining the content to be covered and signalling transitions between lesson parts (c) Drawing attention to and reviewing main ideas.
(3) Questioning	(a) Raising different types of questions (i.e., process and product) at appropriate difficulty level (b) Giving time for students to respond (c) Dealing with student responses.
(4) Teaching modelling	(a) Encouraging students to use problem-solving strategies presented by the teacher or other classmates (b) Inviting students to develop strategies (c) Promoting the idea of modelling.
(5) Application	(a) Using seatwork or small-group tasks in order to provide needed practice and application opportunities (b) Using application tasks as starting points for the next step of teaching and learning.
(6) The classroom as a learning environment	(a) Establishing on-task behaviour through the interactions they promote (i.e., teacher–student and student–student interactions) (b) Dealing with classroom disorder and student competition through establishing rules, persuading students to respect them and using the rules.
(7) Management of time	(a) Organizing the classroom environment (b) Maximizing engagement rates.
(8) Assessment	(a) Using appropriate techniques to collect data on student knowledge and skills (b) Analysing data in order to identify student needs and report the results to students and parents. (c) Teachers evaluating their own practices.

The dynamic model emphasises the interrelatedness of each factor, which "allows the complex nature of effective teaching to be highlighted, but may also allow specific strategies for teacher improvement to emerge" (Muijs et al., 2014, p. 245). Each factor in the dynamic model can be demarcated and measured by five rudiments: frequency, focus, stage, quality, and differentiation (Muijs et al., 2014). The first three rudiments are mainly concerned with direct teaching methodologies, whereas quality and differentiation are more rigorous as teachers are expected to differentiate their teaching and learning and use novel approaches directly geared to developing metacognitive skills (Muijs et al., 2014). Even if the dynamic model is not appropriated at this depth for the context of the present study, there could be useful learnings in the eight interrelated factors for teacher educators and teacher learners alike.

In human discourse the vernacular of learning from experience is habitually touted. As discussed earlier in this chapter, the novice adult learners versus the expert have been shown in several studies to benefit from different teaching and learning strategies. Bokosmaty et al. (2015) advocated worked examples as a specific tool for novice learners. This speaks to learning from experience—the experience of others. Cox (2005) discussed that modelling was impactful in work-based learning in a variety of contexts; and used reflective practice as a focus. Cox (2005) remarked of the learner—"rather than being troubled by change and discord, or being condemned to repeat their mistakes over and over, reflective learners could begin to view each new challenge as a learning opportunity" (p. 471). The provision of modelling in any manifestation may prove useful at some point in the knowledge journey of the adult learner. de Freitas, Oliver, Mee, and Mayes (2008) compared teacher practice models and those provided by government organisations and showed that "practitioners were adept at using existing models and repurposing them to suit their own context" (p. 26). This study allays a fear that models can be used without differentiation, and rather shows that teachers are able to develop models; rendering them best fit, meaningful and relevant. Perhaps where the adult learner is without a compass in their learning, comprehensively structured professional learning (PL) and modelling are of import.

Emotions in a learning setting, whether regarding PL or the classroom, may evidence an influence on learning. Toraby and Modarresi (2018) in the context of language education, considered the role of emotions in learning. They noted that "emotions that teachers experience are not only important for their performance and satisfaction in the classroom, but they also affect their interactions with students and students' achievement" (Toraby & Modarresi, 2018, p. 513). Their findings showed that emotions such as pride and enjoyment were effective motivational tools for students (Toraby & Modarresi, 2018). Due to benefits afforded by positive emotions in teaching and learning, it is incumbent to further understand how these emotional states are reached. Vintilă and Istrat (2014) studied wellness and mental health for adult educators and learners in response to the stress learners encounter because of challenges in their life. Such stresses lead to "decreased work engagement and job satisfaction" (Vintilă & Istrat, 2014, p. 610). They contributed with the provision of tools to manage stress; support creativity and communication skills; increase self-awareness and self-motivation; and, regulate emotions (Vintilă & Istrat, 2014).

Beyond building the communication skills of the adult learner, the skills of the adult facilitator in this area are also significant. Heineke (2013) delved into coaching discourse and how and when it supports teachers' PL. Heineke (2013) highlighted that:

> the teacher/coach relationship was discussed more ardently by coaches and teachers than any other factor related to successful coaching . . . the participants stressed that a foundation for coaching must be laid by coaches who display a respectful/listening attitude toward teachers, who build credibility with teachers, are available and visible among teachers, and maintain trust/confidentiality with teachers (p. 427).

This correlates to a building of relationship by the teacher educator with the teacher learner for the current study and also the potential positive influence this may result in towards an effective professional learning environment.

Scoggins and Sharp (2017) spoke to a mountainous challenge for schools, making PL for teachers resonating and efficacious. Chapter two of the current study spoke to elements of effective professional learning as highlighted by the literature. Park and Choi (2009) studied dropout rates in an online learning platform. They noted that organisational support for learners was critical and that the onus was on instructors to "find ways to enhance the relevance of the course" (Park & Choi, 2009, p. 207). A one size fits all approach, although streamlined by definition, may not prove efficacious. Goodnough (2019) promoted "policies and practices that will allow practitioners to engage in differentiated options for professional learning" in their STEM study (p. 378). Goodnough (2019) concluded:

> Teachers' professional lives and how approaches to professional learning may positively impact their practice can be better understood through a careful analysis of their needs and how the changing context of professional learning can enhance or hinder teachers' ability to foster student learning in STEM (p. 379).

Much like students in a classroom, the adult learners in PL have unique needs and come with their individual knowledge and experiences. Scoggins and Sharp (2016) utilised an online pre-assessment strategy to demarcate teachers, highlighting existing knowledge and inconsistencies in understanding prior to beginning PL.

3.3 Summary

Chapter three sharpened the focus of this study on one area of the theoretical frame of adult education. It centralised the notion of adult learner characteristics; and how life situation and consciousness may also influence the adult learner. Chapter three also presented theory within the adult education framework that distorted delineations of pedagogy for the child learner and andragogy for the adult learner. From these theoretical understandings, the conceptual framework, built upon six core concepts was presented. These are the new curriculum effect; learner plasticity and self-awareness; context comfortability; perceptions of the teacher learner; and, the professional learning setting. Chapter four details the methodology of the present study, and the decisions undertaken to address the conceptual framework and the research questions.

Chapter 4: Methodology

Introduction

This chapter outlines the study methodology. A number of other methodologies were explored before case study was selected. The present chapter also describes the epistemological stance of the researcher. Philosophical underpinnings of the study are canvassed and the methods used are also stated. The ethical considerations associated with constructing the current study are described, as are the criteria to improve its trustworthiness. Previous chapters introduced this study, its questions, theory in the field, and presented its theoretical and conceptual framework. Chapter four highlights the link between the methodology and these elements.

4.1 Paradigm

A paradigm is a way of viewing and knowing the world (Freebody, 2003; Lichtman, 2013). Qualitative research, by nature, often represents daily practices or occurrences. Lichtman (2013) described it as “careful looking and listening of people in their natural settings” (p. 4). It allows the researcher to study issues with depth and detail, and therefore meaningful data may be produced from a small number of participants (Shahalizadeh, Amirjamshidi, & Shahalizadeh, 2009). This speaks to a particular worldview—a paradigm. As such, the chosen paradigm of interpretivism (or constructivism) was deemed most appropriate within the realm of qualitative research, because of the understanding that reality is multifaceted, a social construct of a person’s interaction with their environment (Cohen, Manion, & Morrison, 2011; Kervin, Vialle, Howard, Herrington, & Okely, 2016; Mertens, 2014; Ward, Cromer, & Stone, 2018). Lichtman (2013) acknowledged constructivism as a “theory or proposed explanation of a phenomenon, that says that knowledge is constructed by the researcher and is affected by his or her context” (p. 13). The current study utilises the terminology of interpretivism and constructivism interchangeably when referring to paradigm. This decision was reached based on a thorough review of the literature, and of the shared goal of understanding of the world that both interpretivism and constructivism purport. Both believe "that to understand this world of meaning, one must interpret it" (Schwandt, 1994, p. 222). This study aimed to construct the reality of the twelve teachers involved (three teacher educators and nine teacher learners) without negating the role of researcher.

Within the interpretivist view, constructivism encompassed the epistemologies of this study—that is, subjectivism, constructionism and contextualism. The interpretivist view allowed the research to have meaning attributed, and like most other perspectives, "exhausts the richness of reality" (Paucar-Caceres, 2009, p. 9). It allowed for a broadness to include all opinions on the topic area of adult learning from learners and educators alike. Lichtman (2013, p. 26) noted that "there is no single interpretation that is better than another" and also no one person that is best at interpretation. The interviews conducted and the supplementary data gathered were critical to representing teacher realities. This study placed a serious emphasis on Hogg and Maclaran's (2008) viewpoint that interpretivism rejects the traditional positivist view that there is independent and objective truth waiting for the researcher to discover—rather that the strength of research reigns in subjectivity.

4.2 Philosophical decisions

Paradigm selection in a study involves making philosophical assumptions to support that particular worldview (Isidori, Migliorati, Maulini, & Echazarreta, 2015). These assumptions are ontological; epistemological; and, axiological (Lichtman, 2013). The three assumptions influence the choices of the fourth, methodology (Lichtman, 2013). Firstly, ontology covers the nature of social reality, that is, the belief system about the nature of reality. A qualification is made whether reality is "external to individuals", an objective reality or whether it is subjective, "a product of individual consciousness" (Cohen et al., 2011, p. 5). The current study foregrounded teacher voice and so aligned with the subjective view of reality. Secondly, epistemology regards the ways of knowing—in other words, how do we know what we know? This refers to the underpinning notions of knowledge itself—how it may be attained and transferred to others, as well as its type and essence (Cohen et al., 2011). The present study acknowledged researcher contribution to the building of knowledge, supplementary to teacher voice. Thirdly, axiology speaks to the ethics and value judgements, as it asks of the researcher—what do they believe to be true? (Patton, 2002). Cohen et al. (2011) explained that human beings are either reacting involuntarily to their environment or are acting with free will and imagination to enable their environment. The axiology in relation to the current study acknowledged the interactional interplay between researcher and the phenomenon regarding the nature of the adult learner. Finally, the methodology undertaken is a direct influence of the philosophical assumptions (Bleiker, Morgan-Trimmer, Knapp, & Hopkins, 2019). It utilises robust, appropriate and systematic approaches to answer paradigm influenced questions about the world (Bleiker et al., 2019). Methodology is a justification and validation for the choices made on data collection methods (Atkins & Wallace, 2012).

4.2.1 Ontology

The education of the researcher in this study was firmly grounded in the empirical, with a major in science. They also taught science and the scientific method to child and adult learners. With this background in mind, a subject-centred ontology was a new venture, and so too, the notion that "methods of studying human affairs need to capitalize upon the natural powers of people to experience and understand (knowledge)" (Stake, 1978, p. 5). This was a point of contention for the researcher, as their role as a science educator supported positivist ontology. The "objective and predictable" (Boblin et al., 2013, p. 1269) view of reality was a default position. Original views of knowledge and how one gains understanding on phenomena were challenged and ultimately extended. A point of influence in this process was Stake's (2010) work, whereby knowledge and truth were relative and dependent upon the subject's perspective (Baxter & Jack, 2008; Stake, 2010; Yazan, 2015). It was at this point in this study that preliminary thoughts of case study as a methodology began to surface.

4.2.2 Epistemology

The epistemology of the present study foregrounded the role of *researcher and the researched*. The researcher is definitively linked to the study in several ways. For the most part, the perspective was taken that this was a positive contributor to the depth of understanding reached in this study. The researcher was a co-facilitator alongside the teacher educators in this study at certain times in the professional learning (PL) of the teacher learners across 2015. As such, they may be viewed as a casual fourth teacher educator. Co-facilitation of PL occurred on seven to ten different occasions across 2015. The teacher educators ran all other PL sessions independently of the researcher in this study (aside from off-site support for science content, if it was sought). In 2015, the researcher held the position of Education Officer: Australian Curriculum for the Catholic Education Office, Sydney (now, Sydney Catholic Schools). Part of this role as a science specialist was to support the three regional education officers (teacher educators) in their role of upskilling teachers in the NESA Syllabus for K–6 Science and Technology (2012). All four education officers (three teacher educators and researcher in this study) met several times a year with their team leader to discuss any concerns, issues and successes in their roles.

4.2.3 Axiology

In line with Stake's (2010) constructivist assumption the researcher interacted with the phenomenon over an extended period of time. Value is afforded to this occurrence and the issue of bias is "acknowledged and embraced" (Boblin et al., 2013, p. 1269). The issue of bias cannot be completely explained away using Stake's (1995, 2010) axiology; rather Yin's (2009, 2012, 2017) influence entered this study as certain methods were employed to address bias. One such method is Yin's (2009, 2012, 2017) heavier reliance upon the literature to form a conceptual framework. This was a means of partially mitigating bias in this study.

4.3 Methodology

4.3.1 Case study

Case study research has varied philosophical underpinnings. Different to other methodologies, such as phenomenology, it is not grounded in a strong philosophical historical context. In fact, some researchers (Lichtman, 2013) believed case study has no philosophical underpinnings. What became evident after a thorough review of the literature is that philosophical influences were present; but appear in the choice of methods utilised in each individual study. Case study is dynamic in this way, generally taking its philosophical influences from the epistemological stance of the researcher or those who heavily influenced the researcher and their work.

Case study nestled well as the chosen research methodology within the interpretivist paradigm. Its rich and thick descriptions allowed for a holistic view that was all-encompassing and could include an infinite number of variables and links to be examined (Gummesson, 2007). Notwithstanding this flexibility, this study and its research questions were not boundless. Care was taken to maintain the boundaries of the case, so that the quality and productivity of the case study was preserved (Gummesson, 2007). Boundaries were maintained by the allocation of categories in the overarching research question. These are: a new curriculum (NESA Syllabus for K–6 Science and Technology, 2012); teacher self-efficacy; and, technological pedagogical content knowledge (TPACK). The categories served to limit the units of analysis within the case for viability of this study's timeframe. Boundaries were further preserved by limiting the time allocated for data collection to six months. Participant interviews were conducted soon after the experience of PL across 2015 and were all completed by the end of May, 2016.

In this study it was the constructivist paradigm, as evidenced in Stake (1995, 2010) and Merriam's (1998, 2009) work, and to a lesser extent, Yin (2009, 2012, 2017), which permeated all layers of the methodology. Yazan (2015, p. 134) referred to these researchers as "prominent . . . and foundational methodologists" as their methodological protocols remain a primary influence on educational researchers today. The commonalities among Stake (1995, 2010), Merriam (1998, 2009) and Yin's (2009, 2012, 2017) approaches are that "the topic of choice is well explored, and that the essence of the phenomenon is revealed" (Baxter & Jack, 2008, p. 545)—a vital benchmark for this study. It is the methods that these researchers employed that are considerably different, and as such were an important consideration prior to the commencement of this study. In addition, case study as a qualitative method has a significant uptake in the field of education. The education-based context of this study further rendered case study methodology a good fit.

There appears to be no consensus as to a unified definition of the case study approach. Central tenets become apparent when reading certain authors. As such a myriad of definitions (Atkins & Wallace, 2012; Cresswell, 2013; Cohen et al., 2011; Levy, 2008; Lichtman, 2013; Merriam, 1998, 2009; Stake, 1995, 2010; Simons, 2009; Yin, 2009, 2012, 2017) were considered before an abbreviated definition was put together that best aligned with this study. For the purpose of disambiguation this study utilised case study research as a methodology, of which the methods and rules were garnered from various authors in the literature in an attempt to better understand the contextually bounded case of teacher educators and teacher learners that were a part of PL for the NESA Syllabus for K–6 Science and Technology (2012).

4.3.2 Characteristics of this case study

A case study may align in nature with other qualitative research approaches. In this study there were clear and readily identifiable reasons for its selection over others. Yin (2017) identified at least three situations in which case study is the opportune choice for researchers. The first is when the study seeks an answer that is descriptive or explanatory (Yin, 2017). The second is when studying a phenomenon in its real-world context (Yin, 2017). The final situation regards evaluating the context or phenomenon (Yin, 2017). This study, in its questioning, sought both description (the *what*) and explanation (the *how* and *why*). Yin (2012, p. 5) added that it is the "rich descriptions or the insightful explanations" that may be lost with use of other methods. Yazan (2015, p. 139) stated that it is Merriam (1998, 2009) among Yin (2009, 2012, 2017) and Stake (1995, 2010) that most emphatically emphasised the methodologies' "quintessential and idiosyncratic features" for researchers. The nuances of Merriam's (1998, 2009) contribution to the case study literature were helpful in providing specificity to some methodological choices in this study.

4.3.3 Case identification

A central consideration to any case study is identification of the case (Levy, 2008; Merriam, 1998, 2009; Stake, 1995, 2010; Yin, 2009, 2012, 2017). This is also referred to as *binding the case*. Baxter and Jack (2008) recommend that the case is well bound to ensure the scope of the research is realistic in its broadness, and there is not a multitude of objectives that cannot be met. In accordance with this advice, this study focused on nine primary teachers (teacher learners) that undertook professional learning (PL) and three primary teacher facilitators (teacher educators) that lead that learning. In the context of this case in 2015, the Catholic Education Office, Sydney (now, Sydney Catholic Schools) had over three thousand primary teachers, of which a majority undertook some type of PL for the NESA Syllabus for K–6 Science and Technology (2012). This study narrowed its focus to nine teachers amongst a group of over one hundred that were given the position of *science reference teacher* at their school. Their responsibility was to undertake significant PL which they brought back to the teachers at their school. The intended outcome was that high quality learning fed down the steps of the pyramid model used for this PL setting—eventually reaching students, as shown in Figure 4.1.

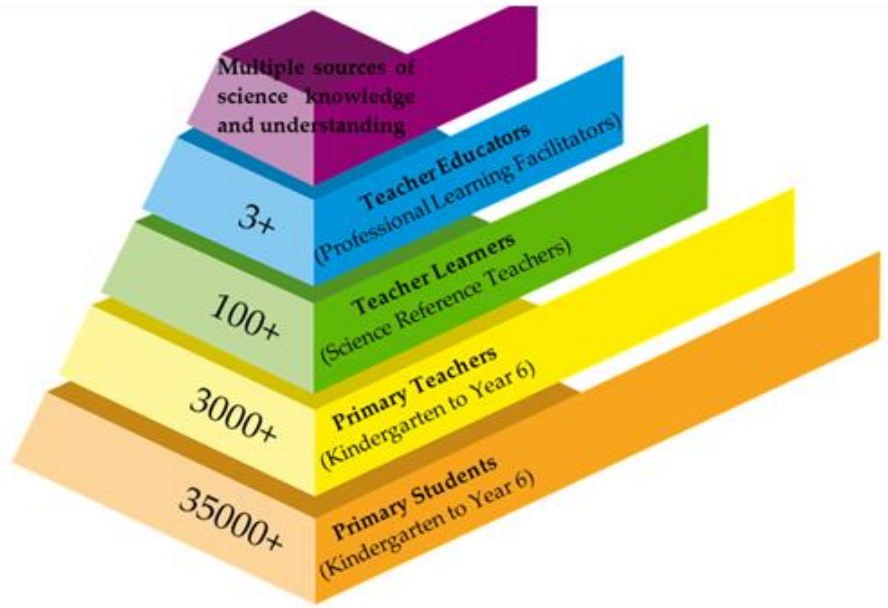


Figure 4.1 *The pyramid model showing the style of professional learning*

Stake (1995, 2010) and Yin (2009, 2012, 2017) viewed the case as a bounded structure or unit. Merriam (1998, p. 27) considered "the case as a thing, a single entity, a unit around which there are boundaries". Merriam's (1998) definition provided more flexibility than Stake (1995, 2010) and Yin (2009, 2012, 2017). Merriam (1998, 2001, 2009) highlighted that as long as the phenomenon can be specified and boundaries drawn, it may be considered a case. For this study, it is Yin's (2009, 2012, 2017) version of a case that was appropriated. The bounded case of this study blurred with the context, as the case of primary teachers leading and undertaking PL for the NESA Syllabus for K–6 Science and Technology (2012) represents both.

4.3.4 Case design

The case study in this research, bounded by context, was also defined according to the basic types of design as presented by Yin (2012).

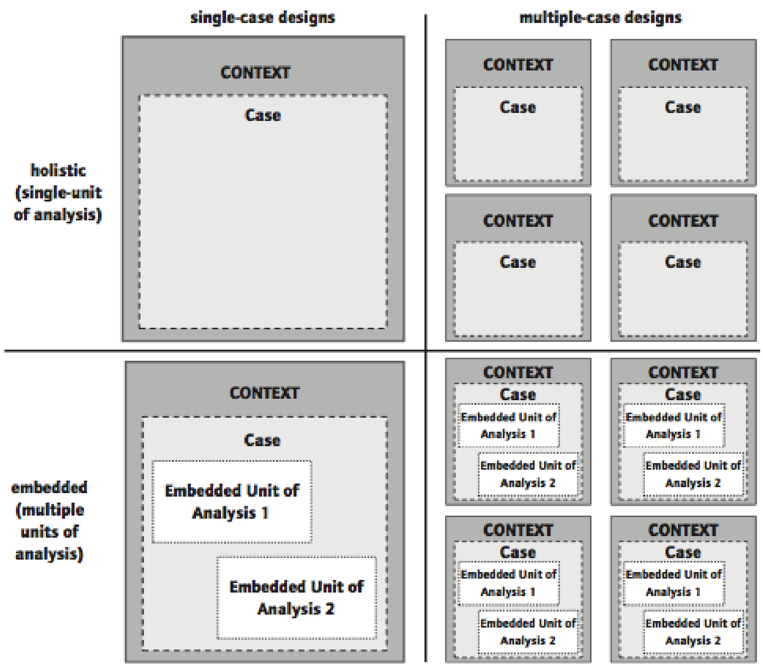


Figure 4.2 Basic types of designs for case studies (from Yin, 2012, p. 8)

The design of this study was an embedded, single case. There was a single context in which the case resided and there were several units of analysis within the case itself. The units of analysis featured as the three factors of influence in the main research question. Yin (2012) re-emphasised the blurring between case and context with use of the dashed line in Figure 4.2.

4.3.5 Case type

The literature is full of definitions or representations of different types of cases or case typologies. In this study, some cross-over occurred between Yin's (2009, 2012, 2017) *explanatory*, *exploratory* and *descriptive* cases and Stake's (1995, 2010) *intrinsic* and *instrumental* cases. As such the current study fell within the realms of an instrumental, exploratory case study. However, having delved deeper into Yin's (2009, 2012, 2017) version of an exploratory case study, mismatches with the nature of this study came to light. Primarily, fieldwork and data collection precede the study questions and methodology. This was not the case in this study. Yin (2012, p. 9) added that because of this initial exploration the study may "assume some other form" and move away from case study altogether. Therefore, a misalignment existed with a strict version of Yin's (2009, 2012, 2017) definition of an exploratory case study. A more generic view of exploration was assumed. That is, a case study that reconnoitrers the nature of adult learning through the case and its context. The two categories of exploratory and instrumental as presented by Yin (2009, 2012, 2017) and Stake (1995, 2010) encompassed the exploratory nature of gaining further insight into adult learning, for the instrumental purpose of potentially adding to or influencing current theory in the area. It is the understanding from the case, rather than the finite particulars of the case itself that were a primary focus in this study. Such is not to negate the importance of the case itself, but rather to extend the usability in broader educational contexts.

This study aligned with selective case study typologies. Levy (2008) provided justification for this decision, stating that "in practice case studies often combine several of these (typologies) aims" (p. 3). Levy (2008) presented the early works of Lijphart (1971) and Eckstein (1975) and their typologies of case study as influencing most other notable authors.

Table 4.1 Case typologies of Lijphart (1971) and Eckstein (1975)

Lijphart (1971, p. 691) case study typologies	**Eckstein (1975, p. 96-123) case study typologies**
Atheoretical	Configurative-idiographic
Interpretive	Disciplined-configurative
Hypothesis-generating	Heuristic

Theory-confirming Theory-informing Deviant	Plausibility probe Crucial

The typologies in Table 4.1 fell within the *nomothetic* and *idiographic* approaches to knowledge; and were both inductive and theory-guided. Levy (2008, p. 3) elucidated the flexibility of these typologies, as research objectives are likely to align with more than one category, resulting in a study with "non-parallel" categories. In accordance, the present study was considered as non-parallel in nature in terms of typology; idiographic by virtue of being concerned with the insights of the individual teachers in the case; and, inductive as it maintained the integrity and uniqueness of an individual's perspective. Moreover, it is theoretically guided in its framework, partly deductive data analysis, and purpose of contributing to theory.

4.3.6 Theory in case design

According to Yin (2009, 2012, 2017) there are three steps in designing a case study. The first two are defining the case and selecting one from the four basic types of designs (2009, 2012, 2017). The third and final step involved using theory in design work (2009, 2012, 2017). This study has not shied away from its reliance on the literature for formulation of theoretical and conceptual framework, generation of research questions and guidance in data collection and analysis. The focus on the individuals in the case was not to the degree that rendered this study purely atheoretical, configurative-idiographic or even descriptive. Certainly as a qualitative study, rich descriptions were characteristic and important, but not in sacrifice of transferability and insights from the case (Pedrosa et al., 2012). Yin (2012) flagged the point that "a case study that starts with some theoretical propositions or theory will be easier to implement than one having no propositions" (p. 9). There was a balance to strike between no reliance on theory as a risky, rarely sought, yet rewarding venture; versus an over reliance on theory that would present this study in a less successful light as having no new insights to add. The ideal was balance between knowledge from the literature and insights from the case.

4.3.7 Propositions

This case study utilised *propositions* (Yin, 2009, 2012, 2017) or *issues* (Stake, 1995, 2010) to guide the development of the conceptual framework. Baxter and Jack (2008) placed emphasis on their inclusion in a case study as a means of maintaining the parameters of the study in order that it may be completed in a timely and reasonable fashion. They maintained, "propositions may come from the literature, personal/professional experience, theories and/or generalizations based on empirical data" (Baxter & Jack, 2008, p. 551). Yin (2009) did not link propositions with exploratory studies, and as this study was exploratory in nature, it may seem redundant to include them. However, this study's scope and direction was strengthened by propositions, and so there was strong justification for their inclusion. Yin (2009) himself observed that propositions work to direct attention to relevant areas of examination in a study. Baxter and Jack (2008) discussed that "propositions are helpful in any case study" (p. 551). When Stake (1995, 2010) referred to issues it was to do with elements that help with the understanding of the case (Harrison, Birks, Franklin, & Mills, 2017).

The propositions of this study were that:

- Pedagogy and andragogy in their purest forms exist on a continuum (termed *principles of learning continuum* or PoLC) across from each other, whereby certain characteristics of the learner may be categorised as more pedagogic in nature and vice versa for the andragogic end of the PoLC.
- Teachers have a self-awareness of their knowledge of the primary science and technology curriculum and subject area in general terms. In this study this is categorised along a continuum (termed *stages of learning continuum* or SoLC) that moves from novice to expert.
- The embedded units of analysis of a new curriculum; teacher self-efficacy; and, technological pedagogical content knowledge (TPACK) are likely to influence where a teacher exists on the PoLC and SoLC – for both teacher educator and teacher learner.

The propositions were canvassed in the visual representation of the conceptual framework. The current study considered a conceptual framework as the "system of concepts, assumptions, expectations, beliefs and theories" that represented "a tentative theory of the phenomena" under investigation in a study (Maxwell, 2013, p. 39).

4.4 Sampling and recruitment

4.4.1 Sampling

Sample size is generally not a significant consideration for case study research. According to Schreiber and Asner-self (2011) as presented by Njie and Asimiran (2014, p. 38), it is grounded theory and ethnography that have thirty to fifty interviews as a "rule of thumb", whereas case study may have a sample size of "at least one" with the option of more. As such, the sample number was rendered less significant than the depth and richness of the information ascertained from interview. This study utilised the logic of representation of categories of teachers to influence sampling size.

The nature of qualitative research and small sample sizes generally results in purposive sampling. This study used purposive sampling for the teacher learners, but so too, criterion and maximum variation sampling. A nuanced sampling technique was applied that encompassed all three definitions presented by Moser and Korstjens (2018).

Table 4.2 Sampling strategies selected for this study (from Moser & Korstjens, 2018, p. 10)

Sampling strategy	Definition
Purposive	Selection of participants based on the researcher's judgement about what potential participants will be most informative
Criterion	Selection of participants who meet predetermined criteria of importance
Maximum variation	Selection of participants based on a wide range of variation in backgrounds

Judgement of the researcher on a participant's "typicality" or ownership of "particular characteristics" was the main influence for the choice of participant (Cohen et al., 2011, p. 153). Selection characteristics of teaching experience and teacher knowledge in primary science and technology were also used. Of the 100 plus identified science reference teachers (SRTs) in primary Sydney Catholic Schools (SCS) in 2015, three were selected from each of the three regions. One participant from across the regions nestled into each of the following categories:

- *novice* OR *advanced beginner* with 10+ years of teaching experience
- *novice* OR *advanced beginner* with <10 years of teaching experience
- *competent* OR *proficient* with 10+ years of teaching experience
- *competent* OR *proficient* with <10 years of teaching experience.

This deliberate classification into categories of teaching experience and self-assessment of participant skill in the area of science and technology allowed for links (if present) to be made with the propositions of this study. Teaching experience in years collectively amongst the teacher learners by 2016 was 172 years. A private category was used to code the participants from TL1 through to TL9 to help maintain anonymity. The teacher educators in this study were all interviewed as they each had unique insight into the teacher learners of their region of SCS. Their collective years of teaching experience by 2016 equated to 72 years. Participant codes applied for the teacher educators were TE1, TE2 and TE3.

A potential by-product of the purposive selection of teacher learner (TL) participants was a general tendency towards theoretical sampling. This term first appeared in the work of Glaser and Strauss (1967, 1999) as a practice for the development of grounded theory. It has undergone several additions and revisions of understanding since then. Edwards and Holland (2013) referred to it in a more general sense as sampling that:

> is made on the basis of relevance for your theory, in order to produce a sample that will enable you to develop the theoretical ideas that will be emerging in an iterative process between your theory and your data, and to enable you to test your emerging ideas (p. 6).

The selecting criteria of teaching experience used for participants was partly to canvass the idea that the least experienced, generally younger teachers may or may not necessarily be (according to the PoLC) the pedagogues of the group of TLs.

4.4.2 Recruitment

Recruitment of participants varied slightly for teacher educators (TEs) and teacher learners (TLs). TEs (as members of the same professional team as the researcher), were aware of the study prior to being asked to participate. They were approached in person, given time to consider, and soon after agreed to be involved. TE participants were then sent a follow-up email with an attached consent form and interview schedule. A signed consent form was received before a convenient time for interview was organised between researcher and TE. The SRTs (potential teacher learners in this study), were given an in-person verbal introduction to this study and its main goals. Teachers were then followed up with an email again introducing the study and giving more detail into what was involved if they were to partake. The email contained two attachments; the first a copy of the consent form, and the second, a copy of the interview schedule. It was important that this information was sent prior to a teacher agreeing to become a study participant to set expectations and avoid pitfalls from miscommunication down the track. SRTs that expressed an initial interest via email, phone or in-person were amongst those selected and followed up. Upon the receipt of signed consent forms, convenient interview times and locations were agreed upon.

4.5 Method of data collection

4.5.1 Interviews

Semi-structured interviews were conducted, and formed the main source of data in this study. As a widely used instrument, a variety of decisions needed consideration prior to the commencement of data collection. Cohen et al. (2011, p. 409) claimed that "fitness for purpose" was the paramount consideration when deciding on the type of interview and the questions involved. Lichtman (2013) consolidated the purpose of interview "to set up a situation in which the individual being interviewed will reveal to you his or her feelings, intentions, meanings, subcontexts, or thoughts on a topic, situation, or idea" (p. 190). Atkins and Wallace (2012) highlighted the flexibility of the method and its ability to answer a broad range of research questions. The ability to "probe and clarify" and check and recheck understandings is another benefit of sitting across from the interviewee and engaging with them one-on-one (Atkins & Wallace, 2012, p. 86). Freebody (2003, p. 132) discussed the "deceptive complexity" of interview in that it moves beyond a conversation that simply and purely relays the thoughts and feelings of participants. Instead, Freebody (2003) called for rigour in the setting up of interviews and their questions so as to have the best chance of analysing the social experience of the interviewee and represent their view of the world. The researcher in this study saw great value in the flexibility of interview and took care to address potential pitfalls.

Qualitative interviewing, although broadly used, appeared to encompass central characteristics. Edwards and Holland (2013, p. 3) conferred three core features. Firstly, the "interactional exchange of dialogue" which in this study took the form of face-to-face between interviewer and respondent (Edwards & Holland, 2013, p. 3). Secondly, the presentation of "topics, themes or issues" that saw the use of predetermined categories to structure the interviews in this study (Edwards & Holland, 2013, p. 3). Lastly, the perspective that knowledge is "situated and contextual" (Edwards & Holland, 2013, p. 3). This meant that knowledge produced from interview in this study was a "co-production" between interviewer and respondent—a unique creation made in situ (Edwards & Holland, 2013, p. 3). This interpretation of interview further supported its compatibility with the paradigm of this study.

A semi-structured approach to interview questioning was decided upon for the present study. This included predetermined questions; but allowed for flexibility in that the interviewer pursued reactive questions that came to light only upon interview (Freebody, 2003). The twelve respondents in this study were each provided an interview schedule with all predetermined questions before agreeing to be a part of the study. This decision was made for full and upfront disclosure and ensured all potential participants knew the core direction the questioning would take in interview.

Probing was utilised at some level in each interview. Probing in the questioning of the interviews explored a notion, thought or feeling that was initiated by a participant response, and so were not pre planned or anticipated (King, Horrocks, & Brooks, 2018). Patton (1990) and Rubin and Rubin (1995) suggested three main probes—the *elaboration*; *clarification*; and, *completion*. In this study, elaboration was used to encourage the respondent to continue conversation and provide more detail about the topic under discussion. Clarification served to further explain a point of disambiguation. Finally, the completion prompted the respondent to finish an account or a point that was interrupted prior to its natural end. King et al. (2018) showed the importance of probes as a tactic to counter an under communicative interviewee, which certainly proved to be a pragmatic and effective tool utilised for two respondents in this study.

Table *4.3* *Examples of probing from the interview transcripts of this study*

Type of probe	**Example from interview**
Elaboration	*Interviewer:* What influence do you think your self-efficacy has on your classroom teaching? *Respondent:* Big, big, big, quite big. *Interviewer:* Okay, can you elaborate? *Respondent:* Just big. I know what it was like before, and I can see in other teachers when you mention 'how are you going?' . . . (answer continues)
Clarification	*Interviewer:* How confident do you feel in choosing the right tool to enhance your science and technology lesson? *Respondent:* . . . there's probably a whole lot of apps put there too that I don't know about, that would be part of my little search at night. I go off and - but again, it's hard to find time. *Interviewer:* So, you'd link that to time constraints? *Respondent:* Timing and understanding . . . (answer continues)
Completion	*Respondent:* . . . we're going to do a big science day and we're going to blitz it, and they say themselves it's not the priority. I've lost my train of thought – *Interviewer:* That's okay, what about the influence on say, the students, on their learning? *Respondent:* I think the more confident you are, the more you believe it's going to work

	. . . (answer continues)

Many sources discussed the skills and techniques of qualitative interviewing. Seidman (2013) placed emphasis on listening when he noted that "the hardest work for many interviewers is to keep quiet and to listen actively" (p. 81). Experientially, there have been many instances in the professional work of the researcher in this study when the art and skill of listening was the difference between success and failure. This study echoed Seidman's (2013) view on the importance of listening, and used his three levels of listening. Firstly, the interviewer listened to exactly what the participant was saying in situ (Seidman, 2013). This afforded the development of a mutual understanding of detail, and also opened up the dialogue for effective probing. The knowledge that each interview was recorded verbatim in this study did not negate the interviewer's purpose of active listening. The transcription process did not reveal significant pieces of previously unregistered or unregarded details—that is, no significant surprises in terms of responses in interview.

Secondly, Seidman (2013) discussed listening to the "inner voice" (p. 81). This referred to the voice behind the external voice that is acutely aware that they are speaking in a public arena, and although not untrue, may be more guarded (Edwards & Holland, 2013; Seidman, 2013). Seidman (2013, p. 81–82) gave the example of when an interviewee speaks of problems they are facing as "challenges" or "adventures". This point resonated strongly with the researcher in this study because they also conducted the interviews. Hence, respondents were likely to display (and in fact, did display) their "outer voice" (Seidman, 2013, p. 81) on some occasions. Some possible reasons as flagged by the researcher in the current study are outlined:

1. Acute awareness that the interviewer was also a teacher working in the same system of schools – that is, the Catholic Education Office, Sydney (now, Sydney Catholic Schools). Therefore, respondents may wish to appear in a certain light to a fellow colleague.
2. The open knowledge that the interviewer was also a teacher educator in the professional learning at some points across 2015, and that they are a perceived expert in the learning area of primary science and technology. Therefore, they

may not wish to appear less learned or lacking in the appropriate knowledge required of being a capable teacher.

3. An understanding that the responses they were given would be part of a study that the Catholic Education Office, Sydney (now, Sydney Catholic Schools) has access to upon completion. Therefore, inadvertently, they were speaking to the broader system and may curb responses that could be viewed unfavourably.

It is important that these incidents from interview are acknowledged, but also the action taken to refocus the inner voice of respondents. On the few occasions that respondents took to their outer voice, the interviewer was quick to reiterate anonymity in the study and that responses were meant to represent "their perspective" and did not have to conform to a particular viewpoint. This tactic appeared effective in returning comfortability to the respondents in interview.

Finally, in alignment with Seidman (2013), this study considered a third level of listening:

> interviewers – like good teachers in a classroom – must listen while remaining aware of the process as well as the substance. They must be conscious of time during the interview; they must be aware of how much has been covered and how much there is yet to go. They must be sensitive to the participant's energy levels and any nonverbal cues he or she may be offering. Interviewers must listen hard to assess the progress of the interview and to stay alert for cues about how to move the interview forward as necessary (p. 82).

There was a subtly of listening in this third level that the interviewer had significant practise with-in both child and adult learning settings. Alongside the gratitude felt for the respondent's time, the interviewer was cognisant that interviews were often conducted before or after school, or during a release from face-to-face teaching (RFF) period which may be as little as an hour a week for a primary teacher. It is in this context that the subtleties of Seidman's (2013) third level of listening became key.

4.5.2 Document-based data sources

Alongside the interviews conducted (that were between thirty to sixty minutes in duration), two supplementary document-based data sources were completed by the twelve teacher participants (see Figure 4.3 & 4.4 for an example of each document-based data sources answered by one teacher learner). Time was allotted for these prior to interview. The researcher was present while teacher participants completed the documents and clarified ambiguities in questioning that arose from the data sources. Rapley and Rees (2018) acknowledged two areas when analytic work is done “on and with documents”, that is, “work that focuses on the actual textual and extra textual content of documents; and work that focuses on some aspect of the use, role and function of documents in everyday and organisational settings” (p. 378). This study and its documents were analysed for their textual and extra-textual (e.g. images, photographs, graphs, diagrams) content. They were specifically designed with this study’s qualitative approach in mind, and not to enable statistical findings—as is the case with the research method of content analysis (Rapley & Rees, 2018). Their primary purpose was to “focus on manifest, latent and context-dependent meaning” (Rapley & Rees, 2018, p. 379). They worked towards at least partially answering the overarching and subsidiary questions of this study.

4.5.3 Site of data collection

Data collection for the nine teacher learners (TLs) took place at their respective schools. Participants were asked where they would like the interviews to be conducted. This was a considered decision to mitigate pressure on participants to travel to a different location; take time out from their weekends, holidays or other days off. Furthermore, it provided the comfortability and influence of their professional work setting—which became the choice setting of all nine TLs. Participants graciously gave of their time, before or after school, and sometimes during their relief from face to face (RFF) time. Interview location decisions were made out of courtesy to the participants and in gratitude of their time. It was heartening to learn retrospectively that “it is generally good practice to ask participants where they would like the interview to be held, and more often than not they will select somewhere on ‘their’ territory – such as their workplace or home” (King & Horrocks, 2010, p. 43). The three teacher educators

(TEs) were each in different settings for their interviews. The first chose their school, as they had resumed their role as a classroom teacher in 2016. The second decided to come into Sydney Catholic Schools' central office at Leichhardt in NSW. The final TE chose to have the interview at home. All 12 teacher participants were in their setting of choice.

Interview environment was a significant consideration for the researcher in this study. As both researcher and interviewer, they were acutely aware of the influence environment would have on the effectiveness of interview as the primary form of data. The setting for each of the 12 interviews was a quiet room. For 11 of the 12 respondents this was an empty classroom, meeting room or staffroom. One respondent was interviewed from home, with no other persons present. In this study, all interview settings allowed for "an adequate sound recording of the conversation" (Edwards & Holland, 2013, p. 43). Privacy in interview was another critical consideration of setting, because "if others are within hearing distance . . . this can create tension . . . and affect how and what can be discussed" (Edwards & Holland, 2013, p. 44). On two occasions privacy was temporarily compromised when somebody walked in to the interview room. This was directly dealt with as interviews were temporarily halted and a new private and quiet setting secured. To ensure continuity of thoughts after the interruption, the interviewer repeated the last question or comment from the interview.

4.6 Thematic analysis

Thematic analysis was used to analyse data in the current study. Although one of the most common forms of analysis in qualitative research (Javadi & Zarea, 2016) it is still viewed by some as "poorly demarcated and rarely acknowledged" (Braun & Clarke, 2006, p. 77). Braun and Clarke (2014) put these inconsistencies of method down to a lack of clarity in the developmental history. Greater specificity and clarity on thematic analysis as a method was laid out by Boyatzis (1998) when he elucidated guidelines around the identification of codes, and theme development. Later, Braun and Clarke (2006) introduced a thorough breakdown of a six-phase approach to thematic analysis in the field of psychology; which had wide uptake within that field and many other disciplines. This study was influenced by researchers such as Boyatzis (1998) and Braun and Clarke (2006), but ultimately utilised a hybrid approach of inductive and deductive analysis as pioneered by Fereday and Muir-Cochrane (2006).

At its core, this study sought to present meaning from data in order to recommend how professional learning practice in teaching may be strengthened by a more thorough understanding of the adult learner in this setting. With this purpose in mind, thematic analysis provided a reliable gateway as "the end result of thematic analysis should highlight the most salient constellations of meaning present in the data set" (Joffe, 2011, p. 209). These most salient constellations were the themes of this study.

4.6.1 The hybrid approach

The hybrid approach to thematic analysis was used in this study to best embody the phenomenon of the nature of the adult learner. This study's theoretical and conceptual framework influenced the deductive codebook with a priori themes that were produced and applied to the data. However, such a top down approach alone would not completely capture the voice of the teacher participants, nor their subjective realities—a key ontological premise of this study. Therefore, a ground up, inductive approach to data analysis was also critical to respect and canvass teacher voice. In this study, Braun and Clarke's (2006) six-phase approach influenced the development of inductive themes formed from interview. Their approach as shown in Table 4.4 was dipped in and out of during analysis. Fereday and Muir-Cochrane (2006) and Yukhymenko, Brown, Lawless, Brodowinska, and Mullin (2014) were critical influences, as they applied the hybrid approach to thematic analysis in a similar context to that of this study.

Table 4.4 Phases of thematic analysis (from Braun & Clarke, 2006, p. 87)

Phase	Description of the process
1. Familiarizing yourself with your data:	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas.
2. Generating initial codes:	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.
3. Searching for themes:	Collating codes into potential themes, gathering all data relevant to each potential theme.
4. Reviewing themes:	Checking if the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic 'map' of the analysis.
5. Defining and naming themes:	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.
6. Producing the report:	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.

Fereday and Muir-Cochrane (2006) developed six stages in the hybrid approach. Yukhymenko et al. (2014) also used these stages. This study applied similar stages as described in Table 4.5.

Table 4.5 *Six-stage hybrid thematic analysis of this study (based on Fereday & Muir-Cochrane, 2006; Yukhymenko et al., 2014)*

Stage	Description of the process
1—Developing the codebook	A priori set of themes were produced based on the theoretical and conceptual framework and organised according to subsidiary research question.
2—Testing the reliability of the codebook	A small portion of the raw data had the a priori themes applied for connectivity.
3—Summarising data and identifying inductive codes and categories	All raw data were analysed inductively by interview question to identify in vivo and descriptive codes (inductive codes). These codes were further extrapolated into subthemes.
4—Applying codebook themes to inductive codes and categories	A priori themes from the codebook were applied to the inductive codes and subthemes produced in stage 3.
5—Connecting codes and themes	Similarities and differences between inductive and deductive analysis were identified. Inductive codes unaccounted for by the codebook were identified and further extrapolated into subthemes and finally themes.
6—Corroborating and legitimising themes	Steps 3, 4, 5 and 6 are iteratively revisited and re-examined to determine a core set of themes that are representative of the codebook and inductive data analysis.

4.6.2 Stages of analysis

Deductive analysis began with the development of the codebook of a priori themes. The theoretical and conceptual frameworks of this study formulated the categories that lead to the development of these themes. The interview questions (as evidenced by the interview schedules in Appendixes 2 and 3) were structured below subheadings. These subheadings were purposeful, as they matched the embedded units of analysis of the case, also represented in this study's overarching question and its subsidiaries. They became the predetermined or deductive categories used to determine themes for the codebook. This structure worked to ensure analysis of data answered this study's questions; comprehended the conceptual framework; and, maintained the boundaries of the case.

The deductive approach allowed for theory to be tested qualitatively (Yukhymenko et al., 2014). The current study acknowledged several sources of theory "including previous research and theoretical concepts, professional and personal experiences, and knowledge of persons and situations that are the focus of research" (Yukhymenko et al., 2014, p. 96). All such sources had a level of influence on the development of the codebook. Codebook themes were organised by name, definition and description. Once the codebook was developed it was crucial to test its reliability. A portion of raw data were taken from interview transcripts as well as one of each of the document-based data sources, and applied to themes from the codebook. This process revealed that several themes were initially evident from the raw data, and thus, established that analysis was heading in the right direction.

Inductive analysis began with stage 3 of this study's hybrid approach. It is here that Braun and Clarke's (2006) influence was evident as phases of their six-phase approach were incorporated. This began with data familiarisation. Recorded interviews were transcribed verbatim by a professional outside of the study. The professional transcriptionist was selected from a reputable website. They resided in the United States. Choice of transcriptionist from outside Australia further served to maintain participant anonymity. Upon completion of the transcription by the professional, the 12 interviews were checked. The audio of each interview was listened to twice and edited where transcription errors or omissions were evident. The transcriptions were then deemed ready—and were read and reread several times. This phase was afforded the time it needed, as familiarisation with data "forms the bedrock for the rest of the analysis" (Braun & Clarke, 2006, p. 87). Initial ideas then became evident and were noted down. At all times during analysis, this study's overarching question and its subsidiaries were in eyeshot, so too the conceptual framework. This kept the aim of the study firmly in the forefront of thinking.

Stage 3 of the hybrid approach saw the production of initial codes (phase 2 of Braun & Clarke, 2006). This was accomplished manually as data were analysed interview question by question for teacher learners (TLs) and teacher educators (TEs).

Document-based data sources were also analysed using the same inductive method. Codes were based directly on "the most basic segment, or element, of the raw data" (Boyatzis, 1998, p. 63). These portions of data were isolated and coded because they were viewed as potentially illuminating to this study's phenomenon—the nature of the adult learner. Some portions of data lead to codes that were construed multiple times across several different interviews or document-based data sources. To ensure this was not an error or oversight in analysis, a return was made to the transcription of the original interview and document-based data sources. Paraphrased codes were left as is at this stage. Therefore, the allocation of codes, much like most other parts of the data analysis was iterative. There was a consistent sense of moving backwards to ensure the right steps forward were taken. Braun and Clarke (2014) clarified the "variability and flexibility of the method" when they said, "the questions of what level patterns are sought at, and what interpretations are made of those patterns, are left to the researcher" (pp. 1–2).

Next, themes were searched for amongst the coded extracts. As the name suggests, the understanding of what constitutes a theme is significant to the process of thematic analysis. The current study viewed a theme as "a pattern found in the information that at a minimum describes and organises possible observations or at a maximum interprets aspects of the phenomenon" (Boyatzis, 1998, p. vii). Furthermore, "theme is a kind of agreement that in comparison to the main text from which the theme is extracted, is more concise, accurate, simpler and shorter" (Javadi & Zarea, 2016, p. 34). As themes were searched for, corresponding subthemes often became evident among the coded extracts. At other times the coded extracts produced subthemes before a theme was revealed.

Boyatzis (1998) considered themes as sitting on a continuum, a serious consideration in this study—whereby major themes provided insight into the phenomenon and subthemes provided more detail into how that insight manifested from the observable data. In the literature, the terms *manifest* and *latent* were used to identify these different levels of themes. In this study, manifest themes that were directly observable in the data were linked with little or no interpretation (Boyatzis, 1998). Conversely, latent themes produced were more interpretive (Javadi & Zarea, 2016), as underlying the phenomenon (Boyatzis, 1998). The current study melded Boyatzis' (1998) understanding of a theme with that of Javadi and Zarea (2016).

Potential manifest themes were identified when broader patterns became evident from organising codes. This was a repetitious process that moved back into codes from a single respondent and across the codes of multiple respondents, both teacher educators (TEs) and teacher learners (TLs). It is important to note that "ideally, the theme will occur numerous times across the dataset" (El Said, 2017, p. 734), but this did not necessarily dictate the importance of theme in this study. The current study moved beyond frequency and focused on data that allowed "a fruitful analytic argument to be developed and tested" (Hammersley, 2015, p. 688). One such example was a theme that was created from the codes of one respondent. Potential latent themes still relied upon the data, but with interpretation. Sources of influence for this interpretation were the literature; researcher background and experience; and, knowledge of the respondents and their inner voice in interview. Latent themes were dependent upon several manifest themes coming together with researcher interpretation (Joffe, 2011). Latent themes and subthemes in this study were vital to the elucidation of the phenomenon of the nature of the adult learner.

Identified themes were then reviewed. Some themes remained unchanged from beginning of analysis to end. This was rare. Other themes were relegated as subthemes or vice versa when subthemes upon closer inspection better served as themes. These ground-up produced themes were fundamental to the philosophical underpinnings of this study and served to provide "the necessary groundwork for establishing valid models of human thinking, feeling and behaviour" (Joffe, 2011, p. 210). Using the subthemes to build context, the inductive themes were given a concise name, defined and described. The definition or story of each theme was derived from the data. In accordance with the advice of Braun and Clarke (2006), a move was made beyond paraphrasing the content of the data, to identifying "what is of interest about them and why" (p. 92).

Stage 4 saw the application of the codebook themes to the codes and categories produced in the inductive analysis. This moved towards building the connectivity between theory and the stories that were emerging from teachers. Themes on the nature of the adult learner appeared in the codebook and also featured heavily in the inductive analysis. Similarities were evident when inductive codes and subthemes naturally fell within the realm of codebook themes. Simultaneously, divergences between codebook themes and the inductively analysed data surfaced, leading into the next stage of analysis.

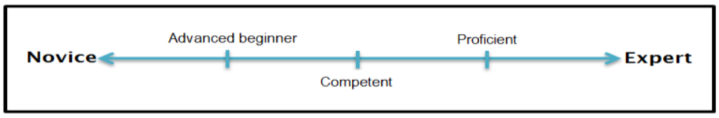
Stage 5 involved connecting codes, subthemes and themes that were produced inductively and deductively to best answer the main research question and its subsidiaries. The main research question was addressed by TE and TL voice. Similarities and differences in the data were evidenced. Other influences on teacher expertise and learner characteristics came to light from the inductive analysis. This showed that many factors (beyond a new curriculum; teacher self-efficacy; and, TPACK) played a role in influencing how teachers rate their expertise, and how they characterise themselves as learners. Continued impetus for use of the hybrid approach was provided when teacher voice revealed previously unknown or unconsidered themes and subthemes not featured in the codebook.

Lastly, it was appropriate to settle on a final set of core themes. This involved consolidating similar inductive and deductive themes. A look back into the original codes and categories of similar themes provided the evidence needed to determine whether such themes should be consolidated or separated. Additionally, inductive themes not evident in the codebook were traced back to the raw data and reconsidered in their own right as having provided a unique insight directly from teacher voice.

4.7 Triangulation or crystallisation

Triangulation seeks to solicit richer data that helps confirm or contradict results of the research (Wilson, 2016). It is arguable that this study at least partially involved data triangulation and methodological triangulation (Flick, 2002). Alongside the interviews that were conducted with the nine TLs and three TEs, two fill-in document-based data sources were completed (see Figure 4.3 & 4.4 for examples). Figure 4.3 document-based data source regards a teacher's self-appraisal of their expertise in primary science and technology before the professional learning of 2015, and after.

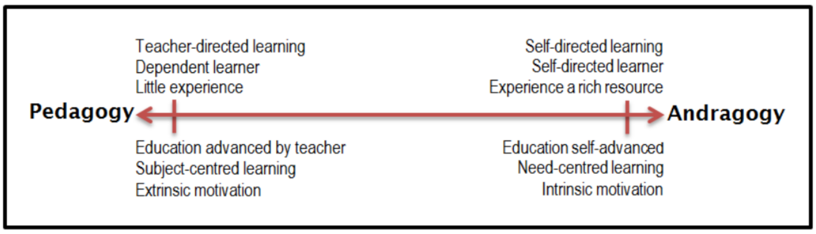
Figure 4.4, the second of the document-based data sources allowed a teacher to self-identify characteristics of learning at the beginning of PL in 2015, and after. These sources may be viewed as different sources of data, or to a lesser extent a different method. The latter was difficult to justify as the depth of time, effort, consideration, and data solicited from interview (the original method) far exceeded that of the two additional document-based data sources. This study viewed them as supplementary to the interviews—designed to strengthen the reliability of the interviews conducted. Both supplementary document-based data sources were referred to in interviews when questions were asked regarding the stages of learning continuum (SoLC) (Figure 4.3) and principles of learning continuum (PoLC) (Figure 4.4). They were interwoven into the method of interview and allowed teachers to add detail and depth to their document responses. This perhaps is the most compelling reason to assert that they did not fully comply with methodological triangulation. Methodological triangulation requires that separate methods are used to study a phenomenon (Casey & Murphy, 2009). Furthermore, two types of methodological triangulation are noted, *across method* and *within method* (Bekhet & Zauszniewski, 2012). The "within-method studies use two or more data collection procedures, quantitative or qualitative, but not both" (Bekhet & Zauszniewski, 2012, p. 40). Utilising this definition, it could be argued that the interview and document-based data sources be viewed as within method qualitative procedures of understanding the nature of the adult learner.



Please note: A learner is in the realm of a particular ***stage of learning*** when the majority of stars selected fall within that stage. For example, two stars selected from ***novice*** and one from ***advanced beginner*** results in the overall allocation of ***novice***.

Stages of learning	Characteristics of the learner (decided by the primary teacher, their own personal view)
Novice	⋆ Beginner awareness of the K–6 Science and Technology Syllabus and / or little or no confidence to navigate through the syllabus ⋆ Little or no confidence to integrate Working Scientifically and / or Working Technologically into a context ⋆ Little or no confidence in teaching K–6 Science and Technology
Advanced beginner	⋆ Awareness of the scope of the Science and Technology K–6 Syllabus and / or limited capacity to navigate through the syllabus ⋆ Ability to apply Working Scientifically and / or Working Technologically to familiar contexts ⋆ Limited confidence in teaching K–6 Science and Technology
Competent	⋆ Ability to apply some knowledge of the K–6 Science and Technology Syllabus to programming and assessment and capacity to purposefully navigate through the syllabus ⋆ Ability to apply Working Scientifically and / or Working Technologically to unfamiliar contexts ⋆ Competent in teaching K–6 Science and Technology
Proficient	⋆ Ability to apply knowledge of the K–6 Science and Technology Syllabus to programming and assessment and efficiently and purposefully navigate through the syllabus ⋆ Ability to suggest creative contexts in which to teach Working Scientifically and Working Technologically outcomes ⋆ Confident in teaching K–6 Science and Technology
Expert	⋆ Expert application of knowledge of the K–6 Science and Technology Syllabus to programming and assessment ⋆ Seeking and engaging in collaborative relationships with other experts ⋆ Refining abilities in K–6 Science and Technology through exposure and practice ⋆ Extremely confident in teaching K–6 Science and Technology

Figure 4.3 Stages of learning continuum (SoLC) document-based data source



	Category 1 characteristics	Category 2 characteristics
About the teacher leaner	• Teacher educator directed learning • Teacher educator evaluated learning • Teacher educator responsible for what is taught and how	• Self-directed learning • Self-evaluated learning • Teacher learner responsible for their own learning
Concept of the teacher learner	• Dependent learner	• Self-directed learner
Role of teacher learner's experience in K–6 Science and Technology	• To be built on, more than used • Little experience • Teacher educator experience very influential	• A rich resource for learning • A greater amount and variety of experience • The influence of teacher educator's experience is negligible
Readiness to learn	• Teacher learner directed by teacher educator in order to advance to the next level of education/mastery in K–6 Science and Technology	• Develops from life tasks and problems and a need to perform more effectively • Teacher learner able to analyse gaps in their own learning in K–6 Science and Technology
Orientation to learning	• Subject-centred • A process of acquiring prescribed subject matter and its sequenced content	• Task or problem-centred • Learning is organised around a need which arises from life (including work situations)
Motivation	• External rewards and pressures (e.g. request to participate by another such as principal, career advancement, etc.) • Extrinsically motivated	• Internal incentives (e.g. curiosity about K–6 Science and Technology, self-esteem, recognition, improved quality of life, self-efficacy, self-confidence, lifelong learning) • Intrinsically motivated

☐ **Before professional learning in K–6 Science and Technology (Beginning 2015)**

☐ **After professional learning in K–6 Science and Technology (End 2015)**

Figure 4.4 Principles of learning continuum (PoLC) document-based data source

In consideration of the philosophical assumptions of this study, the use of all traditional triangulation methods did not seem appropriate for its integrity. Richer data was a positive for this study, however, the notion of confirming or contradicting results would work to push the present study away from its philosophical roots. That is, away from the idea that knowledge is subjective; that reality is a fluid, subject-influenced perception of which many realities may exist and coexist. Cohen et al. (2011, p. 197) pointed out that "critics" of triangulation, such as Silverman (1985), associated its use with empirical study—"the very notion of triangulation is positivistic" (Cohen et al., 2011, p. 197). Further investigation lead to another means of soliciting richer data, a process known as *crystallisation*.

Crystallisation in this study was considered similar to the work of Stewart, Gapp, and Harwood (2017, p. 1)—for the "development of rigor through credibility and trustworthiness". The term itself, as coined by Laurel Richardson (1994), sought deeper thinking by soliciting and representing data in creative methods. The use of the self-analysis in the SoLC and PoLC document-based data sources did not, in this researcher's opinion, go far enough to satisfy Richardson's (1994) interpretation of crystallisation—nor subsequent developers of the method such as Janesick (1998) and Ellingson (2009). Janesick (1998) utilised the method extensively and advocated the use of other disciplines to help understand research findings. Furthermore, she foregrounded the use of different genres such as storytelling, poetry, artistic expression and live performance, among others. Ellingson (2009), to speak in metaphor, added flesh where there were once only bones. In her own words, she offered "a definition, principles, and types of crystallization as a framework for conducting qualitative research" (Ellingson, 2009, p. 2).

The term crystallisation came to be used due to the metaphor's appropriateness in representing the nature of understanding, in alignment with this study's view that it is multi-faceted. Richardson (2000) proposed:

> that the central image for "validity" for postmodern texts is not the triangle—a rigid, fixed, two-dimensional object. Rather, the central imaginary is the crystal, which combines symmetry and substance with an infinite variety of shapes, substances, transmutations, multidimensionalities, and angles of approach. . . .

> Crystallization provides us with a deepened, complex, thoroughly partial, understanding of the topic. Paradoxically, we know more and doubt what we know. Ingeniously, we know there is always more to know (p. 934).

Denzin (2012, p. 83) based on Ellingson's later work in 2011 talked about crystallisation as being on a "continuum"—with a "right, left, middle". Basically, the right encompassed positivism; the left, humanism; and the middle, "is work that offers description, exposition, analysis, insight and theory, blending art and science and often transcending these categories" (Denzin, 2012, p. 83). This middle-ground within Denzin's (2012) continuum set the bar high—this study may not have reached such heights, but as Stephen Hawking encouraged it was important to "remember to look up at the stars and not down at your feet" (Allen, 2018, para. 11).

What this study captured was the spirit of the method of crystallisation through a portion of data collection. Based on the metaphor of the crystal, it is argued that although the markings on the two additional document-based data sources are small, the self-reflection and thinking that likely occurred prior to the teacher learners (TLs) and teacher educators (TEs) recording their answers was of great importance. Shagoury (2011) placed self-reflection as a "cornerstone of good teaching . . . and a crucial tool for teacher-researcher" (p. 230). Many questions could have been required and a lot of time afforded to still not successfully capture the nature of the data collected from the supplementary document-based data sources. In the same vein, the researcher invested significant thought and time to their creation in order that they may provide unique insights and a richer understanding of the phenomenon. In summation, this study crystallised rather than triangulated findings.

4.8 Trustworthiness

Lincoln and Guba (1985) suggested four trustworthiness criteria for qualitative researchers, as replacements for the quantitatively influenced criteria such as validity and reliability. This study utilised the four criteria from Table 4.6 in order that research rigour be established.

Table 4.6 *Lincoln and Guba (1985) alternative quality criteria (from King & Horrocks, 2010, pp. 160–161)*

Quantitative quality criteria	**Replacement qualitative criteria**
Validity	Credibility
Generalisability	Transferability
Reliability	Trackable variance
Neutrality	Confirmability

4.8.1 *Credibility*

Credibility "refers to the extent to which the researcher's interpretation is endorsed by those with whom the research was conducted" (King & Horrocks, 2010, p. 160). Lincoln and Guba (1985) suggested a number of techniques to achieving credibility. This study focused on two techniques—*prolonged engagement* and *persistent observation* (Lincoln & Guba, 1985). Prolonged engagement with the data, and several revisits of the themes created at different points in this study was crucial to data saturation. Because the researcher was unable to separate from the context, being so much a part of it, promoted credibility on some level. The researcher had planned, presented and facilitated professional learning in science for several years prior to the commencement of this study. They are a novice researcher; but have regularly observed synonymous contexts to that of this study for a number of years. It was this persistent observation, even prior to the initiation of this study that influenced its pivotal questions.

4.8.2 *Transferability*

Transferability in this study may be possible through "thick descriptions, so that those who seek to transfer the findings to their own site can judge transferability" (Nowell, Norris, White, & Moules, 2017, p. 3). Perhaps this will not fully come to fruition until this study has uptake with other researchers, or even educators. Albeit, the intention was there, and at every point in this study the aim was to elucidate the phenomenon and its recognisability in settings and contexts that are extremely similar. It is the recommendations of this study outlined in detail in chapter eight which may allow inference and some transferability of learning to synonymous future research and educational settings. In the education sector there will always be a need to understand the learner and how and why they learn as they do.

4.8.3 *Trackable variance*

The conventional notion of reliability required more stability in research, better afforded by replicable quantitative research. Instead this study considered trackable variance. This allowed for the concession that real-world contexts are ever-changing—rendering replication unachievable. Instead, trackable variance required evidence that the researcher has acknowledged that phenomena are "multifaceted and highly-contextualized" (Almutairi, Gardner, & McCarthy, 2014, p. 239). The present study acknowledged the small data pool and the specificity of the case. Also, context will always change in any professional learning (PL) setting due to variables such as facilitators, teacher learners, content, length of PL—to name a few. This understanding should not hinder what is learnt from the case itself and any applicability in research and education.

4.8.4 *Confirmability*

The current study is a qualitative one, and as such cannot purport neutrality. As mentioned previously, the researcher was intrinsically linked with the case and context. To some extent this supports research credibility. With a subjective viewpoint, trustworthiness is further strengthened with confirmability. This means that a reader of this research should be able to determine how and why conclusions were reached. This is achieved when "sufficient detail of the process of . . . data collection and analysis" is presented (King & Horrocks, 2010, p. 161).

4.8.5 *Authenticity*

Authenticity may be viewed as a type of validity for "providing a balanced and fair view of all perspectives in the research study" (Mertens, 2014, p. 273). In this study, all stakeholders in the PL were given a voice, so that the case did not place more emphasis on teacher educators (TEs) or teacher leaners (TLs). All teachers interviewed had a unique insight and in the pursuit of fairness all were given an equitable platform in which to share this insight. Also, a varied demographic of TLs were interviewed for this purpose. Lincoln (2009) elucidated several criteria of authenticity—one of which was ontological, "where the conscious experience of the world became more informed or sophisticated" (Mertens, 2014, p. 273). This was applicable to both teacher participants and the teacher researcher. Firstly, by engaging with the experience of their PL in the interview process, teacher participants were able to reflect on their beliefs about themselves and others in this study context. With the provision of a comfortable environment they shared their story, but more so, they reflected on their role in the PL and how they had changed and evolved in thought and praxis. The teacher researcher in engaging with the varied subjective realities of the teacher participants moved towards a more diverse way of thinking about PL and the nature of the learner—a critical ontological development that ensured a robust discussion of this study and its recommendations.

4.9 Ethical considerations

Ethical considerations were important for this case study because of the relatively small number of participants and therefore the increased chance of deductive disclosure. This is defined by Kaiser (2009) as the possibility for traits of individuals or groups in the research to make them identifiable. The dominant approach to confidentiality (as discussed by Kaiser, 2009) was used in this study, with the ultimate goal of complete confidentiality. Therefore, data were collected, analysed and reported without compromising the identities of the respondents. Mustafa (2011) cited four ethical guidelines, as discussed by Christians (2000), and these were at the forefront of this study. They are the necessity of *informed consent*; the *absence of deliberate deception*; *maintenance of privacy*; and, *confidentiality and accuracy*.

4.10 Summary

The purpose of chapter four was to justify the decisions made throughout this study in terms of the qualitative paradigm chosen; use of a single embedded case; and, the subsequent methodological pathway the research followed. This chapter also described how the continuums that feature in the conceptual framework of this study influenced interview questions and the document-based data sources produced. Finally, this chapter aimed to show (at least in part) how the research question and its subsidiaries, the conceptual framework and methodology, link together.

Chapter five presents the key findings of this study based on the hybrid thematic analysis of interviews and document-based data sources. These findings include the deductive and inductive themes and subthemes that inform the answers to the main research question and its subsidiaries. An overall thematic map organises themes beneath their corresponding research question, highlighting elements of the nature of the adult learner that will be addressed in more depth in later chapters.

Chapter 5: Findings

Introduction

Chapter five presents the analysis of data and outlines the findings from the current study. Firstly, in analysis, a priori (deductive) themes were aligned with their corresponding research question. These themes formed a codebook. The codebook was then corroborated with the raw data. Next, inductive codes produced from a grounded analysis of interviews and document-based data sources were applied to the codebook. Here, connectivity between inductive codes and a priori themes was established. Inductive codes that did not support the a priori themes extended the parameters of the codebook, highlighting new a posteriori (inductive) themes. The integrated findings of both inductive and deductive analysis are presented by research question. This hybrid approach was used to provide a robust answer to the research questions. These findings are consolidated and presented in a summative thematic map which canvasses nine themes in total, with their corresponding subthemes, three of which were inductively extrapolated.

5.1 Main research question and its subsidiaries

The main research question of this study considers factors that influence the learner and their learning characteristics. The question is:

> What is the relationship among factors such as a new curriculum; teacher self-efficacy; and, technological pedagogical content knowledge (TPACK) on the learner in professional learning for K–6 Science and Technology?

This overarching question is multifaceted in that it considered several elements. To address this, a breakdown of the main research question was necessary. A resultant three central considerations were identified:

1. The relationship between a new curriculum; teacher self-efficacy; and, TPACK.

2. The influence of a new curriculum; teacher self-efficacy; and, TPACK on the teacher educator and teacher learner.
3. The professional learning in K–6 Science and Technology.

These considerations lead to the formulation of three subsidiary questions which when answered would provide a whole response to the main research question. The three subsidiary questions are:

1. What is the relationship between a new curriculum; teacher self-efficacy; and, technological pedagogical content knowledge (TPACK)?
2. How do factors such as a new curriculum; teacher self-efficacy; and, technological pedagogical content knowledge (TPACK) influence the teacher educator and teacher learner?
3. What is the influence of the context of K–6 Science and Technology in professional learning?

The main research question used the terminology "factors such as". This was purposeful to allow for the discovery of other relational factors on the learner that may be identified from subjective teacher voice. The hybrid thematic analysis meant the deductive factors of a new curriculum; teacher self-efficacy; and, TPACK could be used as factors of influence, but further that inductively evident factors that were unheeded were also brought to light.

5.2 A priori themes

The a priori themes of this study are "themes identified in advance of coding" which is consistent with King et al. (2018, p. 5). They preceded data collection and analysis and were formulated in response to the theoretical and conceptual framework of this study (King et al., 2018). Chapter three of this study detailed the theoretical framework of adult education and the extrapolation of a conceptual framework from these theoretical boundaries. Accordingly, the a priori themes intuitively nestle within these boundaries as the six concepts presented in the conceptual framework. Figure 5.1

summarises the link between the conceptual framework visual and the deductive a priori themes of this study

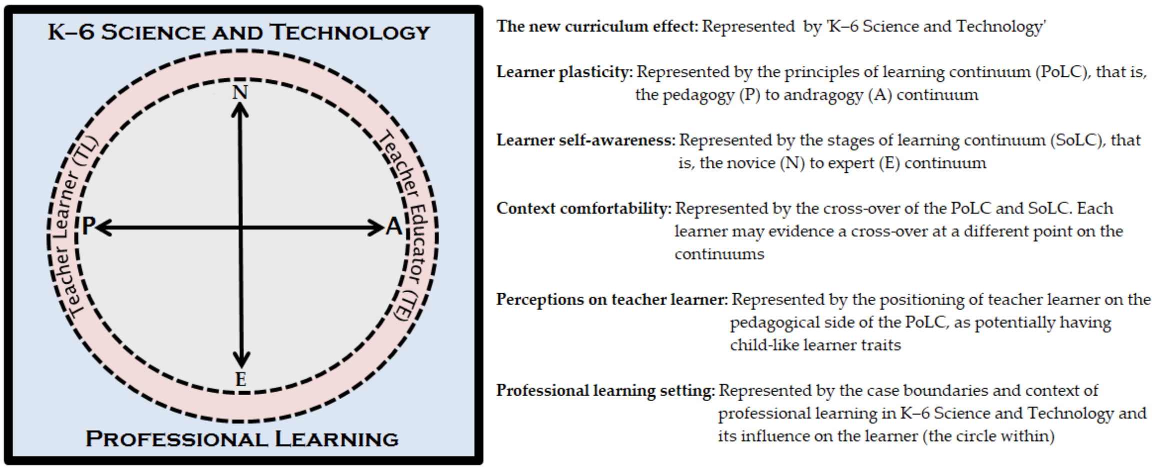


Figure 5.1 The current study's conceptual framework and a priori themes

Furthermore, the a priori themes built on interview schedule questions and the document-based data sources. For example, the a priori theme for research question one identified as *the new curriculum effect* (see Table 5.2) was guided by several questions in the interview schedules of teacher educators and teacher learners. This is evident in questions such as:

- How have your perceptions of a "good" science lesson changed/developed in 2015? (teacher learner interview schedule)
- What in your opinion is the best way to teach science and technology? (teacher learner interview schedule)
- Has this always been how you have taught science and technology in your classroom? (teacher learner interview schedule)
- What are your perceptions of what constitutes a "good" science lesson? (teacher educator interview schedule)
- What do you perceive to be the most important learning for teachers in reference to the new BOSTES K–6 Science and Technology Syllabus (now, NESA Syllabus for K–6 Science and Technology)? (teacher educator interview schedule)

The document-based data source that included the *stages of learning continuum* (SoLC) was influenced by the a priori theme of *the new curriculum effect* as it had the capacity to demonstrate improved teacher practice in primary science and technology. Upon analysis, *improved practice* was deemed to be a significant resultant factor of the new curriculum, and so became a subtheme (see Table 5.3).

Table 5.1 *A priori themes developed deductively and supporting literature*

A priori theme name	Rationale	Supporting literature
The new curriculum effect	For every cause, there is an effect, or several. So too the introduction of a new K—6 Science and Technology curriculum brings with it influence on the learner; teacher practice; and, expertise in the learning area, among other things.	Bayram-Jacobs et al., 2019; DeBarger et al., 2017; Gilbert, 2013; Harris et al., 2015; Harrison, 2018; Ko and Krist, 2019; Koopman et al., 2016; Lacap, 2015; Leal et al., 2013; Marco-Bujosa et al., 2016; Pacthen and Smithenry, 2013; Pringle et al., 2017; Roblin et al., 2017; Yao and Guo, 2018
Learner plasticity	A learner is not fixed in their characteristics of learning. Depending on context, a learner expresses traits that extend beyond what is understood of an adult learner from the andragogical point of view.	Carrusco et al., 2015; Chein & Schneider, 2012; Cook et al., 2009; Denève et al., 2016; Gurunandan et al., 2019; Hackling et al., 2018; Husmann and O'Loughlin, 2019; Hou, 2015; Imlach et al., 2017; Ketenci et al., 2019; Knoll et al., 2017; Lafferty and Burley, 2011; Massa and Maya, 2006; Pitts, 2009; Newton and Miah, 2017; Pashler et al., 2008; Ragowsky et al., 2015; Riener & Willingham, 2010; Rogiers et al., 2019; ; Sardone, 2011; Woods et al., 2016
Learner self-awareness	A learner is cognisant of their strengths and weaknesses in any learning area, so too for science and technology. A learner is therefore capable of identifying any self-development upon professional learning.	Buttler, 2018; de Blacam et al., 2012; Flavell, 1979; Gonullu and Atar, 2014; Karaali, 2015; Schellenberg et al., 2011; Siegesmund, 2017; Steuber et al., 2017
Context comfortability	The undertaking of learning in science and technology renders some learners more comfortable than others because of acquaintance with the learning area. Therefore, the focus is on the influence that familiarity or a lack of has on the learner.	Akerson and Donnelly, 2008; Blayney et al., 2010; Bleicher, 2009; Bokosmaty et al., 2015; Butcher et al., 2019; Çetinkaya-Aydın and Çakıroğlu, 2017; Gu, 2016; Ifenthaler and Gosper, 2014; Newton, 2018; Norris et al., 2018; Peeters et al., 2014; Pyhältö et al., 2015; Schneider et al., 2016
Perceptions on teacher learner	The teacher learner may be perceived as having pedagogical learner traits as well as andragogical because of limited acquaintance and expertise in the learning area of science and technology. These perceptions extend what is understood of an andragogical adult learner.	Barnett, 2013; Dargusch and Charteris, 2018; Glas, 2016; Ferguson and Brownlee, 2018; Knaggs and Sondergeld, 2015; Mezirow, 1981; Mezirow, 2000; Riley, 2015

Professional learning setting	K–6 Science and Technology is a practical based learning area with experimentation and inquiry at its core. This has influence on what a successful professional learning environment for this learning area should encompass.	Bokosmaty et al., 2015; Cox, 2005; de Freitas et al., 2008; Goodnough, 2019; Heineke, 2013; Muijs et al., 2014; Park and Choi, 2009; Scoggins and Sharp, 2017; Toraby and Modarresi, 2018; Vintilă and Istrat, 2014;

In a hybrid thematic analysis the inclusion of a priori themes are purposeful to test the validity of understandings, ideas and theories predicated from researcher background and the literature—a means to qualitatively test or develop theory (Yukhymenko et al., 2014). A priori themes would therefore allow this study to "reproduce, expand and counter existing studies" (Rishi & Joshi, 2016, p. 69). Table 5.1 provides a short rationale for the inclusion of the six concepts and a priori codes as well as the literature that supported their inclusion in the bounds this case study. A more detailed rationale was given in chapter three of this study. Table 5.2 shows a small sample of testing of the a priori themes against data from interview and the document-based data sources.

Table 5.2 A sample of reliability testing for the codebook themes

A priori theme name	Data from interview (I) and document-based data sources (DDS)
Learner plasticity	Teacher learner exhibited many category 1 characteristics (adult pedagogue) prior to professional learning and a majority of category 2 characteristics (adult andragogue) after the professional learning in 2015 (TL6: DDS)
Learner self-awareness	Teacher learner identified themselves at the novice stage of learning prior to professional learning, and as competent upon completion of the professional learning in 2015 (TL6: DDS)
Context comfortability	A new syllabus… "I needed to know the background in order to be able to understand it… I was in a situation where I needed a lot of direction in order to move forward in being able to be confident teaching science." (TL6: I)

Six a priori themes were established across the three subsidiary research questions. Table 5.3 presents the a priori themes by research question, and provides a definition and description of each. Subsidiary question one comprises one a priori theme; subsidiary question two, three a priori themes; and, research question three, two a priori themes.

Table 5.3 *Codebook of a priori themes corresponding to the three subsidiary questions*

Subsidiary question one		
A priori theme name	**Definition**	**Description**
The new curriculum effect	A new curriculum is the impetus for positive changes in teacher self-efficacy, pedagogy and practice	Teachers identify, describe, explain or discuss the benefits that have come to fruition because of the implementation of the NESA K–6 Science and Technology Syllabus (2012)
Subsidiary question two		
A priori theme name	**Definition**	**Description**
Learner plasticity	An adult learner holds malleable characteristics of learning that move between the pedagogical and andragogical	Learners shift between exhibiting pedagogical or andragogical characteristics depending on the context of learning and factors of influence (e.g. a new syllabus)
Learner self-awareness	An adult learner is acutely aware of their level of expertise and the way in which they engage with learning in different contexts	Learners identify, describe, explain or discuss their characteristics of learning and level of expertise in one or more learning contexts
Context comfortability	An adult learner demonstrates the highest confidence and independence in a learning context that is familiar	Learners identify and acknowledge a familiarity or unfamiliarity with a learning context and the influence this has on their characteristics of learning
Subsidiary question three		
A priori theme name	**Definition**	**Description**
Perceptions on teacher learner	An educator forms a viewpoint over time as to the nature of the learner and their learning traits	Teacher educators identify, describe, explain or discuss their perceptions of the characteristics of learning teacher learners exhibited during professional learning
Professional learning setting	A considered environment and context for professional learning is conducive to effective teaching and learning	Teacher educators identify, describe, explain or discuss some of the factors they considered or implemented in the professional learning for K–6 Science and Technology

5.3 Subsidiary question one

Subsidiary question one has a central focus on the relationship between the factors of influence, three of which were deductively included in this study. These factors are acknowledged as part of subsidiary question one:

> What is the relationship between a new curriculum; teacher self-efficacy; and, technological pedagogical content knowledge (TPACK)?

Table 5.4 presents a sample extract of a summary table of the hybrid thematic analysis undertaken for subsidiary question one. Here, inductive codes and subthemes were produced. Inductive codes are represented in the *coding* column and included summary codes. Connectivity was then established between inductive codes and evolving subthemes, to codebook a priori themes. What became evident upon an iterative analysis of the data was that inductive teacher voice elucidated ideas that were not always congruent with the predetermined themes of the codebook. Herein lies the strength of the hybrid analysis. These codes and subthemes led to the development of the inductive a posteriori themes of this study and would have been lost in a purely deductive approach.

Table 5.4 Summary extract of the hybrid thematic analysis for subsidiary question one

Text	Coding	Subthemes	Inductive themes	A priori deductive themes
TL6: Yes. Still lots to learn… I would have been relying on Primary Connections, now I can write a unit of work without using Primary Connections, and being able to confidently achieve all of the outcomes		Primary Connections crop Improved practice		The new curriculum effect
TL7: Yeah. I think in our school we lack the resources. It (science and technology) hasn't been a priority in the past. We're trying to make it a priority; we're trying to build the resources for the teachers so that they are more enthusiastic and more inclined to be positive about teaching… When I was giving professional	Teacher identified resource shortage – resources needed to support teaching Practical attempts to place focus on science and technology at a school level Some teachers	Meeting of support needs Science and technology focus Discomfort Time Practice	Change and its challenges	The new curriculum effect

learning to my colleagues they were still questioning it (the syllabus) a lot. 'Why? What's the difference? We didn't do this last year…' Time was definitely a factor. (Also) the old syllabus was there for what, twenty years, so trying to get people out of their old habits and ways and show them that they have to do a bit of work and program new programs, and they all just went to Primary Connections or this or that	questioning the need for a new syllabus Time limitations Habitual practice and its difficulties Primary Connections a former crutch, for some teachers still current	reversion Primary Connections crop		
TL8: Now, much better equipped, yes. I think there's always room for improvement, but I'm definitely in a spot where I feel confident in the syllabus. When I'm leading the staff… I know I have to keep checking my understanding, because the staff often relies on what (I'm) going to do for a unit… I feel like I'm not always able to guide them as best as I can if I don't have the prior knowledge in those things, and sometimes it's just a revision	Teacher more confident in teaching the syllabus effectively Teacher must continue to upskill in order to meet staff needs in their teaching of the new syllabus	Improved practice Meeting of support needs	Change and its challenges	The new curriculum effect
TE1: I think that many teachers welcomed the new curriculum, but I also think it reflected a change from teaching to learning… So the biggest change for the teachers is to move away from that model of imparting information, to helping students inquire about information. So making the focus on the learner (and needs of the learner) rather than on what's being taught. I think teachers always welcome the support because they want to – many teachers aren't risk takers, they just want to be shown… in a practical manner.	A shift to student-centred scientific inquiry Ongoing need to model learning for teachers before they uptake change or new learning	Improved practice Meeting of support needs	Change and its challenges	The new curriculum effect

Subsequent to analysis of interviews and document-based data sources, an intuitive separation of the data into two categories arose—learner identity and learner environment. Table 5.5 shows a summary of the hybrid thematic analysis for subsidiary question one, of which all themes and their subthemes fall within the learner environment category.

Table 5.5 *Summary of the hybrid thematic analysis of interviews as related to subsidiary question one*

Subsidiary question one: What is the relationship between a new curriculum; teacher self-efficacy; and, technological pedagogical content knowledge (TPACK)?
LEARNER ENVIRONMENT [category] • The new curriculum effect [theme] o pedagogy is paramount [subtheme] - hands-on - inquiry - questioning/scaffolding student questions - experimenting - practical experiences - strong contexts - relevant/ student interest/student background - engagement - wonder and awe - student-centred - student discovery o Primary Connections crop [subtheme] - less reliant - no longer used - gaps - resource only - limitations - last resort - better than old syllabus/some investigating o science and technology focus [subtheme] - cross-curriculum programming - highlighting science in classrooms (e.g. time; improved pedagogy) - highlighting science in schools (e.g. science days; school agenda; school annual improvement plan) - taking science seriously - syllabus compliance - bringing science in whenever possible - high expectations - trial and error/learning process o improved practice [subtheme] - teacher knowledge of science - strong learning continuum - quality lesson - disuse of old/ineffective programs - new programs written - scientific language/jargon - colleague collaboration - syllabus constant reference point - risk-taking in science teaching - confirmation on the right track • Change and its challenges [theme] o time [subtheme] - time management

  - time poor
  - plan for immediate teaching only/what's coming
  - science and technology not a focus
  - no or little teacher release time
  - professional learning in personal time
- meeting of support needs [subtheme]
  - science and technology resources not available/sparse
  - unused human resources (e.g. teacher educator)
  - permanent human resources needed
  - ongoing inservicing/professional learning
  - collegial support in school/school networks
  - principal support
  - collaborative approach
- discomfort [subtheme]
  - more practice with teaching syllabus needed
  - change of known practice
  - challenge to uptake new learning
  - novice in science expertise
  - alleviated by sharing of practice/ideas
- practice reversion [subtheme]
  - teacher disinterest in science
  - principal disinterest in science
  - low confidence
  - low motivation
  - resentment towards extra work
  - old habits (e.g. imparting information)
  - old programs
  - experienced teacher
  - no accountability/consequence
- the technology challenge [subtheme]
  - lacking in science teaching
  - little professional learning focus on technology
  - limited understanding of its influence on science teaching
  - lack of confidence
  - viewed as just another tool/resource
  - technological plateau

Figure 5.2 presents the two themes of subsidiary question one, and their corresponding subthemes. The new curriculum effect theme was derived deductively, and the data inductively influenced the theme of change and its challenges.

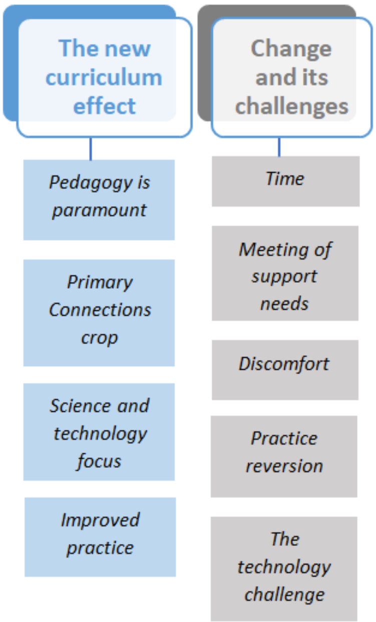


Figure 5.2 *Hybrid thematic map for subsidiary question one, with themes and corresponding subthemes*

5.4 Subsidiary question two

Subsidiary question two speaks to the influence that the NESA Syllabus for K–6 Science and Technology (2012); self-efficacy; and, the teaching framework of TPACK on the primary teachers in the current study. Although, teacher educators take on the role of facilitator, they too are not science specialists, and therefore also undertook a learning journey. Further to this, they provided insight into the learning journey of the teacher learners. Table 5.6 summarises these insights in the assembly of four themes with corresponding subthemes. It is noted that the categories of learner identity and learner environment are both evident in the data analysis of this question. Subsidiary question two asks:

> How do factors such as a new curriculum; teacher self-efficacy; and, technological pedagogical content knowledge (TPACK) influence the teacher educator and teacher learner?

Alongside the a priori themes, inductively produced codes also added further flesh to a theme by elucidating context-giving subthemes that supported its applicability. As an example, the a priori codebook theme of *context comfortability* was inductively extended with four subthemes—*science and technology immersion*; *personal passion for science and technology*; *structured professional learning*; and, *collegial support*.

Table 5.6 *Summary of the hybrid thematic analysis of interviews as related to subsidiary question two*

Subsidiary question two: How do factors such as a new curriculum; teacher self-efficacy; and, technological pedagogical content knowledge (TPACK) influence the teacher educator and teacher learner?
LEARNER IDENTITY [category] • Learner plasticity [theme] o adult pedagogue/adult novice [subtheme] - little to no autonomy in learning - needed to be lead - significant reliance on teacher educator - little to no expertise in science and technology (novice or advanced beginner on SoLC) - not age dependent - not teaching experience dependent (novice or advanced beginner on SoLC) - significant gaps in TPACK o adult andragogue/adult expert [subtheme] - autonomous learner - self-directed learner - confident in ability to learn even with knowledge gaps - solid expertise in science and technology (competent or above on SoLC) - reliant upon past/own experiences - intrinsically motivated to some extent - able to see value in teacher educator o learner modus operandi [subtheme] - Awareness of learning personality - Awareness of conducive environment for learning personality - Tangible patterns of learning - Personality traits that influence learner - Independent to larger group learning - Buoyed/fuelled by learning success - Need to fill learning gaps • Learner self-awareness [theme] o self-efficacy build [subtheme] - increase in self-efficacy in varying degrees - how to further improve understood - classroom positivity/success - student engagement - risk-taking in teaching of science and technology - focus on science and technology in classroom teaching time - greater cross-curriculum integration of science and technology o personal expertise [subtheme] - in TPACK model - in teaching stage - in branch of science (e.g. biology) - in ability to provide professional learning to other teachers - classroom experience o knowledge gains and gaps [subtheme] - knowledge of syllabus content - understanding of how to teach the syllabus

- building understanding of syllabus skills
- practical experience with teaching syllabus skills
- working technologically/the design process
- integration of ICT specific to science and technology
- developing inquiry questions that can be investigated

- Learner discretion [theme]
    - o motivation for learning [subtheme]
        - transition from pure extrinsic motivation to intrinsic
        - varied across the professional learning process/malleable
        - central to making knowledge gains
        - central to addressing knowledge gaps
    - o status [subtheme]
        - teaching a professional position
        - maintenance of professional reputation
        - highlighting ability to lead peers/colleagues
        - indicating suitability for promotional purposes
        - engaged in lifelong learning
    - o duty [subtheme]
        - because of science and technology background/personal passion/capacity
        - selected for role by principal/assistant principal (colleague in position of power)
        - recommended/suggested/selected for role
        - responsibility as teacher/professional/adult/system of teachers

LEARNER ENVIRONMENT [category]

- Context comfortability [theme]
    - o science and technology immersion [subtheme]
        - studied science in primary/secondary/tertiary level education
        - family home environment influenced by science (past or present)
        - family members engaged in science based careers/jobs
        - teaching experience in science outside of primary classroom
        - scientific literature/science news read
    - o personal passion for science and technology [subtheme]
        - love of experimenting
        - curiosity for/interest in science and technology
        - links with/influenced by science and technology immersion
        - understanding that science is all around us
        - placing credibility in/importance to science and technology
    - o structured professional learning [subtheme]
        - goals of professional learning mapped out/understood
        - variety of modes of professional (e.g. large lecture style learning vs. small group targeted learning)
        - ongoing (even beyond 2015)
        - consistent (at regular intervals)
        - based on learner needs
        - to upskill for science reference teacher role
    - o collegial support [subtheme]
        - principal/assistant principal support
        - peer support at classroom teacher level
        - interschool support
        - teacher networking/collaboration
        - teacher relationships
        - sharing of resources
        - airing of teaching successes and failures in supportive environment

Figure 5.3 visually represents the hybrid thematic map of subsidiary question two, with three a priori themes and one a posteriori of *learner discretion*.

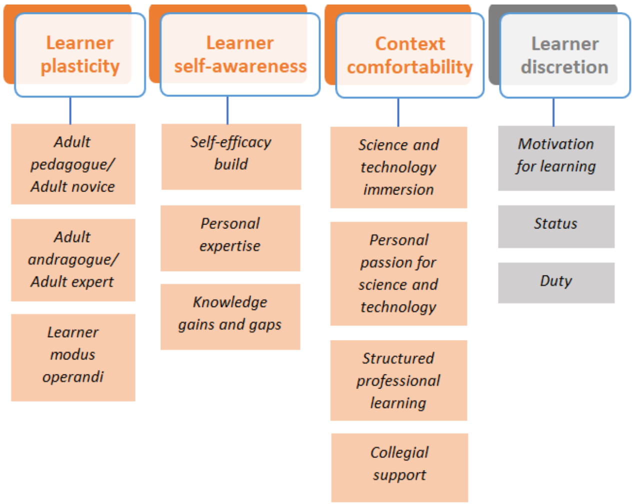


Figure 5.3 *Hybrid thematic map for subsidiary question two, with themes and corresponding subthemes*

5.5 Subsidiary question three

The context of learning for the teacher participants in the current study is of import for several reasons. Firstly, they engaged with learning in a new science curriculum. Secondly, they are overwhelming not science specialists and so came to learning in this arena with a very select context. Lastly, there are likely specific tools and strategies that are best suited to professional learning (PL) in K–6 Science and Technology as opposed to other learning areas. These considerations are accommodated in the third subsidiary question which asks:

> What is the influence of the context of K–6 Science and Technology in professional learning?

Table 5.7 summarises the hybrid thematic analysis for subsidiary question three. Three themes were resultant from data analysis, and both categories of learner identity and learner environment are represented. Figure 5.4 shows the corresponding thematic map for subsidiary question three.

Table 5.7 *Summary of the hybrid thematic analysis of interviews as related to subsidiary question three*

Subsidiary question three: What is the influence of the context of K-6 Science and Technology in professional learning?

LEARNER IDENTITY [category]
 	
• Perceptions on teacher learner [theme]
    o diverse motivation for learning [subtheme]
        - purely intrinsically motivated to extrinsically motivated
        - volunteered for learner role versus assigned for role
        - influenced by science and technology background (personal passion and immersion)
        - influenced by belief in learner ability
        - changeability across professional learning
    o presumptive child learner traits [subtheme]
        - reliant on another adult
        - motivation dependent on another adult
        - potentially unmotivated and lazy
        - requiring classroom management strategies to stay on task
        - inexperienced in science and technology
    o adults learning [subtheme]
        - adult learners treated differently to child learners
        - peers/colleagues/equals to educators
        - years of experience/achievements respected/acknowledged
        - influenced pitch of professional learning
        - learning made relevant to teacher learner's classroom/responsibilities/professional needs
 	
• Perceptions on teacher educator [theme]
    o expert in science and technology [subtheme]
        - qualified for role as teacher educator
        - reason for being awarded role of teacher educator
        - presumption of some teacher learners
        - expert level on SoLC
        - knowledge-bearer
    o confident [subtheme]
        - built on expertise in science and technology
        - built on knowledge of classroom as a practising teacher
        - built on years of teaching experience
        - ability to effectively answer teacher learner questions/queries
        - stage presence as professional learning facilitator
    o learning leader [subtheme]
        - appointed to role as education officer for this purpose
        - relied upon to direct learning
        - inspire/encourage learning
        - foster relationships/networks to benefit learning
        - be readily available to teacher learners
 	
LEARNER ENVIRONMENT [category]
 	
• Professional learning setting [theme]
    o practical/hands-on [subtheme]
        - working scientifically/experimenting
        - working technologically/the design process
        - kinaesthetic - producing/manipulating with hands

- valued method of instruction
- innate to science and technology

- pedagogical modelling [subtheme]
  - used by teacher educators and teachers learners
  - when implementing something new/unknown (e.g. syllabus)
  - clarification of concept/understanding
  - used to highlight potential pitfalls/misconceptions
  - time for modelling shorter than real-life application in classroom
  - provides a repeatable successful model (especially in early stages of syllabus implementation)
- “classroom” management [subtheme]
  - Compared to management of child classroom
  - varied engagement in learning amongst teachers
  - varied level of work completed
  - balancing learner personality
  - balancing learner needs
  - addressing distracted/unmotivated learners
  - applying strategies for management

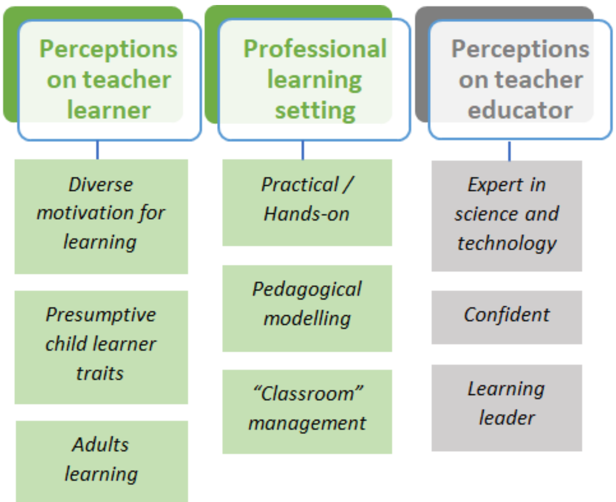


Figure 5.4 Hybrid thematic map for subsidiary question three, with themes and corresponding subthemes

5.6 Document-based data sources

Two supplementary pieces of document-based data sources were provided; completed by respondents; and, collected during interview. These data sources were presented as tables and called on respondents to consider their responses in light of two contexts:

1. The beginning of their professional learning into the NESA Syllabus for K–6 Science and Technology (2012).
2. At the end of 2015, when a minimum of one year of professional learning into the NESA Syllabus for K–6 Science and Technology (2012) had taken place.

This was purposeful to reveal changes in the learner (if any) across 2015. For most respondents the first context of consideration corresponded to the beginning of 2015. A few teacher respondents began their professional learning in 2014 separate to the professional learning setting canvassed in this study.

As discussed in chapter four, the nature of these data sources were for the purpose of crystallisation. The documents therefore added context, depth and supported thematic ideas from the codebook—as well as the inductive analysis of interviews. At certain points in the interview, respondents were asked to elaborate on points from the documents they completed, or even justify their selection of a particular characteristic or category. This cemented the connectivity between the interviews conducted and documents completed by both teacher educators and teacher learners. As a result, significant cross-over occurred between the themes and subthemes from interview and those apparent from analysis of the documents. Table 5.8 summarises the data analysed from the stages of learning continuum (SoLC) document-based data source of one teacher educator participant and four teacher learner participants.

Table 5.8 Summary of the hybrid thematic analysis of document-based data source stages of learning continuum (SoLC)

Stages of learning continuum (SoLC)				
Respondent	**Before → After professional learning in 2015**	**Summary**	**Subthemes**	**Themes**
TE3	Advanced beginner → Expert	Limited confidence to teach science and technology to extremely confident. Now confident in teaching and applying syllabus to new and unfamiliar contexts; seeking and engaging in collaborative	Improved practice Adult beginner (novice) Adult expert Personal	The new curriculum effect Learner plasticity Learner self-

		relationships with other experts	expertise Knowledge gains and gaps Expert in science and technology Confident	awareness Perceptions on teacher educator
TL2	Advanced beginner → Proficient	Limited confidence to teach science and technology transitioned to knowledge of syllabus applied effectively for programming and assessment. Confident teaching and application of creative contexts	Improved practice Adult beginner (novice) Personal expertise Knowledge gains and gaps	The new curriculum effect Learner plasticity Learner self-awareness
TL5	Proficient → Proficient (no transition)	High level of science immersion, strong background and personal passion. Little growth in syllabus knowledge. No transition. Knowledge of syllabus applied effectively for programming and assessment. Confident teaching and application of creative contexts	Personal expertise	Learner self-awareness
TL6	Novice → Competent	All knowledge and application of syllabus extremely limited to non-existent. Transitioned to capable of teaching the science and technology syllabus; working scientifically and technologically even in unfamiliar contexts	Improved practice Adult novice Personal expertise Knowledge gains and gaps	The new curriculum effect Learner plasticity Learner self-awareness
TL8	Competent → Proficient	Capable to teach science and technology and apply some knowledge of syllabus to programming and assessment to knowledge of syllabus applied effectively for all programming and assessment. Confident teaching and application of creative contexts	Improved practice Personal expertise Knowledge gains and gaps	The new curriculum effect Learner self-awareness

The analysis of document-based data sources followed the same protocols as the interviews. The a priori themes of the codebook were applied to the document-based data in a deductive manner, to foreground similarities and differences. The differences lead to inductively produced subthemes and themes. In the early analysis stages of the document-based data sources it was evident that respondents could be divided into two categories—those who transitioned in expertise and exhibited changes in their characteristics of learning; and, those who did not. Further consideration into the polarity of these two types of respondents showed that those few respondents who identified little to no change in their expertise or characteristics of learning were experienced learners in the area of K–6 Science and Technology. They had been immersed in the learning area, for some since their own primary school days. Science education had been a major focus in their high school years, so too their tertiary studies. This information was garnered from interview—another example of how the interviews and document-based data sources related. Figure 5.6 consolidates the data for the current study in a thematic map overview that shows both deductive and inductive themes.

5.7 Interactional categories

Two categories emerged in the latter stages of data analysis—*learner identity* and *learner environment*. When the iteration of data analysis were undertaken, the themes that emerged were about the learner themselves on the one hand, and about the circumstances that contextualise learning on the other. Learner identity is how learners think, feel and behave; while learner environment is about the context of learning. Conceptually, there is a segregation of themes that are internal to the learner; their worldviews and self-perceptions; and themes that are external to the learner, such as; learning environments and contextual influences. Figure 5.5 illustrates this binary division of themes. It shows that the identified themes are essentially either, internal or external to the learner. Further, the double-ended arrow in Figure 5.5 shows that these different theme sets interact. Internal learner identity is influenced by external environments, while external learner environments are influenced by learner identity. Effectively, learning is characterised by internal and external influences.

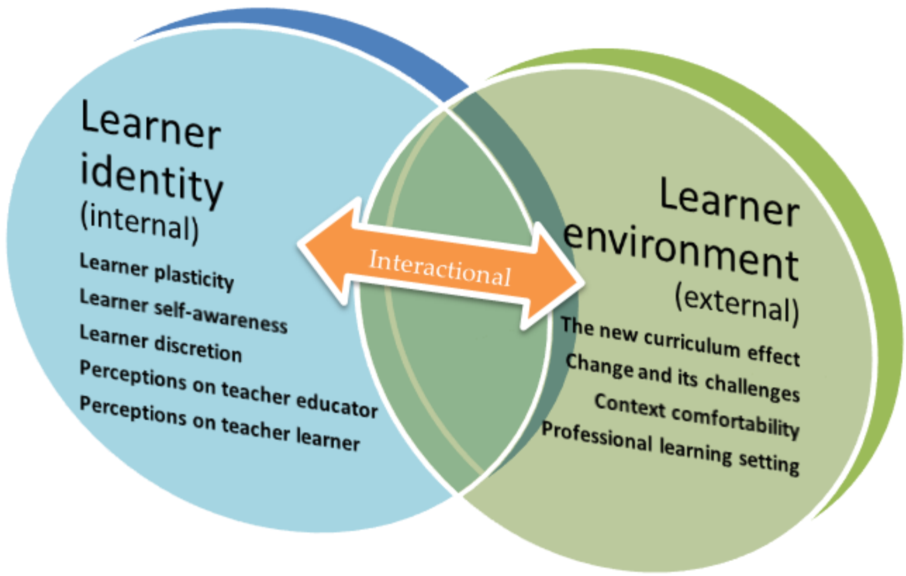


Figure 5.5 *Learner identity and learner environment in constant interaction*

5.8 Summary

Findings for subsidiary question one showed a relationship between the introduction of a new science and technology curriculum, teacher self-efficacy and integration of the TPACK model. Primary teachers were impacted in several positive ways by the NESA Syllabus for K–6 Science and Technology (2012), evidencing improved self-efficacy in science education and a deeper understanding of how to teach science with a pedagogical focus. Inductively, there were the unanticipated findings regarding *the challenges of change*, and the pressure and absence of specific support mechanisms in the rollout of a new curriculum.

Subsidiary question two evidenced findings regarding the influence of the learning environment and context on the characteristics of learning; learning situation; and, level of consciousness of the adult learner. Teacher participants shifted in their characteristics of learning across 2015, as their expertise in primary science and technology grew, and as they built comfortability with the learning area. The adult learners in this study were innately aware of their learner traits and changeability across the learning journey of 2015. An inductive finding, direct from teacher voice, highlighted the *learner discretion* theme. This theme foregrounded an independent, autonomous and critical thinking adult learner; irrespective of expertise in and comfortability with science and technology.

Subsidiary question three spoke to the influence of the professional learning (PL) context that is teacher educators (TEs) and teacher learners (TLs) coming together in a PL environment to upskill in K–6 Science and Technology for a new curriculum. TEs had preconceptions of the TLs they facilitated, and conversely the TLs viewed TEs in a particular light, as the knowledgeable other in primary science and technology. Finally, the themes and subthemes of subsidiary question three spoke to successful PL practice in the context of primary science and technology, which at times mirrored successful teaching and learning practices of science and technology in the classroom.

Collectively, the subsidiary research questions showcased themes that could be categorised according to learner identity and learner environment. Learner identity includes influences that are internal to the learner and is represented in this study by the themes of: *learner plasticity*; *learner self-awareness*; *learner discretion*; *perceptions on teacher educator*; and, *perceptions on teacher learner*. Learner environment encompasses elements of influence outside of the learner, evident for this study in the themes of: *the new curriculum effect*; *change and its challenges*; *context comfortability*; and, *professional learning setting*. Significantly, these internal and external factors interact—an insight towards the phenomenon of this study regarding the nature of the adult learner.

Chapter six of the current study is the narrative case report. This is the definitive presentation of teacher participant voice. It includes quotes from raw data that substantiate themes and subthemes in the present study, organised and presented by research question.

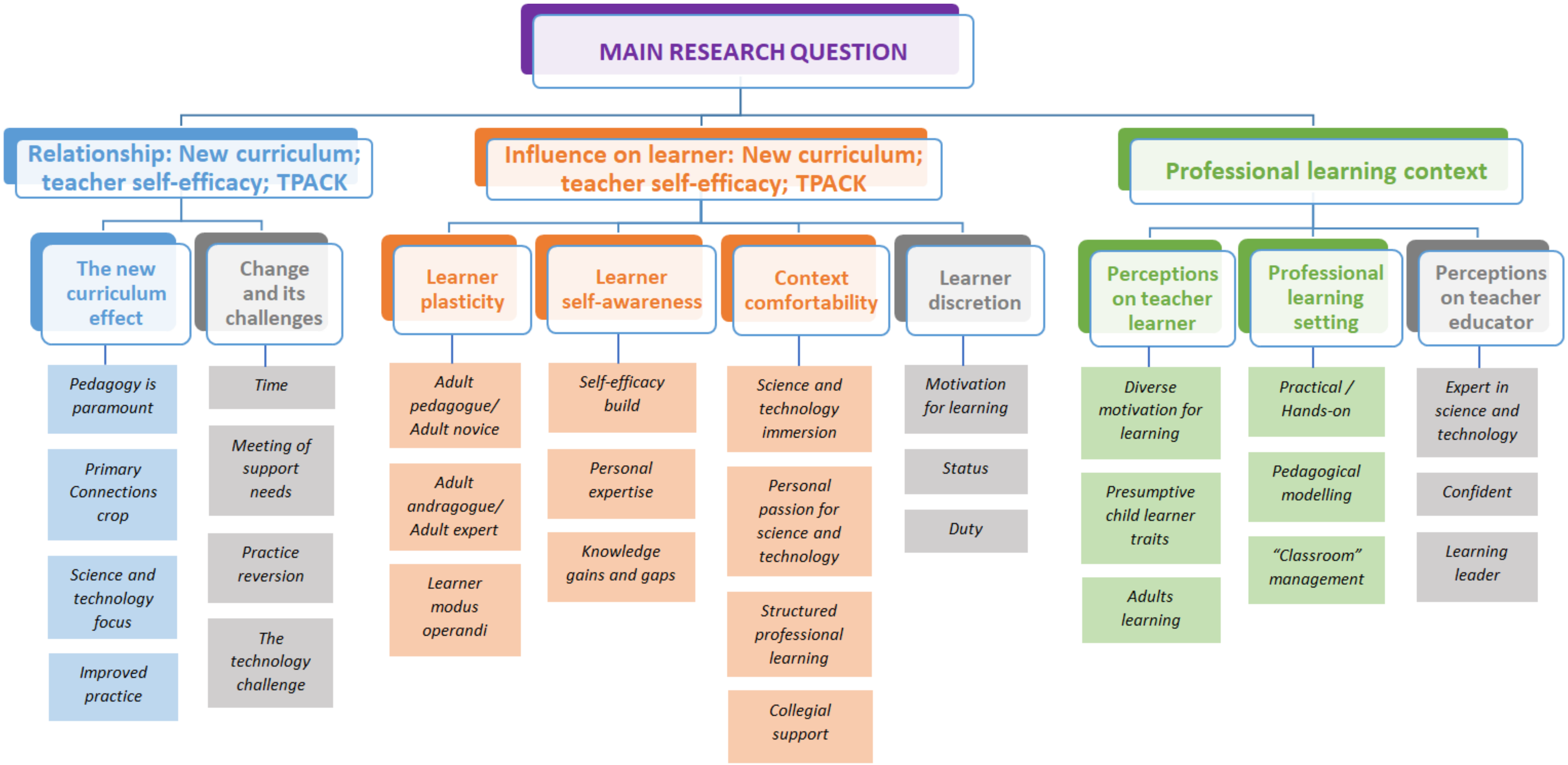


Figure 5.6 Overview of thematic map of current study with deductive and inductive themes and corresponding subthemes

Chapter 6: Narrative case report

Introduction

In this chapter, the opinions and experiences of the participants as they relate to the professional learning (PL) undertaken for the NESA K–6 Science and Technology Syllabus (2012), and teaching and learning practices are put forward. The purpose of chapter six is to relay participant perspectives in line with the interpretivist paradigm of this study. It is teacher voice and story that supported the development of the inductive a posteriori themes and were confirmatory to the deductive a priori themes. Direct quotes from the semi-structured interviews showcase teacher voice. These quotes are organised by the three subsidiary research questions, further categorised by corresponding themes and subthemes. This method of presentation contextualises the main research question and adds detail and nuance to the themes presented in chapter five of the present study.

6.1 Subsidiary question one—what is the relationship between a new curriculum; teacher self-efficacy; and, technological pedagogical content knowledge (TPACK)?

Teacher participants brought to light very clear flow-on effects of the introduction of a new curriculum. Some of these effects were positive, foregrounding teacher awareness of the belief in their ability to teach science (teacher self-efficacy) and some of the best ways to approach science education (through a model like TPACK). The relationship between a new curriculum; teacher self-efficacy; and, TPACK began to unfold. The NESA Syllabus for K–6 Science and Technology (2012) made many teachers reflect on the fact that they were not very confident when teaching primary science and technology and ultimately did not believe they were doing justice to the learning area. Specific models of approaching science education such as TPACK were not even on the radar for many participants, and so by their own admission science pedagogy suffered as a consequence. The introduction of a new curriculum challenged many participants to address their low self-efficacy; and, started a journey of strengthening the practice of pedagogical approaches that come with the TPACK model. The inductively arrived at theme of *change and its challenges* built a story of the negative flow-on effects of the three factors of influence. Participants were able to articulate that change was sometimes a difficult process, and that not all teachers challenged with change would undertake the learning journey required of them.

6.1.1 The new curriculum effect

Undeniably, the introduction of the NESA Syllabus for K–6 Science and Technology (2012) demonstrated considerable positive flow-on effects. These effects were discussed by many respondents, numerous with significant detail, which led to the formation of the subthemes. For the majority of participants self-efficacy improved; so too, the overall focus on the learning area of K–6 Science and Technology. The overreliance on resources such as Primary Connections began to be curbed, in favour of a greater confidence in the syllabus document itself.

6.1.1.1 Pedagogy is paramount

Pedagogy, specific to the learning area of K–6 Science and Technology was an important skill that was built up through professional learning (PL); collegial interactions; and, practise in the classroom. It is an underpinning principle of the TPACK model, arguably, its most important. There appeared to be a shift taking place, whereby there was an art and practice to teaching primary science and technology, different to other learning areas in the curriculum. One teacher educator (TE) concluded:

> TE1: *I think there's not such an important focus on content, it's more about the process— how you go about it, because the content can change. The content can be learned, but to understand the process of engaging with the content (pedagogy) to me is much more important . . . . The way that it's (science and technology) actually taught, so the content changes, the content you can get from anywhere, but the way you go about teaching it can change the whole approach.*

One teacher learner (TL) was very frank in deficits of previous practice when teaching K–6 Science and Technology:

> TL4: *It was more like a history lesson than a science lesson, where the information was given to the children. The teacher would do most of the hands-on sort of*

work out the front, and you'd do some research. There'd be more telling rather than working technologically and working on skills with the children.

This TL also qualified the gains made in practice:

TL4: *More hands-on and more exploration; we've got the scientific diagrams, we've got children coming up with their own questions and how can we solve that. We're teaching the children how to go through the process of fair testing, and we're getting outside, we're incorporating sustainability into our science lesson as well. So there's a lot more action and a lot more involvement.*

A greater focus on pedagogy for many participants meant a greater focus on student experience in learning because of the benefits that ensue. Student experience in learning is integral to a constructivist, student-centred approach to learning upon which the NESA Syllabus for K–6 Science and Technology (2012) is modelled. Several teacher participants remarked:

TE1: *I suppose it's very much setting up authentic learning— it's (science and technology) got to be linked with what the children experience, what they know . . . look at the science behind what's happening around them.*

TL3: *Make it (science) meaningful; make it meaningful to the children… So my practice is to make sure the children have connection with it, so it's not just the science lesson that sits by itself . . . . So today for instance, we did 'heat' . . . . We talked about it in terms of their lives and how it was meaningful to them . . . I just asked them, what do you know about it, and they came up with thermal conductors, thermal energy. They talked about insulators, and this is just them, just sharing.*

TL8: *I'm early childhood trained and you are very much about the child, so from my training background, I've often felt that all teaching no matter what the subject is should be coming from student interest and student background. Start where the child is and move from there, rather than teacher directed.*

Furthermore, primary science and technology encompassing student experience became a useful engagement tool in the classroom. Multiple TLs spoke to this point:

TL2: *You've got to engage the children . . . . I think with science that comes quite easily because everything around us is science . . . . I think I've always done it (taught with enthusiasm) that's the way I was taught.*

TL4: *The children didn't get enough of (science and technology) and I felt that it was a way to bring in those more reluctant students who loved science.*

TL9: *I think they (students) enjoy it (NESA Syllabus 2012). I think it's different for them and it's more hands-on, they've got more control of their learning. You relate it to their life, and I think it engages them more and they enjoy it and get more out of it . . . (students are) a lot more switched on, a lot more focused on what they're doing, and you're a lot more likely to get success . . . . Students learn more when they make the discovery themselves, than when you tell them.*

6.1.1.2 Primary Connections crop

The relationship between a new curriculum, self-efficacy and TPACK challenged many former practices in the teaching of K–6 Science and Technology. Primary Connections and its use (and misuse) was identified across the board by the majority of participants. A teacher educator (TE) put the need for Primary Connections down to low self-efficacy and confidence in the teaching of K–6 Science and Technology, claiming it was something that was "latched onto" (TE2). Several teacher learners (TLs) used Primary Connections with little to no discrepancy, and admitted, "I was following a manual, Primary Connections to the T" (TL6). The honesty from often very experienced teachers on their overuse or misuse of Primary Connections spoke to the underlying issues in their teaching practice. Positive changes were made in this area, and TL participants were able to take control of their teaching—greatly reducing the need for Primary Connections. Many teachers discussed Primary Connections post professional learning (PL) and their ability to scrutinise the resource and use it as intended:

TL1: *Primary Connections . . . that cannot just be used as the prime resource in the school . . . . I'm more aware of that . . . . I can (determine whether) Primary Connections units are good or not so good, whether they're useful or not so useful.*

TL3: *I taught it (science and technology), but I taught (programs) from Primary Connections—in 2015 we branched out, and we started looking elsewhere . . . we could see the gaps . . . we have used them for a long time here at this school and I've used them for quite a while – the more I use them, the more it (Primary Connections) doesn't quite fit.*

TL6: *I would have been relying on Primary Connections, now I can write a unit of work without using Primary Connections, and being able to confidently achieve all the outcomes.*

One respondent summarised their understanding of why Primary Connections was used so widely prior to the introduction of the NESA Syllabus for K–6 Science and

Technology (2012). They discussed the lack of K–6 Science and Technology teaching and learning and claimed, "we weren't really doing much science" (TL8). Also, they revealed Primary Connections provided some positive impetus as without it "I don't think there would have been much investigating" (TL8). Even in recognition of a positive outcome of using Primary Connections, it was understood that it was not "the be all and end all" (TL8).

6.1.1.3 Science and technology focus

Another positive flow-on effect that trailed the NESA Syllabus for K–6 Science and Technology (2012) and the professional learning (PL) engaged with was an improved focus on K–6 Science and Technology in classrooms and in schools. In relation to an improved focus in schools, teacher learners (TLs) articulated "there wasn't anyone really leading science and technology" and that it "was just a bit swept under the carpet" (TL8). This highlights a neglect of the learning area in primary education prior to the introduction of the NESA Syllabus for K–6 Science and Technology (2012).

> TL2: *I thought it (new syllabus) was a great change and it was taking science a bit more seriously . . . it's really highlighting science for the first time in a long time, well, ever, in primary school.*

> TL5: *The teachers that I worked with were very grateful for having opportunities to explore the new science curriculum, and working with (teacher educator) and the leadership group, meant that science had a higher profile in the school, but I think it's really important that profile remains – all the areas are important but – if we're a 21st century education system, science needs to be up there.*

From the point of view of improved classroom focus on primary science and technology, several teacher learners were cognisant of positive changes:

> TL2: *(I'm) connecting the syllabus now to me and my teaching, whereas before it was there as a guide, but I wasn't so religiously looking at it . . . I do now.*

> TL4: *Science has become a very important part of the week for myself and for my children.*

> TL9: *I think since seeing the new syllabus . . . it's more scientific. There's more focus on using the scientific language and the development of scientific skills from Kindergarten to Year 6.*

Of these TLs, one articulated the ongoing struggle of keeping the focus on K–6 Science and Technology, putting it down to a lack of continued focus from the bureaucratic end of Catholic education.

> TL8: *It's (science) not really on the agenda much from the Catholic Education Office (now, Sydney Catholic Schools) that I've seen yet this year, and it's not named on our annual improvement plan this year, so I know if I'm not trying to push myself and to push the agenda, then it will collapse . . . . I'd say there's pockets of experts in schools, but because they're not in leadership roles, they don't have the opportunity to sort of drive.*

6.1.1.4 Improved practice

Arguably one of the strengths of the NESA Syllabus for K–6 Science and Technology (2012) is the focus on scientific inquiry in a student-centred manner. As teachers built their knowledge of this new curriculum, they engaged with more sound pedagogical practices around student-centred scientific inquiry. The grasping of this skill by teachers was integral to building scientific literacy and capacity. A TE discussed the change in thinking:

> TE1: *I think that many teachers welcomed the new curriculum, but I also think it reflected a change from teaching to learning . . . . So the biggest change for the teachers is to move away from that model of imparting information, to helping students inquire about information.*

Furthermore, they qualified this change in thinking as underpinning the purpose of primary science education, to foster "engaged" students "inquiring with questions, and being curious" (TE1). Multiple TLs thought the changes in practice at a base level were because of the strengths of the new syllabus document itself, which were made more apparent by deficits in the previous syllabus.

> TL2: *I think it's (new syllabus) a real reference point now, whereas before, it wasn't so much, I would just sort of wing it with what I knew. I just knew that they had to learn certain things, like about magnetism (previous syllabus) . . . (teaching to the topics) that's what I was doing. Whereas now, it's (new syllabus) is a constant reference that I have to cover all those outcomes properly.*

> TL4: *It has changed, yes. I refer back to the document (syllabus) a lot, whereas previously, I would look at the scope and sequence . . . . I'd go and get the Primary Connections and I'd just teach from (that). Whereas now, I go back to the document (syllabus) and I pull apart the outcome, what can I do with this*

outcome, and what are the children going to get from this, and how are the children going to achieve this.

TL5: *I think some of the content areas are laid out very clearly and I think being able to know exactly what you should be teaching in the new curriculum makes it easier. Also in the continuum that we're given (in the syllabus).*

TL9: *I think in our school, a lot of the units maybe didn't have as much working scientifically and working technologically in them as they should have. They were sort of going off on a bit of a tangent because the old document (syllabus) wasn't so explicit.*

TL9: *(K–6 Science and Technology as taught using the previous syllabus) It was kind of dumbed down a bit before and now the expectation has been sort of raised a bit that that's what's expected now.*

The work done by teacher educators (TEs) and teacher learners (TLs) appeared to be reaching the students at a classroom level, suggesting student gain. One TL evidenced change through student reflections and evaluations which were now "more scientific" in their use of "language" (TL1). Student participation in K–6 Science and Technology was also noted to have improved.

TL4: *When I saw that they (students) were actually wanting to investigate and learn to use the skills . . . they were just flying through it, they loved it.*

TL6: *The children enjoy science so much more than they did when I was teaching it before, because the lessons are more rich . . . . I'm more confident to be able to get them to do their own inquiry learning, and really stretch them and have high expectations of their ability.*

Two TLs evinced personal reflection as they talked of the challenges that lay ahead in their changing practice, they stated:

TL2: *(Over scaffolding for students) I feel as though a lot of times when I'm experimenting, I don't think I unleash them (students) where it's like, you go and explore it. I've got to really cut back in the direct teaching that I do.*

TL3: *Hands-on. Less teacher talk, more involvement. Also putting the onus back onto them (students) so they become the teachers in a way, I suppose, of their own learning. Identify risks, look at what materials are possible, research what's happened before. I mean these are not all things that I've done, but they're things that I'm working towards.*

6.1.2 Change and its challenges

The positive relationship between a new curriculum, improved pedagogical practices and teacher self-efficacy was not all that came from teacher voice in interview. Some participants spoke to the difficulties of change—the roadblocks that impeded their ability, and that of their colleagues, to maintain genuine and sustained positive change. The strength of these sentiments was not accounted for by the a priori theme codebook, and thus the revelation of an equally important a posteriori theme that spoke to the less positive elements of change.

6.1.2.1 Time

Of the many challenges that face teachers in Sydney Catholic Schools (SCS), time and a lack of it, was a recurring idea that came through participants' perspective. One TL spoke of time in relation to teacher responsibilities which highlighted a clear discord:

> TL3: *RFF is like an hour . . . so everything comes home, and with the English demands and all the paperwork that happens, it's just unbelievable. Thirty four children, so many of them with needs, there's no time. So that's why I basically do what I know is coming.*

TEs as practising teachers themselves were also aware of the notion of the time poor teacher. One commented:

> TE2: *(Works against adult-centred learning) Time poor, and that is what teachers will say about the classroom as well.*

This lack of time affected their teaching of the adult TLs. Their ability to run the PL inservicing in a hands-on, learner-centred manner was compromised. TE2 remarked:

> TE2: *If I could do a hands-on activity and work like that, we certainly did, but sometimes it was literally going through the syllabus and pointing things out… For example, the meeting this afternoon is literally a crash course. So a lot of it is teacher-directed.*

The discord was partially offset when time for PL was provided.

> TL4: *Being given the time to do it. In teaching, we have a lot of things that we have to do after 3pm, and you don't actually always have time to have a document in front of you and go through it . . . whereas at the in-services, they gave us time to actually just focus on science.*

> TL7: *Time was definitely a factor. We were lucky to get extra time.*

6.1.2.2 Meeting of support needs

Whether teaching students in the classroom, or adults in a professional learning (PL) setting, support needs are an important consideration. The meeting of the support needs of teacher learners (TLs) was not always achieved, thus this highlighted a challenge in the change process. What is evident from teacher educator (TE) interview responses is that they were cognisant of the importance of the needs of the learner. Two commented:

> TE1: *You assess the learner, you assess the environment, and then you change yourself to suit the needs of that environment.*

> TE2: *For every group of people that you work with, you start with the basics and then go in the direction to meet their (teacher learners) needs.*

In certain situations, there was disconnect between the support that was available and the knowledge of that availability by TLs.

> TL2: *I don't think I ever contacted (teacher educator). To tell you the truth I don't think I would have even thought to contact (teacher educator). Maybe I should have used that link a bit more . . . . I didn't rely on (teacher educator) at all. Maybe that's my fault, I didn't use that resource.*

Open lines of communication went some way in mitigating this disconnect, but the onus remained on the TL to put their case forward in terms of their support needs.

> TE2: *They'd (teacher learners) send me an email saying I wanted to do this, have you got any resources, and I'd say yes – look here, look there.*

6.1.2.3 Practice reversion

There was evidence from teacher story that there was a propensity for some to revert to the way in which they have always taught primary science and technology irrespective of external changes such as a new syllabus. One TL was forthcoming on their specific reversion to teacher-directed practices:

> TL2: *A lot of the times I like to talk about the theory before the experiment and (students) don't discover it themselves, and that's probably something I've got to change a bit more.*

Another TL voiced in detail their struggle in the role of science reference teacher (SRT). The difficulty lay in affecting sustained change in their, at times, much older and more experienced colleagues. One reason was the indoctrination of K–Science and Technology teaching and learning because "the old syllabus was there for what, twenty years" (TL7).

This TL went on to say:

TL7: *Trying to be that person, you're a little fish in a big pond, so to speak, but a lot of people who just go well you've only been teaching 'x' amount of years . . . . A community that is very hard to change their ways . . . not the executive, but more the teachers that have been here for ten, fifteen years, because that's the staff we've got.*

Another TL put the idea of practice reversion down to low self-efficacy and confidence. Perhaps the pyramid model of professional learning (PL) was showing some deficits in the level of change once the PL hit the level of primary teachers that were being taught by SRTs (teacher learners) (see chapter four, Figure 4.1).

TL8: *(Little science background) They're very unsure, they're very doubtful and they'll end up giving students the answers rather than having lessons where the students are actively engaging in discovering how to obtain answers, and what the answers are out there. I feel like some teachers because they don't have that belief in themselves, they default to content… so I find where teachers aren't as positive about science or confident in science, the student work will often be less.*

6.1.2.4 The technology challenge

Of all elements in the NESA Syllabus for K–6 Science and Technology (2012), it was the understanding of technology in its multiple forms that seemed to be what challenged teachers most. These multiple forms as elaborated on in chapter two of the current study are working scientifically, the skill; information and communication technology (ICT), the general capability; and, technology, the learning area. It was almost uniformly identified as an area of need in terms of learning where significant knowledge gaps existed. Many teachers, both educators and learners alike commented that it was "not a strength", especially the skill of working technologically.

TE3: *Working technologically was the thing that they (teacher learners) always asked for help with, because there weren't any resources to support it . . . . It was often that they'd say we need help working technologically.*

TL2: *Working scientifically is fine . . . . I think the working technologically is still a work in progress for me.*

TL7: *Working Technologically, I think that's the one thing lacking in my science teaching.*

TL9: *(Working technologically) Less confident . . . . I think the more you do it, the more confident and the better you become at it.*

Multiple teacher learners (TLs) referred to their technology deficits in reference to ICT, the general capability:

TL2: *I think I could learn to use that (technology) a lot more . . . . I'm sure there's apps out there, and I haven't investigated a lot of that sort of thing, where we can use other forms of technology in the classroom to do with science.*

TL3: *I don't feel confident (in ICT integration). I don't really think about it all that much to tell you the truth . . . . The majority of things that we do is watch something that I got off YouTube . . . or they (students) will do their own research on their own devices . . . . I sort of realised I need to be more adventurous . . . find the possibilities.*

TL5: *I do use a range. I'm not as good as I know a lot of teachers are . . . I'm a bit more old school, I suppose . . . I'm not as good at that (ICT integration) as the other things.*

Although technology was a challenge for many, the knowledge and understanding were building.

TL1: *Finding working technologically a challenge (beginning of 2015). Now I have a better understanding of working technologically.*

TL9: *I'm becoming more confident. I often go to our ICT teacher here (for ideas) . . . I'm not an ICT expert or anything, but I see the benefit of using that in the classroom.*

Ongoing knowledge gaps in technology were discussed a few times by respondents, some put it down to a lack of focus in the PL setting.

TL6: *Not (covered) so much in the professional learning.*

One confident ICT integrator identified the technology challenge as coming down to a lack of resources. They commented regarding their use:

TL6: *So very confident. Love to use (ICT tools) . . . . I use it a lot (in previous school) . . . . Now (in current school) I've come here and there's none (ICT tools). So that's really difficult, to have the resources is critical.*

In general, there appeared to be a greater challenge in the uptake of the skills of the syllabus, over the content knowledge.

TE3: *I think the outcomes, the content outcomes and the knowledge and understanding outcomes teachers can cope with. I think teachers are pretty good at looking at an outcome, dissecting what they need and then if they know they don't have that information themselves, finding it. That's not so easily done with the skills outcomes.*

6.2 Subsidiary question two—how do factors such as a new curriculum; teacher self-efficacy; and, technological pedagogical content knowledge (TPACK) influence the teacher educator and teacher learner?

Participant responses, both those of the educators and the learners reflected a general consensus that the learner was not fixed in terms of the characteristics they display as a learner. Some participants drew on their knowledge of the child learner, making links with the adult learner and their characteristics. Others reflected on their learning needs as it related to where they were in their learning journey. For example, if at the beginning, and therefore less familiar with the syllabus, they recognised a greater reliance on the teacher educator (TE) and other external support channels such as other teachers and school networks. If further along their learning journey, many participants identified a greater autonomy in their learning. Certain responses linked autonomy in learning with a building of confidence in the learning area of K–6 Science and Technology. Those teacher participants that came from a background rich in experiences in science and technology (identified by the subthemes of *science and technology immersion* and *personal passion for science and technology*) highlighted yet another dimension of the learner—that when in a familiar context, self-direction in learning was second nature. Beyond the scope of the conceptual framework of the current study arose the inductive theme of *learner discretion* which spoke to the innate traits that adults in the profession of teaching appeared to have irrespective of their familiarity with science and technology; their learning personality or *learner modus operandi*; and, their initial motivation in up taking professional learning (PL). Once teachers found themselves in the role of science reference teacher (SRT), commonalities in learner discretion surfaced.

6.2.1 Learner plasticity

All participant responses made reference to the changeable nature of the adult learner at some level. This emphasis justified the a priori theme of *learner plasticity* and the notion that adults can function as a learner within the traditional pedagogical or andragogical sense or as the continuum of this study's conceptual framework purports—somewhere in between.

6.2.1.1 Adult pedagogue/Adult novice

Prior to beginning PL in K–6 Science and Technology the majority of adult learners in the current study categorised themselves as an *adult pedagogue/adult novice* according to the principles of learning continuum (PoLC) and stages of learning (SoLC). This categorisation occurred through the completion of the two document-based data sources, and via the analysis of verbal responses in interview. The adult learner according to a number of participant responses was viewed not dissimilarly to children in the classroom. One TE participant commented on how this influenced their teaching:

> TE2: *I'm a reasonably successful teacher because I learn the way kids learn . . . . So I think that the way that I learn and think, makes it easier for me to turn that around, to make it easier for the children to be engaged and understand.*

Other participants focused on the pedagogical traits that adult learners demonstrate. This was qualified by a TL:

> TL3: *We say that children will learn if they do practical stuff. Don't talk so much at them . . . the teacher talk ten percent, seventy percent is practical, the other bit between is where the teacher interacts, and that's exactly what works. It works, and we're (adults) no different.*

6.2.1.2 Adult andragogue/Adult expert

Among the data there was one teacher participant that exemplified the subtheme of the *adult andragogue/adult expert*—this was TL5. They were immersed in science and technology from a very young age and through the years developed a deep passion for the learning area. They were confident to learn in the area and were extremely comfortable teaching K–6 Science and Technology to their students, and other teachers. As a learner they demonstrated clear andragogical traits (Knowles,

1978) and were very skilled in terms of their teaching practice before PL had even begun:

> TL5: *I think certain elements probably of the programming have changed . . . really looking into how and why we work scientifically and technologically, but I don't think necessarily my perception of an ideal science lesson has changed. So I still strongly believe that it needs to be practical and linked to the real world, and about student interest and following a scientific process.*

Even as an adult andragogue/adult expert, TL5 was able to improve in their ability to teach their adult colleagues as part of the pyramid model of PL.

> TL5: *I think most importantly in the ways of helping teachers . . . rather than my personal knowledge.*

6.2.1.3 Learner modus operandi

This subtheme speaks to the way a learner learns—that is, how they operate as a learner. Some participants favour independence over group interactions, and vice versa, and many saw the benefit of both. TE responses put forward the idea of a learner personality. Two of the three TE participants commented:

> TE1: *Some want to have a lot of support and some people want to check everything with you, so you've got to understand the learning style of the individual . . . . It's very much about understanding the personality of the person that you're working with (teaching).*

> TE2: *I think you've got to think about that (learner personality). We're not all gunho, different personalities. It's more of a personality thing as opposed to probably confidence, skills, anything like that. I'd say it's more personality.*

Time and again, participants were conscious of their own learning personality and how they operate when tasked to build knowledge and capacity in a learning area such as primary science and technology. For some this meant mainly independent learning—one participant even claiming all learning was "completely independent" (TL5). The independent learners still acknowledged the benefit of another with greater expertise. They commented:

> TL1: *When I'm learning, I do it independently, when I'm planning and programming . . . . I would sit with a colleague.*

TL2: *I usually learn on my own, and if I'm not sure of something or I've forgotten something, I'll just go and look it up or ask my (spouse) or (offspring). Number one, I'd look it up and number two I'd probably ask someone at home.*

TL3: *Very independent . . . . The learning is more in the small group, having someone sit with you who knows the stuff and can mentor you . . . . That to me is effective learning.*

TL4: *I'm a dive in feet first person, so if you've got to try something new, give it a go. I think that's probably my science background coming out as well, give it a go and see what happens . . . I think by trying it first before rolling it out to other teachers, I was able to give personal experiences around programming and assessment with the new curriculum, with a knowledgeable point of view.*

TL7: *I enjoy sitting down and talking to people at the same time.*

TL8: *I'm the sort of learner that when I look at the syllabus or something that I'm required to teach, I'll just go out and research it myself.*

For other participants greater value was afforded to professional learning (PL) group interactions.

TL9: *I can do it (learning) independently; however I prefer to work collaboratively with others. I feel that I'm more confident doing it that way, whereas if I'm doing it on my own, I question myself. Am I on the right track? Whereas getting other's opinions and ideas is sort of reassuring that yes, I'm on the right track here.*

6.2.2 Learner self-awareness

All 12 adult participants were at some point in the introduction of the NESA Syllabus for K–6 Science and Technology (2012) learners. They were able to clearly identify their capabilities as a learner; where their expertise lay; and, what shortfalls in knowledge and understanding they carried forward in their learning journey. Furthermore, they indubitably were aware of their self-efficacy in primary science and technology teaching and learning, and whether or not they had developed in this area across the PL of 2015.

6.2.2.1 Self-efficacy build

Almost unanimously, the PL journey of 2015 improved self-efficacy for teacher educators (TEs) and teacher learners (TLs). One TE commented:

TE1: *I think because I learned so much, I think it did (self-efficacy improved). I think you learn a lot as you go and that's what life is all about, so you're always* *adding layers onto what you already know, and sometimes you look back and think oh I misunderstood that, and that's all a part of learning.*

They went on to talk of the combination of factors that came together for this to happen—that is, "the professional development, the support of colleagues, and the actual syllabus" (TE1). Many TL participants appeared to connect self-efficacy to confidence as they discussed improved confidence.

TL3: *It's been a process, it's been a few years that I've been doing this (science and technology professional learning). If you had asked me two years before . . . I'd say really bad, confidence wasn't as great as it is now . . . it's slowly built up . . . . I'm hoping if you ask me again next year, I'll be more confident again next year. It's been building.*

TL4: *Whilst I still have to do a lot of research, and I still have notes next to me, I think I'm more confident now.*

TL7: *I've definitely become more confident in what I'm teaching and I'm always changing it . . . I'm a bit of a perfectionist.*

TL8: *I always loved teaching science and I always felt like I could do it. I very rarely went into a science lesson thinking ugh science. I guess my confidence and belief in teaching it had improved in that I've taken it that step further in my teaching of science, I'm looking at different ways of teaching it, and I guess using a bit of trial and error in seeing what works and what doesn't.*

Old practice was discussed, as influenced by low self-efficacy.

TL6: *Before (PL) I didn't have high expectations of what they (students) were able to achieve because basically I didn't think I was confident in my own teaching of science . . . . I was asking questions they already knew.*

Several TL respondents credited the work of TEs, and its influence on their self-efficacy.

TL1: *They've really helped show me how to guide teachers into developing good units.*

TL5: *I think (teacher educator) helped (me) develop the skills and strategies I needed to help other teachers. (Teacher educator) fine-tuned the information I already knew, and brought other information . . . and laid the syllabus clearly out to enable me to spread it to other teachers.*

TL9: *(Teacher educator) often gave suggestions and ideas on how to make things better and run more smoothly. In some of the professional development we did investigations and I think having that experience, you're then more confident to go and do that with your class because you've actually gone through that already. (Teacher educator) did come out and run a staff meeting with me,* *where we got the staff to do some investigations, so I think even for them and myself, the actual doing it yourself gives you more confidence to then go and run it in your classroom.*

Risk-taking in teaching was an idea that came to light when there was evidence of a self-efficacy build. TLs made reference to risk-taking:

TL4: *Now I take more risks than I would have before.*

TL6: *I am willing to try new things whereas before I was like I'm not going to be very good at this.*

Confidence in teaching spoke to some influence on classroom management. A classroom that is well managed manifests its own set of benefits for teaching and learning, and teacher participants agreed:

TL7: *The kids will ask this tangent question . . . my confidence allows me to deal with those changes and those tangents, and if I'm not confident, I'm quite open with the kids because I think they need to know that we're (teachers) not the keepers of all knowledge and I'm not perfect.*

TL9: *(With my class) If you turn your back and you're trying to get something organised because you weren't organised or you don't know something, they then take that opportunity to get off task and do their own thing, whereas if you go in there and you're planned, you're confident and you know what you're doing, they stay on task quite easily.*

For one participant their improvement in self-efficacy was down to collegial relationships, and the knowledge shared through these networks.

TL1: *That whole notion of sharing and being able to knock ideas off each other – I don't think my self-efficacy would have gone that high (without it). It's really impacted me as a teacher and my (knowledge of) pedagogy and how I teach science.*

6.2.2.2 Personal expertise

Overwhelmingly, participant expertise centred around their teaching stage, which was not wholly unexpected. *Teaching stage skilfulness* was linked to teaching in these stages, sometimes for repeat years, and at other times to the time constraints that followed all teachers and resulted in a narrower focus on a section of the syllabus.

TL1: *I would say that I had a broad understanding of the science and technology syllabus. I came from a stage one level, I would say that I know the stage one content quite well because I actually did teach science in the stage one.*

TL2: *If I teach year three… when I get the unit and I look at it, I'm fairly confident in the content and what I have to deliver… I (can't) tell you off the top of my head what all the syllabus is about now.*

TL9: *I'm not novice, because I have taught science for a number of years . . . I was somewhat familiar with the syllabus . . . I haven't ever done any specific science tasks throughout uni . . . so I would say pretty much general knowledge . . . no particular expertise in any particular area . . . . I would do my own research.*

The sentiments on teaching stage skilfulness were echoed from the point of view of teacher educators (TEs):

TE3: *We had to focus on it (content knowledge) heavily in the beginning because we had to draw teachers to the changes. As much as I'd like to say that they all picked up the syllabus and read it, not everyone did, and if they did, often they just picked up their own stage and read that.*

6.2.2.3 Knowledge gains and gaps

Participants showed awareness of knowledge gained and also knowledge gaps moving forward. Several remarked:

TL3: *I'm not amazing at science – even though I know what the document (syllabus) says, sometimes there will be things that come up that the kids ask that I don't know . . . so we'll find out and search together . . . being ready to research and be a learner myself, and show them I'm a learner.*

TL4: *I still need a lot of practise . . . So my challenge or my goal is to continue to work with the syllabus.*

TL7: *I've always been pretty confident to teach it (science), but I think my ability to program and teach a good unit has changed.*

Knowledge and confidence building in the non-teaching stages of the syllabus was very much viewed as a work in progress, something that ongoing professional learning (PL) could address. Again, many participants commented on how "time poor" they were, which left them with little choice but to focus all energy on their teaching stage.

TL3: *I have no background knowledge, other than perhaps what I've taught before . . . for my stage, if I'm programming for next term, I'd be saturating everything . . . . There's no time to do anything else.*

TL8: *I did have some knowledge of the content of science and tech, more so in stage two and below because that's what I'd experienced teaching.*

Knowledge gains were viewed by a number of teacher learners (TLs) as something they could independently pursue beyond the structured PL that was provided in 2015, also knowledge gaps.

> TL3: *The more you focus on something and the more you try something, what works, works and what doesn't work, you throw in.*

> TL4: *I think I can push forward with it on my own now, but that's only because of the support that I received last year.*

> TL9: *After we finished a unit, there were things that we changed, things that didn't work or more ideas that came about, so that's then going to be reflected in what we do this year. It's a learning process.*

6.2.3 Context comfortability

Participants appeared most contented and confident in learning for primary science and technology if there was at some level familiarity in their background and education. This led to the subthemes of *personal passion for science and technology*, and *science and technology immersion*, as influencers of how comfortable a learner was during the professional learning (PL). A greater comfortability with the learning context evidenced more andragogical traits on the principles of learning continuum (PoLC) and greater expertise on the stages of learning continuum (SoLC).

6.2.3.1 Science and technology immersion

A number of teacher participants were immersed in science and technology through their education, some from an extremely young age through to their tertiary education. The immersion for others came through the work they had been involved in as an adult. A final category of immersion was acknowledged by participants that had at times multiple family members working in the field of science and technology and the influence this exercised over them.

A teacher's science and technology immersion influenced their learning journey and the building of expertise in the learning area. TL5 was immersed in science from a very young age and talked of their strong background in science. They described their science knowledge as "quite deep":

> TL5: *I think it just made me really inquisitive, and the fact that my (parent) used to just have little experiments running around the house. What's the difference*

between glad wrap and plastic bags, or the mould in the fridge, or come and look at the stars. There were always little things happening about science, and it just made me think this is very practical. It's interesting information and it's useful in the world as well.

TL5: *The magazine of choice in the house is New Scientist, so it's a very science household, and I grew up in a very science household . . . . My (parent) is a research scientist and has a PhD, and my (sibling) is also a Geophysicist and has a PhD.*

This led to a strong confidence in the classroom and in the use of the syllabus document:

TL5: *I had chosen to use it (syllabus) when it wasn't compulsory . . . . I have a lot of content knowledge personally, which enables me to be confident that I'm giving children the correct information, but also the ability to question what they're doing.*

Others too echoed the influence of a strong science and technology background or work in the field.

TL7: *I think I'm pretty good at that (content knowledge). I think it comes from my background, I also grew up in a medical family, so I think that's why I'm a bit more in tune with that side of my brain.*

TL8: *Teaching genetics . . . kept me interested and engaged in the field of science (after tertiary graduation).*

6.2.3.2 Personal passion for science and technology

Another factor that built *context comfortability* and the greater likelihood of adult andragogues and adult experts was a personal passion for the learning area. A number of TL participants purported a genuine interest in and love of science:

TL1: *I'm very interested in news articles and things to do with science . . . . I read a lot of books on science.*

TL2: *I love it, I love science, so number one, I love science.*

TL4: *I don't have any science and technology background. It's something that I'm interested in, and I think that's why I took it up at the very beginning.*

TL7: *My background is exercise science that's why I became a teacher and it's just how my brain works. It's a passion and a love; I just enjoy teaching science from before the new syllabus came out.*

TL8: *It's (science) something I was always highly interested in at school, and it's something that stuck with me, I guess.*

Personal passion and confidence in teaching primary science and technology seemed to go a long way in the classroom as shown in these participant responses:

TL5: *If as a teacher you show you love something and you value it, then children will love it and value it. I think it's almost a self-fulfilling prophecy, if you do it well, then the children will love it and make gains.*

TL7: *My enthusiasm and my passion, they're (students) like sponges, so they live off it. If I get enthusiastic about something, it might not happen for them the first or second time, but then they might start building that interest.*

One respondent's personal passion for science and technology did not come from the stereotypical early exposure or educational immersion, but from teaching itself.

TL6: *I was scared of it (science) in high school, it wasn't made practical . . . . So my love of science came through when I was teaching kindergarten, and the units that I taught, and that's where my love of science started, when I was teaching . . . I only had one science subject on science throughout my whole four years of teaching (at university).*

6.2.3.3 Structured professional learning

Context comfortability was linked by several participants to robust and structured professional learning (PL). The importance of an effective PL regime was expressed by teacher educator (TE) and teacher learner (TL) alike. A TE commented:

TE1: *The responsibility is to deliver focused, authentic, relevant professional development . . . . There's always a chance someone is going to walk away and say I knew all that, but you want to have a large degree of any professional development where teachers say, I learned a whole lot there.*

The fact that the PL was ongoing over the year provided opportunity for TLs to initiate and fine-tune genuine change to their practice.

TL6: *The in-servicing really changed a lot of people's teaching, and they were going back and they were trying things that they never would have before.*

Another participant spoke to the idea that the PL was pitched at a level and included learning that met the need of teachers in relation to the new syllabus. This meeting of needs was viewed by a number of participants as influencing how well they functioned as learners in the PL setting.

TL8: *I do my own online research and I read the science journals and those sorts of things, but it doesn't necessarily (cover) what you need from the syllabus, or what you need next.*

One respondent summarised their experience of the PL and it too reflected the dialogue of a number of other teacher learners:

TL2: *The inservicing, I thought that was fantastic, and that really put me up to speed and just concreted everything (in regards to the syllabus) for me.*

Participants took the opportunity in many contexts to comment on the need for ongoing learning as a means for strengthening teacher self-efficacy—a continued PL program, and the time afforded for science and technology expertise to remain a focus.

TL8: *(Further improve self-efficacy) Probably just continue trial and error and continue the revision of how I teach it (science), and how I encourage others to teach it . . . continued professional learning.*

TL9: *I don't feel that I'm expert level or even close to expert level, but the more professional development, the more experiences, will then better equip me to teach in the classroom . . . something ongoing . . . every so often an update would be beneficial rather than just sort of you're done, off you go now.*

Even participants that described their knowledge in science and technology as sound saw benefit from the PL.

TL5: *PD . . . and through the teacher educator being involved in schools . . . made it much more practical and much more achievable in that we were well supported in finding resources and how to do it (teaching the new syllabus) . . . PD last year gave me the confidence to know that I was on the right track and it was all part of what we should be doing.*

TL6: *I had to go in late one day, and I was so disappointed in myself because I missed so much. So you know how people say 'oh whatever' . . . but I made sure I got the notes . . . and understood what it was all about, because it changed the way I taught science. It made me feel like I was confident and competent, and therefore my whole attitude changed and I knew I was actually doing justice to the children.*

TL8: *I feel like I had really good knowledge on the science investigation process prior to the professional learning that I had, however I think it's (professional learning) just enhanced it that bit further and really challenged me.*

6.2.3.4 Collegial support

Several different forms of PL took place within the pyramid model undertaken by TLs and facilitated by TEs. Several times a year, all science reference teachers (SRTs) across all three regions of Sydney Catholic Schools (SCS) came together for an all-day session. Other forms of PL were at a regional level, whereby SRTs met in smaller groups led by their respective TE or another facilitator with science and technology expertise. The notion of working together was a fundamental influence on the adult learner—and a majority of participants shed light on the importance of *collegial support*. This support came from either the leadership team (e.g. from the Principal) in the school of the TL; from the TE; and from other primary teachers that formed networks and even ran small, local PL sessions.

Strong principal support was mentioned multiple times across the interviews as being critical to an effective and successful PL experience. The valuable resource of time and principal support coming together was elucidated by TE.

TE1: *There were some good people (teacher learners) who were keen, but weren't given time; other people who were given time to do really well; and people who were given time, but weren't engaged and then they wasted it . . . . The best formula is when you have a principal who is supporting, they were fully engaged, they were working with someone else, and there was time provided for them to do the job.*

TE2: *(Absolutely fantastic) The principals had given them time to have staff meetings.*

The underlying idea is that the PL had to be seen as important by the principal.

TE1: *Most of them (teacher learners), with credit to the principals were very good, but there were a few that seem to just have been given the job. Also, that reflected in the lack of interest or the lack of emphasis the principal gave to it (science and technology). There were schools that needed to be supported because the principal didn't commit to the process (of professional learning) and if the principal doesn't commit to the process, the process doesn't work.*

TL8: *(Science professional learning) It was valued here by the principal which always helps.*

A strong relationship with the TE at times matured a sense of comfortability for the learner. Some participants commented:

TL4: *I was quite reliant in the beginning, because we needed someone to guide us with the scope and sequence . . . then I found it was good to have someone I could ring when I had a question.*

TL6: *I don't need it now (support of teacher educator), but looking at the big picture, they had been a very important part of it – if you're going to change a teacher's* *teaching, get authentic and quality teaching, I think we need to have teacher educators in their different fields.*

The relationships built in the professional learning (PL) environment and their importance rang true for multiple respondents. Firstly, teacher learner (TL) participants talked of their relationship with the teacher educator (TE):

TL3: *Very high. I relied on them (teacher educator), once I got to know them.*

TL6: *I relied on (teacher educator) a lot because when I was doing my staff meetings, I would co-present with (teacher educator) and I relied on (teacher educator's) expertise, which was outstanding.*

TL7: *I would say I definitely rang and asked (teacher educator) for advice and used (their) knowledge, expertise and skills.*

TL9: *I'd say (teacher educator) was a very important part of it because for me . . . it was through (teacher educator) that I built up my knowledge and confidence and skills. It would have been a lot harder if I didn't have that support.*

Relationships built amongst TLs and other primary teachers not directly involved in the PL were also integral to a contented and fruitful PL experience. A myriad of comments supported this notion:

TL1: *I feel that programming with a colleague is much more beneficial than programming on your own . . . nutting it out together . . . . This year I'm working with a colleague who has a science degree . . . . I think he will be a really good influence for me . . . I think he will really help me with my planning for science.*

TL4: *Just hearing teachers say oh, are you doing this unit, how did you do that, I couldn't do this . . . I'd come back to school and I tried out a lot of things that other teachers had suggested, and I learned a lot from what they'd said.*

TL5: *My personal preference is the network meetings with small groups of teachers . . . I find that very helpful professionally. I find the big (PD days) useful in that you come away with information from a system perspective.*

TL6: *Being exposed to professionals, being able to collaborate with others and talk about different things . . . what they're doing in other schools. Having that whole forum where we can work together collaboratively to write a program . . . being able to have access to other people's programs . . . that just affirms I'm doing the right thing.*

TL8: *I do ask for feedback sometimes . . . . I still tap in sometimes with my old grade partner because (they) have post graduate recognition in science.*

TL9: *I think that last year – because I did have the opportunity to spend a lot of time with the document (syllabus) and I went to professional learning and spent a long time with (teacher educator) and other science reference teachers, that really sort of made things clearer for me and I was able to pass that on and run some staff meetings for the staff here, in order to be able to use the document themselves.*

TEs echoed the importance of the professional relationships and collegial sharing established among TLs and their colleagues.

TE1: *Support of colleagues is one thing because you're all talking from the same base . . . you can learn from that point . . . . I think being able to have that very close support . . . mentors, coaches and colleagues to draw upon their knowledge, have them to give feedback and get honest feedback from them. Being able to run ideas by them, and working in a team rather than working as an individual.*

TE3: *So throughout the year, as we moved into the teachers (teacher learners) having more experience, they were able to say I used this in this way, we got these results, the students were then able to do this, and they would share this with friends. So they'd lead themselves as opposed to me facilitating them all the time, and then I would also find . . . they'd link up with each other and say we did this this way, have you tried this, this worked really well.*

6.2.4 Learner discretion

Participants seemed aware of their behaviour as learners. Certain behaviours were named many times during participant responses; and were focused on the nature of being an adult, and also, a professional adult accountable to a system of professional peers. These behaviours, themed collectively as *learner discretion* were evident irrespective of participant confidence, self-efficacy and expertise in science and technology. They could therefore be positioned as being inherent to the professional adult learner. There appeared to be an influence at some level of an underlying motivation from the TLs to improve through learning, no matter how they came to be in the role of science reference teacher (SRT). Being a SRT had a status attached, and accordingly solicited a sense of duty in the role.

6.2.4.1 Motivation for learning

There were mixed motives (intrinsic and extrinsic) for learning evidenced from discourse in interview. The principles of learning continuum (PoLC) of the current study, as featured in the conceptual framework accounts for adult learners that show intrinsic or extrinsic motivation. This inductive subtheme extended the understanding of motivation, as it positioned adult learners in a professional context such as teaching, as demonstrating an underlying motivation unique to this context. That is, a motivation that comes from wanting to better one's professional standing; to choose to learn because it was the responsible choice that showed good judgement. One teacher educator (TE) summarised the mixed motivation they understood from the teacher learners (TLs):

TE3: *There were some (teacher learners) like me who had a passion for science. There were some that were just looking for a leadership opportunity anywhere they could get it, and there were others that were already leaders and science just got tacked onto everything else and they could do it.*

A nuanced view of motivation was influenced greatly by TL respondents. They commented:

TL6: *I like to challenge myself, and it was an area that I didn't feel confident in . . . . I asked if I could implement the new science and technology (syllabus). I put my hand up for it.*

TL9: *I just saw it as an opportunity for me to do something different – I thought it was going to benefit me as a teacher as well as an employee, I just took it on.*

TL participants also foregrounded their personal motivation for engaging in professional learning (PL) for K–6 Science and Technology; and take on the role of SRT.

TL1: *I think I saw a need and I thought with my prior experiences and what I know about science and technology . . . so I put my hand up.*

TL3: *I do like a challenge, so that was it, I wanted something different. I wanted to put my hand up, I thought I could do it, and I sort of challenged myself.*

Certain adult traits of perseverance in learning and utilisation of available resources to achieve learning goals became apparent. From participant responses, there appears to be a degree of difference between these qualities, and andragogical characteristics as presented in traditional literature on andragogy.

TL3: *I just keep looking and if I can't get the answer . . . . I will go and research until I'm happy that I've solved my own problem . . . having them (teacher educator) is invaluable.*

TL6: *No, not at all. I wasn't reliant on (teacher educator) for that (personal learning journey), but I was reliant on (teacher educator's) knowledge of how to present particular things.*

TL7: *Developing the scope and sequence . . . but in the reliance of my professional leaning, I wouldn't say I was reliant on (teacher educator).*

6.2.4.2 Status

From discussions with several participants in interview, there was an underlying impetus that came from just being an adult. Furthermore, the influence of being an adult in the teaching profession meant there were certain responsibilities that were part and parcel of the job. Participants, both TE and TL were tasked with teaching teachers at some level. TEs facilitated PL for the TLs, who then took that learning back to their respective schools (as SRT) and led PL in the school context. This pyramid model (as discussed in chapter four and shown in Figure 4.1) seemed to elicit a status for those educating others at any of the levels. Therefore, educators felt they had to demonstrate capacity; this too afforded a status.

TL4: *So I sort of step up to the challenge and become more confident for them (students), to build their confidence . . . . The more confident I am and the better I know the content, the more interested the children are . . . . They have to see me knowing a little bit about science as well.*

TL6: *Having to go back to the staff on many occasions – because that was my job, going back to the staff and having to go and practise it and practise it and be able to inform the staff, the input from the staff was really helpful.*

6.2.4.3 Duty

Duty is defined by the Cambridge Dictionary (2020) as "something that you have to do because it is part of your job, or something that you feel is the right thing to do". This definition encapsulates the premise of this inductive subtheme. When a leadership team member placed a SRT in the role, this stemmed a sense of duty. Duty in accepting the role; and, a duty to be an effective learner in the PL, in order to bring back that learning to other teachers in the school context. Two TL respondents summarised:

TL2: *They asked me before I had even thought about it and I just said yes.*

TL7: *I got put forward to do it by my AP… You could tell that people were there because they were sent if that makes sense.*

6.3 Subsidiary question three—what is the influence of the context of K–6 Science and Technology in professional learning?

The professional learning (PL) context foregrounds the perceptions of teacher educator (TE) and teacher learner (TL), and the setting where these teachers interacted. The undertaking of learning in primary science and technology certainly evidenced an influence. In the context of primary education, the learning area of science and technology is little understood. The majority of TL respondents were on the novice end of the stages of learning continuum (SoLC) and talked of little to no expertise in science and technology prior to PL. This influenced the observations made on TLs by TEs. The conceptual framework of this study accounted for these potential interpretations. Teacher voice highlighted the perception on the TE by TLs—that they were (as the teachers in the PL) operating at an expert level in the SoLC. Both TEs and TLs spoke at length about the nature of the PL setting and what worked best for them as learners.

6.3.1 Perceptions on teacher learner

The TEs articulated their observations on the TLs they interacted with in the PL of 2015. All three TEs agreed that there was a myriad of reasons SRTs were motivated to undertake the K–6 Science and Technology PL. Perceptions from the TEs were that at earlier points in the PL, TLs definitely exhibited traditionally pedagogical traits in learning—acknowledged by the subtheme, *presumptive child learner traits*.

6.3.1.1 Diverse motivation for learning

All three TEs articulated some notion of diversity in motivation to take up the role of SRT, and therefore, learning in K–6 Science and Technology.

TE1: *I think it's about their own passion for science, their own journey in leadership, but mainly around their own passion for learning. Whether they took it on, or whether they were just appointed, whether they're of age in teaching or it was just a job given to them. So there's a full spectrum of teachers.*

TE2: *Some of them (teacher learners) were absolutely fantastic, strong advocates.*

TE3: *There were some (teacher learners) that were sort of like me that liked science, so they wanted to learn about it because they perceive it like I do – it's the fun part of my teaching . . . so I wanted to make sure that I'm doing it right. But* *there were others that were just sort of told that they were going to be science reference teachers and that's what they had to do.*

Teacher learners (TLs), as classroom teachers, were also aware of diversity in motivation to learn. One respondent summarised:

TL7: *But just generally some kids like school and some kids don't. Or some kids are only doing something because you asked them.*

6.3.1.2 Presumptive child learner traits

Two of the three teacher educators (TEs) spoke to noticeable child learner or pedagogical traits amongst the TLs in their professional learning (PL) group, especially prior to PL in 2015:

TE1: *You've got to get them engaged . . . understanding how long they can stay focused for.*

TE3: *Most would say I have no idea what I'm doing; I've never done this before, regardless of their age . . . . There were some standouts (teacher learners), but they were very reliant. The science reference teachers became really good by the end of the year.*

Some TLs with less teaching experience were seen to have less autonomy in the role of science reference teacher (SRT), rather than in their own learning of K–6 Science and Technology.

TE1: *You had to form more into the mentor role, where you guided them a bit more rather than just doing the coaching. Some had a bit more experience, and some it was the first time they've lead a curriculum area. So, they needed a bit more mentoring. There was that flicking between mentoring and coaching.*

Even more experienced teachers honed their skills as a SRT as the year of PL wore on.

TL5: *What the PD last year did for me was it enabled me to take my knowledge and my understanding and put it out there for the other teachers in the school … gave me the confidence and the skills to enable that to happen.*

6.3.1.3 Adults learning

This study's principles of learning continuum (PoLC) articulates that adult learners can at different points in their learning journey champion theoretical pedagogical characteristics over andragogical, or more autonomous, adult learning traits, and vice versa. An example of this idea was put forward by a TE participant:

> TE1: *What you do with adults and what you do with children – what you're doing is moving through like a pendulum to scaffold and support, so they can move right through to fully independent learner*

Conversely, one TE elucidated the differences between child and adult learners.

> TE3: *The way I teach adults as opposed to children is completely different. I would never walk into a room and pretend I knew everything . . . . I would always say in my experience this has worked.*

TLs, as adults learning, were seen to always bring a positive to the PL setting, especially those who had a healthy self-efficacy. One TE described them as "passionate . . . engaged . . . enthusiastic . . . open" (TE1). Another TE commented on the general benefits of working with other adults and stated, "each time you interact with a group of people or a person, you go away with something from that" (TE2).

6.3.2 Professional learning setting

This theme is almost solely supported by TE respondents. Undoubtedly, the context of providing PL to primary teachers, a majority of whom with little to no experience in science and technology, influenced the setting in which learning took place. Science and technology, by nature of the learning area, has its foundations in the practical—science by doing, by investigating, by inquiring. This understanding came through strongly in interviews with the TEs, as they used their experience of teaching and learning and the dynamics of a classroom; knowledge of the practical learning area that is science and technology; and, perceptions of the adults they were teaching to shape the setting.

6.3.2.1 Practical/Hands-on

There was agreement among TE and TL respondents that a good quality science lesson had to be practical in nature and involve a hands-on approach. TEs put forward strong opinions in interview that teaching a group of adults, even under the banner of PL in primary science and technology should utilise the classroom approaches to a good quality science lesson.

One TE repeatedly spoke to the benefits of limited talk, and a focus on practical and engaging activities:

> TE1: *Because they're teachers, you've got to be active. Don't speak too long – like any good lesson, give your input in five minutes and then move into activity where people can engage and talk and learn.*

They went on to discuss that if the K–6 Science and Technology syllabus advocates teaching and learning with practical and hand-on approaches, there was a responsibility to use this model in the professional learning (PL) setting. To do otherwise would be inauthentic.

> TE1: *You've got to give people activities – doing things and discussing and working in groups. You can't talk about inquiry based authentic learning and then teach with some old model. You've got to model – if you want to be authentic and want them (teacher learners) to teach authentically, you have to model it.*

The literature on learning in general supports the idea of limited teacher talk. This notion was articulated when a participant stated "watching people talk for about three hours and the fact that you shouldn't talk for more than about seven minutes was always fascinating to me" (TE1).

6.3.2.2 Pedagogical modelling

Pedagogical modelling is considered in the current study as a strategy for use in PL. It entails demonstrating, undertaking and explaining practice to the adult learner in order to establish pedagogical practice for classroom teaching and learning. Although there are acknowledged differences between adult and child learners, when a learning context is relatively unknown, pedagogical modelling offers a potential safeguard of understanding.

One TE viewed pedagogy in the classroom as not dissimilar to the art and practice of teaching in the PL setting, highlighting the amount of scaffolding as the main difference:

> TE1: *I don't think there's much difference—good pedagogy for children should be the same as good pedagogy for adults . . . . You might need to scaffold more (for children).*

As a strongly skills-based curriculum, the NESA Syllabus for K–6 Science and Technology (2012) requires the teaching of skills, which opens the door to the use of pedagogical modelling.

> TE3: *So I think that that is one of those things that you learn from either doing it or working with someone who has done it, or watching someone.*

The background of the cohort in the PL setting was also linked with the use of pedagogical modelling.

> TE3: *There were a few standout teachers who had either had experience in science themselves – one or two science reference teachers that had degrees in science . . . The rest of them were more on the pedagogical side . . . . They weren't confident enough to make changes where they needed to, because they were still at that base level of learning.*

6.3.2.3 "Classroom" management

Alongside the usefulness of the modelling of pedagogy, another parallel between the classroom and the PL setting was made. This related to the management of the wide array of learners in the PL setting, and the likeness of this management to a classroom of students.

> TE1: *(Teacher learner autonomy) It's like a class. Some are very autonomous and some needed a lot more support.*

> TE3: *So you would see the people and – I suppose it's the same as the classroom. You see the people that you're able to present something to, they take it, they run with it . . . and you see others who are just sitting there and did nothing unless you went to them and kept sort of holding their hand and pushing them along.*

6.3.3 Perceptions on teacher educator

The preconceptions on the teacher learner (TL) were an acknowledged element of this study's conceptual framework. The discourse from interview brought to light presumptions on the teacher educator (TE) by some respondents as being confident, an expert and a leader of learning. This was unanticipated because of the known background of the TEs. All three TEs are practising primary teachers, peers of the TLs, and although they acknowledged an interest in science, had no formal tertiary education or experience in the field. Even with such a background, some TLs still spoke to the leadership, expertise and confidence of the TEs.

6.3.3.1 Expert in science and technology

Taking on the role of TE as the three education officers did in 2015 produced a perception by some TLs that they were experts in primary science and technology.

> TL9: *Anything that I wasn't 100 percent on, I would refer to (teacher educator) and (teacher educator) was very helpful in answering anything that I couldn't.*

Sometimes this was contrary to the personal perceptions of the TL themselves:

> TE3: *I think they (teacher learners) see me as the science expert.*

This TE went on to say:

> TE3: *I found it difficult to go into schools with people (teacher learners) who had more teaching experience than I'd been alive.*

Perceptions made by TLs needed to be challenged in some cases:

> TE1: *People had a perception of what I might have been like because of not seeing me in that role (as science and technology teacher educator) and because they thought it was a new role.*

At other times the notion of the TE lacking in some capacity was not perceived by the TLs, but a self-perception of the TE themselves.

> TE3: *(On a perceived lack of experience) No, it was just in my own head.*

The antidote appeared to be a building of confidence:

> TE3: *The more confident I became, I suppose the more confident they (teacher learners) were at trying what I was saying, and then the more they tried it the better they got at it.*

6.3.3.2 Confident

From the TE point of view, confidence in the role and in their abilities built across time. For many TLs, the perception was that the TEs began the professional learning (PL) with inherent confidence as a primary science and technology educator.

> TL6: *Because it was a new syllabus . . . . I was in a situation where I needed a lot of direction in order to move forward in being able to be confident in teaching science scientifically and technologically . . . . I really was at the beginning of my journey.*

6.3.3.3 Learning leader

Teacher voice in interview supported the basis that a learning leader fosters relationships that encourage and support individual learning. Therefore, the level of reliance on the TE as learning leader varied amongst TLs. Critically, the TE was still leading learning through the encouragement and facilitation of individual learning no matter how much they were relied upon:

TL1: *If I had an eager question . . . . (Teacher educator) came to my school to check-in with me . . . (teacher educator) gave me the idea of doing a stocktake of resources, which I did and we now have that in operation in our school. (Teacher educator) has given me guidance.*

TL5: *I wouldn't describe it as a reliance . . . I wasn't seeking (teacher educator's) approval to tell me what to do, but I certainly found their inputs valuable and they brought a lot of good ideas to the table.*

A learning leader challenges preconceptions that are in fact misconceptions.

TE3: *You'd see people's faces (teacher learners) when you first walked in, they'd see how young you are, they'd look at you and go what's this idiot doing here, are you lost and then by the end of a PD or by the end of the year, they had a bit more respect about what I was able to bring to them.*

6.4 Summary

The evidence from teacher participant voice is critical to this case study for the substantiation of themes and their subthemes. Adult learners, by their own account are changeable learners. Their self-efficacy; confidence; level of expertise; and, learning characteristics all evidence some changeability. Further to this, their environment has a notable influence on this changeability. Many teacher participants were called on to upskill for professional purposes in a learning area that was unfamiliar, uncomfortable and underutilised in their teaching praxis. This environmental context has its own influence on the adult learner and the level of support; structure; and, scaffolding they require for learning gains. Multiple parallels were drawn between the adult and child learner, as well as the professional learning (PL) setting and the child classroom. A changed environment for the adult learner interacts with a change in learning characteristics, and vice versa. Inexpert novice adult learners strongly represented traditional pedagogical traits, and as expertise grew, so did the evidence for andragogical learner characteristics. Alongside this, there was a recurrent notion represented across all levels of expertise and experience of an intuitive, discerning and self-determined adult learner. This was significant as a distinct showcasing of adults in a professional setting that were undertaking learning, irrespective of whether they demonstrated pedagogical traits in their learning.

Chapter seven delves into, with more depth, the themes and subthemes; and, also highlights their interconnectivity. This discussion chapter is theoretically framed, and once again recompenses the power of teacher voice in this study.

Chapter 7: Discussion

Introduction

Chapter seven discusses the phenomenon of the nature of the adult learner by subsidiary research question with respect to the themes garnered in this study, alongside the adult education frame assembled from the literature. The correlated nature of themes is chronicled, and each theme is also discussed in its own right as a significant contributor to the findings of this study. Participant voice is used throughout, in reverence of the philosophical decisions and subjectivity of the present study. Participant responses significantly underpin the discussion of this chapter and are a critical stepping-stone to conclusions and recommendations made in chapter eight of this study. The discussion highlights the noteworthy influence the environment of the adult learner has on their internal identity, and equally how that identity effects the environment. Rachal (2002) referred to these internal and external adult learner factors as “situational variables” (p. 224). Pedagogical and andragogical learner traits are ends on a spectrum, but they are not hierarchical—and so pedagogical traits do not necessarily always precede the andragogical. The findings of this study also evidenced the influence of the bounds of the learning context on the learner. Learning for the participants of this study was confined to K–6 Science and Technology for a new curriculum, in order to prepare for classroom praxis and the presentation of that learning to school colleagues. These professional precincts had a regulating influence on the autonomy and agency learners were able to exhibit, which challenges negative notions of learner dependence.

7.1 Subsidiary question one—what is the relationship between a new curriculum; teacher self-efficacy; and, technological pedagogical content knowledge (TPACK)?

Subsidiary question one established the interconnectivity of external and internal environmental influences on the adult learner in this study’s context. The notion of the internal speaks to influences within the learner—such as their thoughts;

feelings; and, actions. Whereas external influences are inclusive of all environmental factors outside the learner—for example, workplace responsibilities; course requirements; and, educational background. Laurillard (2012) acknowledged the internal and personal qualities that adult learners bring with them to learning, such as learner characteristics; conceptions; skills; and, motivation. Laurillard (2012) also posited that these internal learner influences must be balanced by instructional goals and curriculum; put differently, balanced by influences on the learner that are external to them. Diep, Zhu, Cocquyt, De Greef, Vo, and Vanwing (2019) represented this interplay between the learner and environment in their study of adult learners in the context of online and blended learning with the terminology of subjectivist (for internal learner orientations) and positivist (for external influences on learning). Knowlesian adult learner self-direction is a defining trait of andragogy (Knowles, 1977). However, this study contends that alongside this, adult learners require the external influence of elements such as aims and objectives; and, specific subject matter content and pedagogy. Several studies align with this view regarding the importance and need of the external for the adult learner, claiming that these external constructs provide a sense of security in learning (Milheim, 2012; Phillips, Baltzer, Filoon, & Whitley, 2017).

The terms internal learner force (ILF) and external learner force (ELF) are introduced and will be utilised as part of the terminology of this study's findings. These terms are necessary to qualify discussion between the internal aspects of the adult learner and the influence of the external environment. When data were analysed in this study, the themes appeared to intuitively fall within the categories of learner identity (the internal) and learner environment (the external). These are substantial findings for this study. The need to discuss these categories is therefore important to understanding the nature of the adult learner. The use of lexicon specific to this study works in several ways—to remove ambiguity of meaning; to encompass examples from the literature that apply to and justify the terminology; and, to provide a benchmark for discussion on which the conclusions of this study are built. The presence of the term force in both ILF and ELF is considered, and for the science educator may conger the idea of forces in physics. A force in physics is understood to be:

> a push or pull upon an object resulting from the object's interaction with another object. Whenever there is an interaction between two objects, there is a force upon each of the objects. When the interaction ceases, the two objects no longer experience the force. Forces only exist as a result of an interaction (The Physics Classroom, 2020).

The notion of force in ILF and ELF parallels this definition because of the interactional nature, the back and forth (in a push and pull action). Isaac Newton, the foundational physicist for the understanding of forces developed three laws of motion. The third is the *law of interaction* that states for every action there is an equal but opposite reaction. Simply put, what will become evident from this study is that learning evidences an action-reaction between ILFs and ELFs.

The NESA Syllabus for K–6 Science and Technology (2012) is an ELF, so too, the theoretical construct of TPACK. Teacher self-efficacy is a belief about self, a self-perception and thus aligns with learner identity as an ILF. The syllabus and the pedagogical insights from TPACK exerted a force on the learner, and teacher self-efficacy as an ILF was impacted. However, the interplay between ELFs and ILFs is not unidirectional, nor one-sided. Thus, teacher self-efficacy, whether low, high, or somewhere in between, exerts its own force on the environment of the learner. For instance, some teacher participants with identified low self-efficacy had an overreliance on Primary Connections in their science education praxis. Figure 7.1 uses findings and teacher participant voice to illustrate a simplified scenario of interplay between the reflection and action of the internal environment (the learner) and the environmental and contextual factors—that is, the ILFs and ELFs. Learning in this study's context can be truncated as soon as the push and pull between the ILFs and ELFs is broken anywhere along the learning journey. The highlighted sections of Figure 7.1 show areas where learning has the potential to be curtailed.

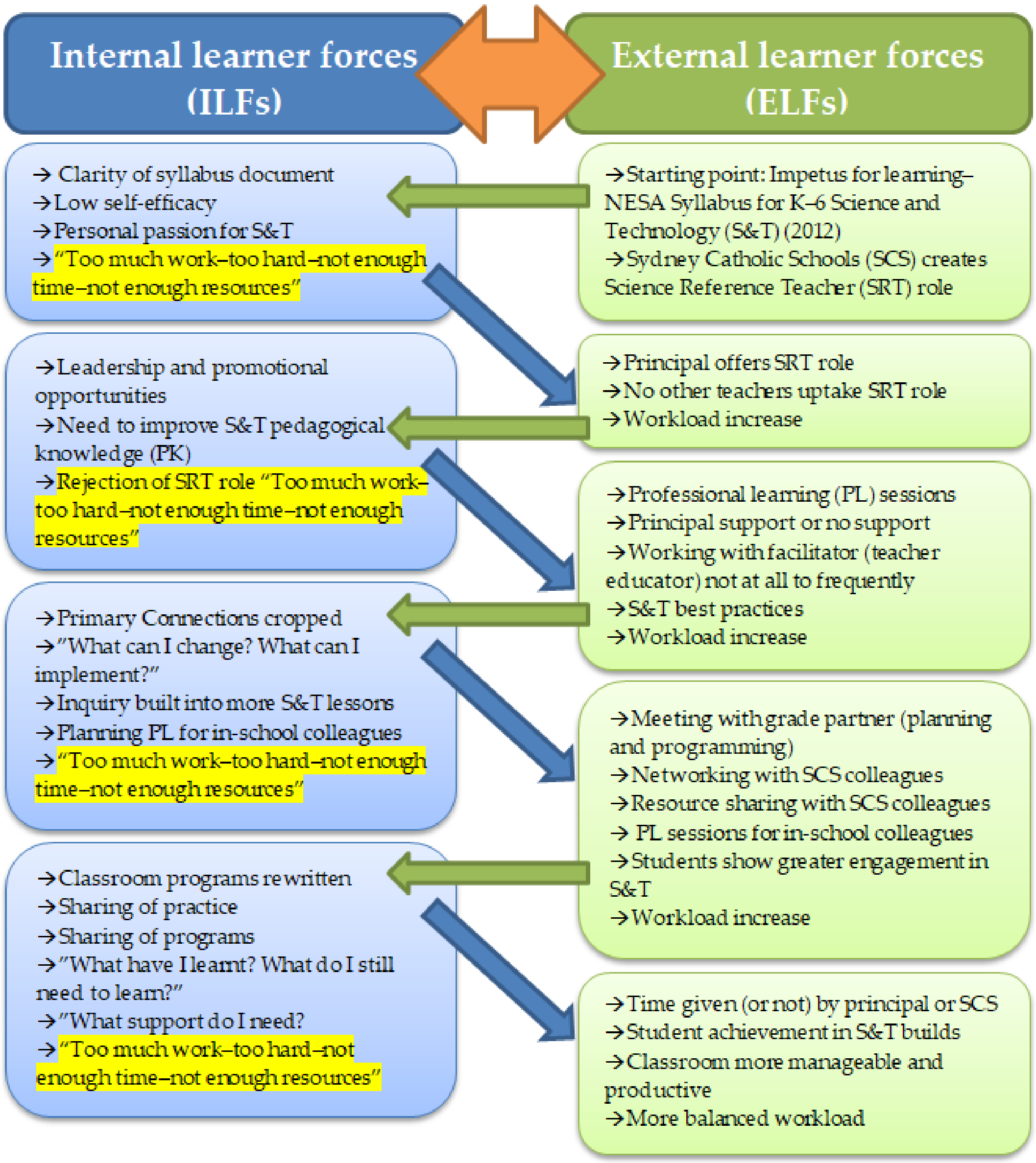


Figure 7.1 The enduring interplay between ILFs and ELFs

7.1.1 The new curriculum effect

The NESA Syllabus for K–6 Science and Technology (2012) brought strong impetus for teachers to initiate a learning journey in science education. At the beginning of 2015 it was a new curriculum, an ELF that exerted a pressure on teachers. This pressure was received by some with positivity and used as an agent for change. Debarger et al. (2017) contended that quality curriculum is a key strategy for purposively altering science education praxis. The findings of the current study support this notion when applied to the learning journey of teacher participants.

Perhaps here the teacher participants were a microcosm of the positive effects that moved through the teacher professional community upon the introduction of this new curriculum—further study would be needed for this assertion. For teacher participants, the NESA Syllabus for K–6 Science and Technology (2012) redirected focus to the learning area; revitalised pedagogical practice; and, contributed to the wherewithal to use resources like Primary Connections correctly and not in substitution of the syllabus.

For many teachers in this study, the NESA Syllabus for K–6 Science and Technology (2012) shone a light on weaknesses in their science education practices. Several teacher participants acknowledged that primary science and technology had been somewhat of an afterthought in their teaching and learning regime—"I was teaching it, but I wasn't teaching it well" (TL6). They disclosed that K–6 Science and Technology "does get pushed aside" (TL3) because teachers are "not familiar with it" (TE3). Here teacher participants demonstrated a level of reflectivity on their previous practice, which is acknowledged as a marker of the adult learner by education theorists such as Mezirow (1981, 2000). This reflectivity is internal to the learner, and as an ILF, can move a learner towards a learning environment that fosters change and learning—if the appropriate ELFs are engaged. Rashid (2017) claimed that changes in consciousness were collectively one of three critical adult learning principles; that is, the aptitude to reflect on experiences in a particular context. This certainly was concurrent in the finding of this study that foregrounded teacher participant reflection. This preserves Mezirow's (1981, 2000) *critical reflection theory* which centres on learner experience and reflection and its acute influence on learning.

The belief that primary teachers were not teaching K–6 Science and Technology soundly was established from participant responses in interview, and linked with poor teacher self-efficacy. Mitigating low self-efficacy is critical as teachers are considered one of the most significant influencers of student achievement (Ham et al., 2015). Teacher participants agreed with this influence on the student, evidenced when the majority heralded its importance. They could "see by the student's reflections . . . that their evaluations were more scientific than what they were" (TL1) and that "participation" (TL1) had improved, as well as, the "passion" (TL1) for K–6 Science and Technology. Students could "sense when the teacher is interested in something, and when the teacher knows something, or when the teacher is confident in something" (TL8). Teacher self-efficacy as an internal learner force (ILF) is an adult learner musing—a thought about self that is made when external factors draw it out. Previously, teachers had overshadowed their low self-efficacy in K–6 Science and Technology with a proficiency in other learning areas that were deemed more important—"its's not something that I can do as easily as I do English and maths and those subjects that I've taught more of" (TL3). The introduction of a new curriculum refocused teacher consciousness back on the learning area of K–6 Science and Technology.

Of all the elements in the TPACK framework, it was the pedagogy of K–6 Science and Technology that was acknowledged as the key element in effectively teaching the learning area. Pedagogical knowledge (PK) comprises the methods, processes and approaches used to teach a learning area (Koehler et al., 2013). The present study, upon review of the literature, foregrounded inquiry learning based on a student-centred hands-on approach as critical to PK in K–6 Science and Technology. Goodnough and Hung (2009) were clear in their advocacy of PK as the most valuable tool for teacher science education reform. The vast majority of teacher participants concurred that "pedagogy is the most important to get right" (TE1) because "if you get the pedagogy right, then everything goes right" (TE1). The benefits of PK include an influence on student learner attainment, "where the children are really inquiring, they're asking questions . . . thinking independently . . . participating . . . feeling confident . . . they're learning new things" (TL6). This coincides with views in the literature such as that of Van Driel and Berry (2012). The syllabus document itself was for some participants the only benchmark they had to best teach K–6 Science and Technology, in other words, of PK understanding. The document extends beyond content knowledge (CK) and what should be taught. Previously, several participants were teaching K–6 Science and Technology with very little focus on the inquiry and skills of the learning area—lessons would be built on "what you'd read in books, rather than actually fair testing and experimenting" (TL4).

Upon the introduction of a new curriculum and the corresponding professional learning (PL), an overwhelming number of teacher participants replaced the habitual use of Primary Connections. For many participants the deep attachment to Primary Connections was due to a lack of knowledge in and experience with science education. This reliance on external fixes is highlighted in the literature on primary science education in Australia and countries like the Unites States (Fraser, 2010; Hume, 2012). The commonplace predicament was that "here's Primary Connections, and I'm just going to grab onto that really tightly and teach whatever is in there because I wouldn't have the background knowledge that I have now" (TL4). The problem lies is utilising Primary Connections in its entirety, as it is a resource intended for use with discernment, not a cover-to-cover manual for teaching K–6 Science and Technology. Teacher educators in the current study were aware of the overuse of Primary Connections, understanding that most teacher learners "took it as the whole science program, they had taken it on board, and they were very reluctant to let it go" (TE2). Promisingly, after a year of PL for the NESA Syllabus for K–6 Science and Technology (2012) all participants either no longer required Primary Connections or began using it sparingly and as a resource only. This change corresponded with a building of K–6 Science and Technology expertise and experience across 2015. Equivalences to Grow's (1991) *staged self-directed learning model* (SSDL) appear in that teachers exhibited a stage one dependence on Primary Connections, based on limited learner experience and expertise despite their sometimes long-serving experience as a teacher professional. The release of the use or overuse of Primary Connections was praxis-shifting for a number of participants, teachers "could see a whole new world and a whole new version" (TL6) of what could be done and then they "started to really love science" (TL6).

The findings of this study indicated a neglect of K–6 Science and Technology in the primary school context. Hume (2012) presented this long-term neglect, citing the speculative view of science as difficult to understand and being unconnected to everyday life. Several participants noted this view as being representative of their perceptions prior to the introduction of the NESA Syllabus for K–6 Science and Technology (2012) and their undertaking of PL. In the context of this study, this perception by the learner, and ILF, could have a significant impact on whether a learner initiates or even continues a learning journey. A change was evident for many teachers in this study which placed a renewed focus on K–6 Science and Technology. Previously, many teacher participants "weren't really doing much science . . . prior to the new syllabus being taught" (TL8) and there also wasn't "much investigating" (TL8) because K–6 Science and Technology was "too difficult or too messy" (TL4) and would just be skipped over. At times the renewed focus on K–6 Science and Technology was forged from the ground-up, by teacher learners (TLs) coming back to their schools and classrooms with a new or renewed expertise in and passion for science education. Also discussed was a top-down focus on the learning area, beginning with Sydney Catholic Schools (SCS) investing time and resources into the NESA Syllabus for K–6 Science and Technology (2012). This in turn predisposed the focus individual school principals in the system placed on the learning area, and the delegation within their schools all the way to the classroom teacher level. Under the right conditions, both ground-up and top-down approaches were capable of affecting positive change and a focus on K–6 Science and Technology, one via the "internal" (TE1) motivation of the teacher and the other due to "the support given by the school" (TE1) with the principal being "vital in the process" (TE1). Here again, it is evident that the interplay between ILFs (learner expertise, learner focus, learner passion) and ELFs (system support, principal support) were both capable of initiating successful learning journeys for teacher participants in K–6 Science and Technology.

Fundamental to a focus on K–6 Science and Technology; a revitalised understanding of science pedagogy; and, the shifting of habitual pitfalls such as the misuse of Primary Connections, was a general consensus of improved practice. Teachers were now teaching K–6 Science and Technology more often, with higher order pedagogical knowledge, and for a number of participants, using teaching programs they had written themselves based on the NESA Syllabus for K–6 Science and Technology (2012). Ownership in teaching was transformational for a number of teacher participants and it was noted that "you're more likely to teach something that you write" (TL3). This ownership idea draws on the principles of teacher agency in which a teacher exhibits autonomy of choice to best influence student learning. Biesta et al. (2015) linked a teacher's skillset, knowledge and personal traits as greatly influencing teacher agency. In this incremental way, a teacher builds skills and expertise, which further influence an increase in self-efficacy—that appropriates greater teacher agency in choices made for student learning at the classroom level. The importance of building teacher agency in the praxis of K–6 Science and Technology was confirmed in the findings of this study.

7.1.2 Change and its challenges

One challenge is well understood in the literature as a limitation on teacher learning, and that is time (Durksen et al., 2017). In concurrence, time was a precious and limited resource for participants in the present study. Time encompassed that incorporated for professional learning (PL); discourse with colleagues; planning and programming; and, for reflection and evaluation. As a restricted resource it resulted in teachers in the system of Sydney Catholic Schools (SCS) withdrawing from the learning journey for K–6 Science and Technology. They "just resented the amount of work that they had to do that was extra" (TE3). Although teacher learners (TLs) and teacher educators (TEs) did not appear to embody this negative reaction, they spoke many times about teacher colleagues and other science reference teachers (SRTs) outside of this study that responded in this manner. Even when a TL was already in the role of the SRT and on an established learning journey, time for that learning was more often than not in deficit. Participants mentioned specific examples when they requested time for PL or to teach colleagues, only to be given "pretty much nothing" (TL3). Time or lack thereof, is an ELF capable of interfering with the interaction between the learner and their environment, and thus impeding or even ending a learning journey. In this study's specific context, and reflecting back on the idea of forces between the learner and their environment, once the push and pull interaction stops, so does the learning. Some participants encroached even further on their personal time in order to continue their PL journey.

Technological pedagogical content knowledge (TPACK) is an established framework by which to teach K–6 Science and Technology with technology, pedagogy and content as separate and interconnected constructs (Ocak & Baran, 2019). The NESA Syllabus for K–6 Science and Technology (2012) was written based on a constructivist approach to learning. That is, a particular pedagogical approach that places students at the centre of learning and builds upon their knowledge and experience (Julyan &

Duckworth, 2005). Technology is inbuilt in the NESA Syllabus for K–6 Science and Technology (2012) through the integration of information and communication technology (ICT); the content knowledge of the learning area of technology; and, the skill of working technologically. As such the TPACK framework worked as an external marker by which to compare the science education praxis of teachers. It emphasised teaching and learning insufficiencies, in a similar manner to the syllabus itself—which influenced how the teacher gauged their teaching work and reflected on their self-efficacy. Within the framework of TPACK it was technological knowledge (TK) that was a recurring and acknowledged shortfall for the majority TEs and TLs, because they were "not so confident" (TL3) in addressing it in praxis.

Evident in the findings of this study was the inkling that once the focus on the NESA Syllabus for K–6 Science and Technology (2012) diminished a teacher may revert to teaching as they had always done—rarely, poorly, and without a technological and pedagogical focus. This denotes impermanence to the learning associated with the NESA Syllabus for K–6 Science and Technology (2012). For learning to have taken place, and according to its definition canvassed in section 2.6 of chapter two of this study—learner change in behaviour or self must be perceptible across different contexts, therefore, must be repeatable. Practice reversion indicates that the learning never took place to begin with as learner changes were not demonstrable time and again. A return to previous practice was evident in teachers who weren't a part of this study; but was discussed by TEs and TLs in reference to colleagues. The challenge remains "trying to get people out of their old habits and ways and show them that you have to do a bit of work and program new programs, when they all just went to Primary Connections or this or that" (TL7). Here, perhaps teacher agency and autonomy, an ILF, assumed within its construct was counterintuitive to teacher learning. Aptly applied ELFs would force teacher accountability and improve praxis in these circumstances where motivation to learn is non-existent. In adult education, an adult's life situation and where they are in their stage of life is influential on their learning (Rashid, 2017). This was certainly true for teachers demonstrating practice reversion. They were often older, with more entrenched practices and some were only a few years from retirement. The entrenchment and challenge to change comes from perceptions that they had been educating children "for this amount of years and (had) always done it this way" (TL7).

Where there was impetus and motivation, but limited support, change through curriculum implementation was curtailed. The meeting of all support needs, as with learners in the classroom, is a mammoth undertaking and difficult to perfect. In the context of this study, some teacher learners (TLs) were not aware of the support available and conversely teacher educators (TEs) may not have known who required support. The challenge of meeting support needs is ameliorated by time; communication; and, differentiation. TE participants were aware, at least theoretically, of the power of communication—"I always liaised afterwards with them (teacher learners)" (TE2); and, differentiation—"Different science reference teachers, different schools, different principals . . . some people want to have support, some people need more support" (TE1). TEs recognised that "some need support with science content, and some need support with actually managing the situation, managing the staff" (TE1). As for time it remained a restrictive factor to the meeting of support needs in a practical sense and beyond this, in the theoretical understanding which fortifies the work of Darling-Hammond et al. (2017) who recognised adequate time as one of the six pillars of effective professional learning (PL).

Subsidiary question one acknowledged the relationship between the factors of a new curriculum, teacher self-efficacy, and TPACK, among other internal and external learner factors termed internal learner forces and external learner forces (ILFs and ELFs) for this study. It highlighted that such forces can initiate and provide impetus for the adult learner to begin their learning journey. Critical to this learning journey is the continued interaction between ILFs and ELFs. Adult learner thoughts, feelings and actions are powerful ILFs that have the potential to buoy or hinder the learning journey. Furthermore, it is imperative that ELFs support the internal rhetoric of the learner. Learning in the context of this study was incumbent on change, and subsidiary question one has shown that change may be taken positively by the adult learner, but at times, also negatively.

7.2 Subsidiary question two—how do factors such as a new curriculum; teacher self-efficacy; and, technological pedagogical content knowledge (TPACK) influence the teacher educator and teacher learner?

Subsidiary question two elucidates how the relationship between ILFs and ELFs influences the adult learner. The adult learner is a malleable learner, with propensity for change. Unlike assertions made from foundational adult learning theorists such as Knowles (1968, 1970, 1977, 1980, 1984, 1998) and Merriam (2001, 2007, 2014), intrinsic motivation did not represent the main form of motivation in this study's group of adult learners. In the context of this study, it is change from comfortability for the learner that is the main ingredient for learning. The adult learner is self-aware, and because of this they provide valuable insight into how they achieved learning. For teacher participants with expertise, comfortability in the learning of K–6 Science and Technology was innate—it was an ILF. These teachers "enjoy doing things (by themselves) and know (they) can independently go off and learn" (TL7). For teacher participants on the novice end of the stages of learning continuum (SoLC), their comfortability in the learning undertaken in this study came from ELFs, that is, structured professional learning (PL) and collegial support. "The way that the in-servicing was implemented was very structured and very paced in order to be able to" (TL6) use the syllabus document effectively; and PL was practical, "it was fantastic because you could really put it into practice" (TL6). A commonality appeared among teacher participants that existed, regardless of years of teaching experience; age; level of expertise in K–6 Science and Technology; self-efficacy; and, also gender. Learner discretion appeared to be the leveller, a trait common across the teacher participants which resulted in teacher judgement being used intelligently to fill a professional need in their school; advance their career; and, extend their personal learning journey in K–6 Science and Technology.

7.2.1 Learner plasticity

Foundational adult education researcher Malcolm Knowles (1968, 1970, 1977, 1980, 1984, 1998) developed in depth theory about andragogy for the adult learner. Merriam (2001, 2007, 2014) built her work heavily upon Knowlesian theory. The Knowlesian adult learner is autonomous in their learning, intrinsically motivated and relies heavily on their own experience. Only the most expert of the teacher participants seemed to function as a learner within typical Knowlesian andragogical traits. The overwhelming majority of teacher participants verified that pedagogy is not relegated to children alone; it pertains to certain adult learners and is not age dependent. This by default challenges andragogy as the theoretical umbrella representing all adult learners. Gravett (2005) articulated that the presence of a universal adult learner is a fanciful notion, which is in direct contrast to the unique learner lineage of life and educational experiences. The adult pedagogues of this study at times acknowledged the synonymy with child learners in the construct of the classroom—"we're no different as learners to the children . . . I don't know why we think we get older and become different" (TL3) as learners. There appears to be more to this comparison of the adult novice and the child learner than just a lack of expertise.

In many theoretical concepts in the literature from Grow's (1991) staged self-directed learning (SSDL) to Canning's (2010) three levels of learner transition, there is a gradual transference of the learner from low confidence and dependence to robust confidence and autonomy in learning. Similarly, within the adult education theoretical frame, pedagogy may be positioned as representative of the dependent learner, with limited confidence and expertise; and andragogy as the confident, autonomous learner. Teacher educators (TEs) recognised the diversity present among teacher learners (TLs) and that "the amount of dependence was very much about individual learners, also where they are up to in the process" (TE1) of learning. The findings of the current study are concurrent with these adult education theoretical frames of learner confidence and autonomy building with greater experience and growing expertise. This demonstrates a level of changeability in the learner, and in the traits that they exhibit. Such an idea moves away from the strict adherence to a learning style as advocated in theories such as the *mind styles model* (Gregorc, 1984) among several others (see Table 3.3 in chapter three of this study). These shifts in the adult learner are capable of occurring long-term over a lifetime from childhood to adulthood, as may be evidenced across the learning journey of the lifelong learner. However, the adult learner is also capable of significant gains in expertise and autonomy of learning within a matter of months as was substantiated across the professional learning (PL) in the current study. Therefore, allocating an adult learner to the realm of andragogy because of chronological age or even teaching experience falls short of capturing the true and nuanced understanding required of them. Each adult learner is unique and learner plasticity captures the difference between each of the adult learners in this study.

Changeability of the adult learner across a learning journey is also critical to this discussion, as learning seemed dependent upon change in learner characteristics—in direct contrast to theoretical constructs of adult learners identifying with a fixed learning style (Clarke, Lesh, & Trocchio, 2010; Deniz, 2013). Adult learners, outside of identifying with pedagogical or andragogical traits, evidenced a learning personality, a manner in which they were accustomed to approaching learning. This *modus operandi* was either reinforced by the PL experiences of 2015, or sometimes even challenged when learners were asked to engage with protocols of learning that were not their preference, with one participant commenting that they "didn't like the group sessions" (TL3). Again, many teacher participants demonstrated malleability as they adapted to the particular learning mode of the PL sessions in this study. Ayers (2011) argued that responding to every perceived learner want or learner preference moved towards a "customer service mentality" (p. 3), and not necessarily impactful learning. Laurillard (2012) built on this point further and claimed that learners should be supported to extend beyond their favoured learning approaches and methods of operation. In this study, many teacher participants saw themselves as independent learners, seeking knowledge and understanding independently. However, in the milieu of teaching there are clear benefits to group PL sessions over just independent learning. The balance becomes learner independence, which speaks to autonomy in learning and knowledge-building group interactions—to "feel pretty independent" in learning and yet still "enjoy the professional learning with others" (TL7).

Again, push and pull forces exist for the learner between the internal learner force (ILF) of preference for independent learning and the external learner force (ELF) of group session PL. For this study, the optimal learning occurred when the forces were interactional, each challenging the other. Isaac Newton's first law of motion, the *law of inertia*, states that an object at rest will remain so or an object in motion will stay in motion unless acted on by an unbalanced force. Alternatively stated, things will not change unless something forces that change. This contemplation aligns with findings from the present study, that learning for adult participants was incumbent upon an unbalanced force—such as an antagonism to the way they were teaching K–6 Science and Technology and their level of expertise. Those teachers who checked out of learning early upon the release of the NESA Syllabus for K–6 Science and Technology (2012) were not influenced by that unbalanced force, for example the syllabus document itself; reflections of their low self-efficacy; or, deficits in K–6 Science and Technology pedagogical understanding. Thus, they remained as they ever were, stagnated or in an unchanged pattern of praxis, not open to the idea that "education is an experiment, we try things, we learn, we grow" (TL4). Rashid's (2017) notion of changes in consciousness as one of three critical principles of adult education is supported here. Teacher participants reflected upon their experiences and environment in order to engage with change for learning. Mezirow's (1981, 2000) foundational work on reflection showed how deep reflectivity could go for the individual learner. He provided a breakdown of changes in consciousness and theorised a learner moves from objects of reflectivity which are the habits of perceiving, thinking and acting—into the higher order state of consciousness, and finally critical consciousness (Mezirow, 1981). It was evident for teacher participants that objects of reflectivity had to be challenged in the their learning journey, that is, the way that they perceived, thought and acted in primary science and technology practice; what Mezirow (1981, 2000) referred to as habitual "objects of reflectivity" (p. 12).

7.2.2 Learner self-awareness

The current study composed data that time and again showed the understanding participants had of their deficits and strengths in primary science and technology teaching and learning. One such area of self-awareness was that of self-efficacy. Seifert (2004) connected self-efficacy theory with motivation, based on the notion that motivation is dependent upon beliefs and emotions. This view aligns with findings from this study that linked an increase in self-efficacy upon PL across 2015 to improved motivation. Munns and Martin (2005) in reference to child learners (students) claimed that motivation as cognitive and thought-based preceded the behaviour and action-based notion of engagement. This study, although focused on adult learners, evidenced the same order of operation—motivation before engagement.

Once again, adult learning in this study brings together a significant crossover with child learning in line with theorists such as Samaroo et al. (2013) that proposed pedandragogy—the combination of the learning loci of pedagogy and andragogy. Upon improved motivation came the engagement by teacher learners (TLs) as seen through increased risk-taking in the classroom—"now I was going out of my comfort zone teaching things that I never thought I could teach because I had the confidence" (TL6); a greater focus on teaching K–6 Science and Technology—"I'm bringing science in wherever I can" (TL7); an improvement in teaching the skills of working scientifically and working technologically—"teaching the actual pedagogy of science, like how to integrate skills together" (TL1); improvements in planning and programming—"I think I'm a better planner, a better programmer" (TL7); and, the use of more effective pedagogy for K–6 Science and Technology—"I think my belief in how science can be taught has definitely been altered and been challenged" (TL8). Motivation is needed for engagement and learning, but in contrast to Merriam's (2001, 2007, 2014) allocation of intrinsic as the premier form for adult learners, this study posits that it is not the type of motivation which should be the focal point, but rather its very presence or absence.

Teacher participants often spoke interchangeably about confidence and self-efficacy, discussing a corresponding increase of the two ILFs. An increasing belief in one's own ability coincides with an enhancement in confidence—"I've always liked to teach science and technology, I think I've just become better at it, so now I feel confident" (TL4). These findings support works from the literature such as Norton (2019) that show the relatedness of self-efficacy and confidence. Further to this relationship, confidence has been linked to teacher enjoyment (Martin, 2006). Again, several teacher participants spoke of their new found gratification in teaching K–6 Science and Technology and the flow-on effect of greater student pleasure for the learning area. Previously those "who wouldn't have been interested in science are now saying the kids love it, and I can't wait" (TL3) to teach it. There was a strong building of competence among teacher participants which improved confidence, that manifested in enjoyment for teacher and student alike and a genuine "passion" (TL1) for science education whereby "science was actually not only fun, but it was part of everyday life" (TL4). According to Grow's (1991) staged self-directed learning model

(SSDL) learners become a more interested party in learning when the teacher takes the role of motivator and guide. In this study, with its focus on adult education, teachers first became motivated through competence and confidence which results in more interested students, a far cry from previous experiences "when the children came to the class and said they didn't like science" (TL4). Therefore, teacher participants that began their learning journey lacking the ILF of a personal passion for K–6 Science and Technology were able to develop it through impactful PL and collegial support, gaining greater comfortability with the learning area.

Overwhelmingly, TLs in this study cited a very specific ILF as the reason for their area of personal expertise in K–6 Science and Technology. As an ILF, personal expertise was heavily influenced by the teaching stage of participants who were "not particularly interested or particularly skilled in any area", but had some expertise "based on what the scope and sequence was for the grade" (TL9) they were teaching. Time was an acknowledged constraint here, and teacher participants were covering the content of the syllabus they were immediately required to teach. This aligns with both pedagogical and andragogical learner characteristics as outlined by Knowles (1977) and shown in Table 3.1 in chapter three of this study. Adult learners in this study were once again moving between the realms of theoretical andragogy and pedagogy. Firstly, TLs who were building expertise in just their teaching stage fit with andragogical readiness to learn, in that participants were learning with a deficit of time for a life task that they wished to perform effectively in, for their contemporaneous teaching needs (Knowles, 1977). Secondly, the participants' orientation to learning was influenced by a need in work life, to understand the stage of the syllabus they are required to teach (Knowles, 1977). Finally, motivation is heavily influenced by external pressures and the consequences of failure, which are clear pedagogical alignments of motivation according to Knowles (1977). Therefore, these adult learners do not fully appropriate with Knowles' (1977) andragogy, once more blurring the binary theoretical lines of pedagogy and andragogy.

As part of teacher participant self-awareness was their understanding of the knowledge gains made in PL across 2015, and conceded gaps in learning that still needed to be addressed. Gaps were often related to the syllabus sections outside of the participants' teaching stage, where teachers "still struggle with some of the content" (TL8) and the integration of technology into the curriculum which required "bringing in that technology side and bringing it in confidently" (TL7). In terms of professional learning (PL) geared to the teaching of technology; working technologically; and, ICT integration, "there wasn't a lot" (TL6). It was noteworthy that the teacher educators (TEs) in this study were aware of the technology challenge—"there's a big gap in teachers' ability to work scientifically and work technologically themselves and so they struggled to teach that to students" (TE3), and yet PL sessions did not address this need. Specifically, the ability to analyse gaps in learning is an andragogical characteristic noted as part of an adult learner's readiness to learn (Knowles, 1977). In this facet, the participants of this study both TEs and TLs align with the Knowlesian viewpoint of andragogy for the adult learner. This discussion noted the present study's adult learners as decidedly reflective, which aligns with changes in consciousness discussed by various adult education theorists (Mezirow, 1981, 2000; Rashid, 2017). Furthermore, there is a link of this reflectivity with Knox's (1980) work on proficiency theory that details that given the chance, adult learners are adept in performing. Teacher participants in this study were able to articulate their knowledge gains and gaps; and what they required for further learning because, "effective adult learning is transactional and developmental, with periodic assessment of discrepancies between current and desired proficiency" (Knox, 1980, p. 378).

7.2.3 Context comfortability

Adult learners, depending upon their comfort with a context of learning will be buoyed by predominantly internal or external factors. The pedagogical learner in the present study is an adult learner that is mainly guided by external factors, named external learner forces (ELFs) in this study, most especially in the early stages of their learning journey. For these learners, external forces were the school principal; teacher educator; and, colleague teachers, among others. The andragogical learner in the present study functions as a learner with a primary reliance on their internal learner forces (ILFs). They value their autonomy; experience; and, expertise. It is important to understand these contextual learner principles, in order that learning is pitched at an appropriate level—and that challenge for the adult learner results in meaningful learning. Rashid (2017, p. 3) placed this understanding of an adult learner's "life situation" as critical to their education. This evokes the adage—if you don't know where you've come from; you don't know where you're going.

Context comfortability, as a theme, highlights the context in which teacher participants began their learning, in 2015. But as discussed for this study, learning is manifest upon change, the unbalanced force that changes the teacher participant's learning trajectory. Therefore, a personal passion for K–6 Science and Technology as a consequence of background immersion in the learning area represented the autonomous learner—secure in their expertise and independence. They, like the externally influenced adult pedagogue or novice, needed change for learning. Their autonomy required balancing with reliance upon the knowledge, praxis and experience of the teacher educator (TE) and their colleagues. Similarly, their expertise had to be challenged with an area of K–6 Science and Technology curriculum implementation that they were not well versed in, a fresh set of learning to entice, challenge and change them. For the most expert of the teacher participants, this challenge for learning came in the form of learning how to teach other teachers; to develop facilitator skills and the "ability to teach other people about the skills (of the syllabus) and the importance of them" (TL5) in line with the pyramid model of professional learning (PL) (see Figure 4.1 in chapter four).

Contrastingly, for the adult pedagogue or novice, they required the challenge of less reliance on the external, such as their colleagues and the structured PL to more internal and autonomous adult learner characteristics. The satisfaction of learning successes could drive this autonomy for the externally reliant adult learner; where "next time (novice learners) go back in because (of) success—success breeds success" (TE1). A greater immersion in K–6 Science and Technology was the antidote to an overreliance on ELFs for learning. The more the adult pedagogue teachers in this study engaged with PL and "working with the staff" (TL8) the more "confident" (TL8) they became, evidencing the experiential by-product of "great satisfaction and great joy" (TE1). Therefore, these learners begin with a heavy dependence upon the external and move towards a love for science and an increased personal passion, acknowledged as an ILF of learning.

The structured professional learning (PL) implemented as part of the curriculum release was a necessity as the majority of teacher participants began their learning in K–6 Science and Technology as a novice or advanced beginner on the stages of learning continuum (SoLC). Structure provided stability for these learners and a comfort in learning. It was noted that "when courses are offered centrally from Sydney Catholic Schools, it will be targeted" (TL8) and "specific to what" (TL8) teachers need, and likely to be "really, really useful" (TL2) in successful syllabus implementation. Some TLs were empathic in the benefits of structured PL—"I enjoyed every minute, and I learned every minute of the day . . . . It made me feel like I was confident and competent, and therefore my whole attitude changed, and I knew I was actually doing justice to the children" (TL6).

Among the most influential of external learner forces (ELFs) was collegial support—a requisite for the novice and advanced beginner adult learners in this study. Collegial support came from the school principal or school executive, the teacher educator (TE), or classroom teachers within Sydney Catholic Schools (SCS). For some teacher learners (TLs), the TE was the primary support point—"the point that is at the centre of a network, bringing ideas from other places" (TL5). Some TEs placed the central support needed for learning on the principal as "vital in the process" (TE1). Others took the view that all teachers, no matter their position on the hierarchy and "authority" (TE2) were critical in learning success, because of the need to "work as a team" (TE2), each with "a different role to play" (TE2). The subtheme of collegial support strongly corresponds to the work of Darling-Hammond et al. (2017) on effective PL in allusion to the strengthening of learning through collaboration. Effective adult education in the context of the present study is not achieved in a silo, but rather with teachers engaging with one another in a concerted manner.

7.2.4 Learner discretion

Learner discretion was thematically built upon the decision-making of the teacher participants in the present study. Faced with ILFs and ELFs, all teacher participants exhibited hallmarks of decision-making that balanced the greater good of the profession of teaching, and their personal standing within that profession. The Merriam-Webster online dictionary (2020) defines discretion as a noun for "individual choice or judgement; the quality of having or showing discernment or good judgement; the ability to make responsible decisions; and the result of separating or distinguishing". This definition captures the nature of this theme. Teacher participants called upon to take on the role of science reference teacher (SRT) did so at times in response to a request by the principal, or as part of their duty to the school; their colleagues; and, students. At other times, there was a professional-standing teachers could assume within the role of SRT that afforded a status among their colleagues, and the potential for promotion. Whether for status or duty, learner discretion highlights that mixed motivations for learning of the external and internal were noted among the teacher participants. This theme strongly supports Martin's (2019) study on professional agency; in the balance of "personal agency" understood to be the decision-making of the teacher for themselves and their students with "professional agency", pertaining to decisions made for the "institutional requirements" of teaching (p. 1298).

The theoretical work of Knowles (1968, 1970, 1977, 1980, 1984, 1998) and Merriam (2001, 2007, 2014) asserted that adult learners were primarily intrinsically motivated in their learning. This was one of the adult learner characteristics that differentiated them from the child learner. Contradicting this, extrinsic motivation was just as critical for the adult learners in this study. Teacher participants had to balance their dwindling time for planning and teaching with external pressures that came from the principal or the institution of SCS. Teacher educators (TEs) were aware that: "being a science reference teacher became a lot of work . . . . It did take a lot of energy and a lot of effort" (TE3). The external forces were acknowledged by several teacher participants even in cases where they volunteered for the role of SRT—"I put my hand up as a member of the leadership team" (TL1)—"I asked for it . . . . I was an executive member" (TL6)—"I volunteered, but I was approached as well" (TL9). Alongside the external learner forces (ELFs) was the intrinsic motivation to evolve and improve in K–6 Science and Technology practice; the need for "challenge . . . something different" (TL3). The taking on of the SRT role was rarely evidenced as purely intrinsically or extrinsically motivated, but more often a complex melding of the two—"it's a little bit intrinsic . . . a bit of wanting to improve in leadership capacity, and it was a bit of wanting to know a bit more about science" (TL8). Motivation was "a bit of a scope"

(TE3) for teacher learners (TLs) in this study, tantamount to Martin's (2019) balancing of the internal and external forces that shape teacher professional agency.

The level of momentum required for the SRT role and continued learning across 2015 operated in magnitude to the mixing of intrinsic and extrinsic motivation. This was necessary as the combination of both forms of motivation seemed to result in more successful learning journeys for teacher participants. The extrinsic motivation took the form of the need for "someone to take that leader role" (TE1) and "push" (TE1) K–6 Science and Technology learning in the school, alongside a "can do" (TE1) attitude. The intrinsic motivation manifested when teacher participants became "capable of doing" (TL3) the work for learning, and accordingly build "self-confidence" (TL2). Several teacher participants acknowledged that K–6 Science and Technology was a learning area that they "didn't know about and hadn't had any experience with" (TL4), and so felt they "needed to work on it" (TL4). This was another manifestation of intrinsic motivation. The two forms work together to patent ongoing and successful learning.

Newton's second law of motion, named the *law of acceleration* contended that the force needed to move an object was equal to the mass of that object multiplied by its acceleration. In other words, what does it take, and how much of it does it take to move an object and keep it moving? What force is needed to shift the adult learner and keep them accelerating in their learning? This study contends that mixed motivations for learning of the intrinsic and extrinsic are optimal for the adult learner in a professional context such as teaching—to keep them personally engaged and externally accountable all at once. Extrinsic motivation alone results in situations in which "people were there because they had to be there" (TL2). A mixing of the intrinsic and extrinsic establishes optimal learning with "people who got sent but had a genuine interest in it as well, even as adults you could see the definite divide" (TL7). This TL participant alluded to the benefit of mixed motivation over just extrinsic, and the findings of this study as a whole support this assertion. The positives of extrinsic motivation for the adult learner are supported by the work of Reeve et al. (2004) and Rothes et al. (2017). The findings of this study concur with these researchers, and help to remove the stigma and negativity surrounding adult learners relying on the external for motivation. Further to this, Yoo and Huang (2013) discussed the pragmatism of extrinsic motivation because of occupations and family accountabilities, well evidenced by the learner discretion theme of this study. Teacher participants may have been placed in the role of science reference teacher (SRT) and accountable externally to compliance at the school and system level; but also benefitted greatly in their learning journey from successful exchanges of learning with colleagues and their students in the classroom. Again, there is a synergy between external pressures and recompenses, and internal drive and reward.

For some teacher learners (TLs) there was a need to maintain status within the SRT role and also as a teacher professional worthy of promotion. TLs “had to know” (TL6) and understand K–6 Science and Technology for the new syllabus in order to “in-service the staff” (TL6). It was critical to demonstrate “confidence and competence” (TL4) so that teacher colleagues in school were contented to rely on the SRT in their learning journey. This confidence and competence notion is critical to the success of the pyramid model of professional learning (PL)—in order that learning trickle down from system facilitators all the way to classroom teachers of Sydney Catholic Schools (SCS):

> I was asked to do it (become a science reference teacher), probably because of the science in my background . . . but I’m really glad that I did . . . it reinforced a lot of the things I was doing. I didn’t mind doing it, but off my own bat, I don’t know (if I would have chosen to do it) (TL2).

These findings bolster Seifert’s (2004) assertion on motivation and the “pivotal role that feelings of competence and control play” (p. 147).

A sense of duty was beholden to several TLs and influenced the decision to initiate their learning journey and to take on the role of SRT. Duty, by definition, speaks to something that is required of a person because of their profession or alternatively because it is the correct thing to do (Cambridge, 2000). This definition covers the impetus of all teacher participants in this study that were extrinsically motivated to take on the SRT role. As mentioned, extrinsic motivation does not negatively impact learning especially when the learner also capitalises on opportunities for intrinsic motivation along their learning journey. As such, duty is not necessarily a foreboding choice for successful adult learning. It is an impetus for learning, like any other, and may be used successfully as an agent for change and learner development. Although duty is subject to external forces and pressures, it does not follow that the effect of a dutiful learner choice cannot be as fruitful as the purely intrinsic influence to learn. Again, the adult's life situation, as a key principle of adult education (Rashid, 2017), is in exposition, because of the sense of duty participants felt in their professional roles.

Subsidiary question two showcased several effects that the relationship between ILFs and ELFs had on adult learners in this study. These learners are clearly not able to be categorised as resolutely andragogical in nature. Rather, the findings show that adult learners are difficult to categorise in terms of their learner traits because of their changeability—their ability to demonstrate plasticity in learning. Understanding learning for the adults in this study becomes more than just identifying their characteristics as a learner, their modus operandi. It requires the demystification of how such learner traits interplay with the back and forth of ILFs and ELFs, and how these interacting factors may be best utilised for effective adult education.

7.3 Subsidiary question three—what is the influence of the context of K–6 Science and Technology in professional learning?

Subsidiary question three speaks to the influence of contextual elements in this study. Collectively, these elements are professional learning (PL) undertaken by primary teachers, facilitated by their colleagues, as part of required learning for the NESA K–6 Science and Technology Syllabus (2012). Further to this, teacher learners (TLs) were also required to provide PL for their colleagues back on school campuses as part of the pyramid model shown in Figure 4.1 of this study. When considering adult learning in line with Knowlesian ideas of learner autonomy and self-direction, these contextual elements could be perceived as constraints. However, what the findings of this study show is that the contextual bounds served an essential purpose for the adult undertaking learning in a professional setting. They provided clarity, direction, support; and for many teachers that were novice in their initial stages of learning, a scaffold upon which to build learning.

7.3.1 Perceptions on teacher learner

The teacher educators (TEs) came into their role as facilitators of K–6 Science and Technology with views about the science reference teachers (SRTs) they were tasked to teach. This theme encompasses these views; and collates and organises them for dual purpose. Firstly, to take the TE's perspective on the cohort of learners (the SRTs) and secondly to contrast this to self-perceptions of SRTs in this study (the TLs). There were several points of alignment between how TLs perceived themselves as learners and how they were seen by the TEs. It was evident that TLs engaged with learning in 2015 with mixed motivation, some with extrinsic and others with intrinsic motivation. This was discussed in subsidiary question two in reference to the theme learner discretion. Furthermore, the child-like or pedagogical traits that novice learners recognised in themselves were also perceived by the TEs in this study. Despite this, there was always a fundamental recognition that it was a cohort of adults that were on a learning journey, and not children, even though pedagogical traits were noted by both TLs and TEs at various points across the data.

Motivation came in a myriad of forms for the SRTs that participated in PL in 2015. This was represented in the responses of TLs in this study, and from the broader view taken from TEs. The initiation of the learning journey in 2015 was incumbent on the presence of some motivation, "between the internal and the support given by the school" (TE1). The externally motivated SRTs that "didn't have much motivation, but the principal did" (TE1) could "change" (TE1) and garner learning success. This again manifests an interactional relationship of internal and external motivation, a back and forth of the internal learner force (ILF) and external learner force (ELF). However, an absence of any form of motivation resulted in the "perfect storm" (TE1) and curtailed learning "because there was no consequence, there was no accountability, there was nothing" (TE1). Considering the PL model required SRTs to upskill their colleagues at school, placing an apathetic and unsupported teacher in the role made it "tricky to create any sort of motivation, or anything that you're going to carry over to the staff"

(TE2). These SRTs built up bitterness towards the PL as further encroaching on their depleted time “especially if they weren’t getting success in the classroom” (TE3).

Motivation for adult learners in this study does not neatly fit into Knowles’ (1977) categorisation of andragogical learners as intrinsically motivated. It is important to note that even Knowles (1977) acknowledged that his separation of pedagogy and andragogy were not “black and white differences” (p. 211). This study and its findings fit within this concession and evidence the need for both intrinsic and extrinsic motivation at different points in the learning journey. Those SRTs that began learning because of extrinsic motivation (an ELF), because “nobody else put their hand up” (TL3) did not remain in this space long, they aptly found intrinsic motivation and “would do it because they saw value in it” (TE3). For many SRTs, as evidenced by TE perception and the self-perceptions of the TLs themselves, this shift from extrinsic to intrinsic motivation was a result of “students engaging with and loving science” (TE3). This generated an internal motivation (an ILF) “to keep teaching the other teachers because of that” (TE3) which was necessary for a well-functioning PL pyramid model. It was the experience of success for TLs, sometimes in the classroom with their students, and other times with their colleague teachers at school, that was the internal fuel for learning—“there was great satisfaction, great joy” (TE1).

As acknowledged by the majority of TLs in the present study, they functioned within a pedagogical realm of learning, especially in the early stages of 2015. This was supported by TE perceptions when it was noted that TLs “were really not confident at all” (TE3) and that “it was very much hand-holding” (TE3) during the PL sessions at school. The presumptive child learner traits lead to an inference regarding learning to “treat adults and children the same” (TE1). This equal treatment regarded the level of support required by the learner and the most effective means to engage them in learning. Julyan and Duckworth (2005) claimed that in the context of science education children and adults build understanding about concepts in a very similar manner. This seemed to play out in several learning experiences within this study.

For the more experienced TLs in science education who functioned within the realm of andragogical learner traits as outlined by Knowles (1977), a challenge to their modus operandi was just as important as it was for the novice learners with child-like traits. These andragogical learners required a new area of learning within K–6 Science and Technology to move them out of their autonomy, and into a greater reliance on the experience and knowledge of their colleagues and the TE—that is, a movement from ILF to ELF. TE participants recognised that "when you take on something new, you go back into that pendulum as well, where you need things scaffolded a bit more and then you're through to an independent learner (again)" (TE1). For the experienced and expert TLs, the novel came in the building of their facilitating skills in order to teach their colleagues, "to be able to try and facilitate the understanding" (TL5). Even the most experienced teachers with a "healthy knowledge" (TL6) can gain by being "actively involved with other teachers in collaborative situations, breaking it open" (TL6) to "full understand" (TL6) K–6 Science and Technology. Collaboration as a building block of successful PL (Darling-Hammond et al., 2017) may be seen as constraining because it encroaches on learner autonomy and self-direction. However, in the context of teacher professional learning, it becomes a powerful tool to improve the professionalism of the practising teacher. Engle (2006) understood that the more diverse the viewpoints and examples of praxis in a learning community, the better the uptake of knowledge. The findings of the current study align with these suppositions. Furthermore, where collaboration and communities of practice (CoP) are commonplace in PL, hierarchical structures that can hinder learning are mitigated (Nielson et al., 2010)—"I think we all work as a team so I don't perceive anybody to be really different because everybody has a different role to play" (TE2). In this context, adult education, in line with Sandberg's (2016) views concerns the professional standing of a learner, their journey of lifelong learning as well as "how adult education should shape students" (p. 266). The adult learner cannot be separated from their learning context, to do so is unrealistic and in arrears of the practicalities of their learning situation, and the positive influences these have on the learner.

No matter the age, expertise, and perception of child-like pedagogical traits there was always recognition of the adult learner, a professional teacher with their own knowledge and experience. The breaking down of hierarchies for PL success as outlined by Nielson et al. (2010) potentially comes into play here when colleagues teach colleagues, as unlike the teacher-student learning interaction where "children don't mind being told what to do" (TE3), adults don't "like to have someone tell them what to do" (TE3). The commonalities in teaching children and adults that were discussed were always in regard to "the amount of scaffolding and the amount of support" (TE1) required by the learner, not the manner in which you act and address a fellow adult learner, because it was important "to be careful not to be condescending to adults" (TE3). It was evident that all TEs were "not really big on the authority type of thing" (TE2) and worked alongside their science reference teacher (SRT) colleagues for this reason. TEs also recognised that they were not experts in science education, and were also on a learning journey—even though they were theoretically further along in their understanding of the NESA Syllabus for K–6 Science and Technology (2012). The perceptions on the TL as an adult, who was learning, appeared to maintain the dignity and professional standing of the adult learner—even though many were novice according to the stages of learning continuum (SoLC) breakdown.

7.3.2 Professional learning setting

The literature review of the current study presented an overwhelming consensus of the need for practical and hands-on approaches in science education and professional learning (PL) (Kenny & Colvill, 2008). These practical and hands-on approaches were a weighty talking point for teacher participants in this study for three reasons. Firstly, participants began to understand that the NESA Syllabus for K–6 Science and Technology (2012) was purposefully organised around the practical and hands-on skills of working scientifically and working technologically. Secondly, with PL and in light of experiences with students, participants now understood these approaches to be among the most effective pedagogy to improve praxis for student attainment—"I've always valued a hands-on approach" (TL4). Finally, many participants noted that the practical and hands-on approaches were the most engaging and useful for them as learners during PL in 2015, that they "need hands-on" (TL3) for learning. If engagement is the action portion of motivational thoughts as determined by Munns and Martin (2005) and supported in this study, then utilising a practical, hands-on approach becomes critical to the ongoing learning of the adult participants. That is, keeping the adult learners interested and cognitively motivated begins with ELFs such as practical demonstrations; and investigations push them into involvement (the action of engagement) which is the third stage in Grow's (1991) staged self-directed learning model (SSDL). Grow (1991) contends that before a learner gets "involved" (stage three of SSDL) they must become "interested" (stage two of SSDL). Teacher participant voice in the current study certainly reinforced these theoretical constructs for themselves as learners, and their students—"I know this from myself . . . I think if you did more interest based, then they'd (students) be able to show their expertise a bit more" (TL8).

The present study uses the term pedagogical modelling in regard to teaching and learning practices that are explicitly broken down and demonstrated in PL for the purposes of assimilation by teachers in classroom praxis. Pedagogical modelling provides example practices that can greatly support novice teachers in the initial stages of learning, in line with the "scaffold and support" (TE1) notion discussed earlier. This was especially useful for areas of weakness in science education where "maybe not so much" (TL7) was understood about how to teach "working scientifically and working technologically" (TL7). Teacher participants, both educators and learners were in unanimity that "skills need experience, and someone has to teach it" (TE3) explicitly. A flow-on effect was that teacher participants began doing "a lot of modelling of scientific experiments" (TL1) in class and students were given greater opportunities to engage with practical, hands-on inquiry and "discover something themselves" (TL2). This study's findings are in line with the importance Darling-Hammond et al. (2017) placed on the use of models and modelling in effective PL. For this study's context of adult education, pedagogical modelling was not constraining—"I think as an adult learner, people like an example . . . . They like a starting point" (TE2). For the novice learner, these examples were especially useful—"I'd find the things that I would show them, specifically for say their stage, they would replicate in their classroom exactly as it was" (TE3). Bokosmaty et al. (2015) noted a similar reliance on worked examples for mathematics learning in their study of novice learners.

Adult learner participant self-awareness was critical to identify when support through pedagogical modelling was useful and when expertise had pushed them beyond its necessity. However, as collegial in nature, communities of practice (CoP) benefit greatly at all times from examples of praxis—"program sharing" (TL1) and "getting ideas from other teachers and schools" (TL1); a balance between reliance on a learner's own experience in Knowles' (1977) andragogical assumptions and the experience of the external other (often the teacher) as shown beneath pedagogical assumptions. White's (2000) interactive model sought to balance the idea of andragogy for the adult learner alone, with mutually created motivation between teacher and learner, and collaboratively created learning goals. These ideas all inform in some manner a harmonising of pedagogy and andragogy, rather than a polarising of the two adult education theories. During the use of pedagogical modelling for adult learners in this study there was always awareness that adults were at the centre of learning in a "gradual release model" (TE1) and "you wouldn't spend as long as you would with your year two class in order to get the teachers to understand what (something) means" (TE1).

Another analogy between educating adults in the PL setting and educating students in the primary classroom was the management of learners. This subtheme was named *"classroom" management* because of the commonalities between the adult and child educational settings. SRTs as adult learners, came in all forms, with differing needs; experiences; and, levels of autonomy—"so it's very much like a class . . . you've got variants" (TE1). Some SRTs were studious and "some wouldn't work in an iron lung (lazy)" (TE1). The studious among the SRTs were "those people that were motivated and you can lead and they're going to keep working on their own" (TE3). The SRTs lacking motivation were clearly disengaged and "you'd have to go and work with them . . . (like) the classroom" (TE3). This array of adult learners once again highlights the mixed levels of motivation and engagement, and how for some learners where learning had stagnated, an ELF such as facilitator presence and interception was needed to cajole learning. In light of adult education for the teacher, some are in great need of and benefit from the ELF of extrinsic motivation, a Knowlesian pedagogical trait. In this situation these learners are also employees demonstrating varying levels of readiness to learn in line with Hersey and Blanchard's (1988) *situational leadership theory*. These learners represent the highly dependent students in stage one of Grow's (1991) staged self-directed learning model (SSDL) where they are drilled, and the teacher assumes the role of authority in order to overcome "deficiencies and resistance" (p. 129). This exemplification of the adult learner in this study is thus markedly different to the theoretical adult learner of Knowles (1968, 1970, 1977, 1980, 1984, 1998) and Merriam (2001, 2007, 2014).

7.3.3 Perceptions on teacher educator

Even with the knowledge that their facilitator in learning was a colleague, teacher learners (TLs) generally regarded teacher educators (TEs) as an expert in K–6 Science and Technology. This was in strong contrast to how the TEs viewed themselves. Although they occupied the role of Education Officer: K–6 Science and Technology, TEs identified themselves as learners too and in reference to knowledge—"I still don't think I am" (TE3) an expert. TEs saw themselves as learners across 2015, and only ranked themselves as *expert* on the stages of learning continuum (SoLC) by the end of professional learning (PL) in 2015. Self-perceptions of the TE did not appear to impact the perceptions of TLs in qualifying the TE as expert. Rashid's (2017) adult learning principle of life situation comes into play, in reference to TEs in the stage of their professional life; they were in a position to engage with fairly fast-paced learning because of personal passion and professional need. Yet again we see a balance between the internal love of science (an internal learner force) and the external pressure to facilitate learning for colleagues (an external learner force). TLs also identified with this external pressure when they were tasked to provide professional learning to their school colleagues:

> I think in order for me to present it to the staff, I had to understand it and be confident in it myself so that sort of pushed me to be more familiar, to be more experienced, so that when I did present it to the staff – not that I had all the answers, but that I could answer as much as I could (TL9).

Proficiency became the remedy that moved TEs towards the expertise and confidence that they were perceived to have by TLs. At times it was TL teaching experience that intimated the TEs—"they were sort of coming to me and I was supposed to be the expert, when they obviously had had a lot more experience than me" (TE3). In line with Knox's (1980) adult learner proficiency theory, expertise was addressed by TEs with "experience, learning effectiveness, sense of proficiency, and commitment to enhance proficiency" for the "acquisition of new learnings and the reorganization of old" (p. 378). The more TEs experienced, and the greater the success in these experiences, the more confident they became. This further influenced the success of TLs in their undertaking of new learning, as when they were confident in the TE, they took their example and experienced their own success and confidence building—"it sort of went like that, so sort of feeding itself" (TE3).

Once proficiency was established, TEs benefitted greatly from their confidence and newly refined expertise in a similar manner to TLs that experienced these changes in their science education classroom praxis. The perception of TE as learning leader was not an immediate shift that occurred at the beginning of 2015, instead it manifested over the year. On occasion, when a TE was well known in a different role in Sydney Catholic Schools (SCS), adjustment time was needed to reposition them in the PL environment—"once I was in there I think I changed those perceptions" (TE1). Preconceptions can at times be misconceptions that necessitate challenge, especially when the TE is labelled because of their background; age; teaching experience; or, teaching stage. TLs' perceptions evolved as they were shown how the TEs could enrich their learning journey, and many came to "rely on (them) quite a bit" (TL1).

For a majority of the TLs that began their learning journey in 2015 as novice, the TE was heavily relied upon for paving an appropriate learning path. The provision of strong learning direction is in line with the role an educator takes in the traditional pedagogical paradigm of teacher-centred learning (Taylor & Kroth, 2009) whereby "the most effective thing was having (teacher educator) sit and just help us work through it" (TL4). This study, because of its findings, does not view effective adult education as purely learner-centred, most especially in the early stages of experience and expertise-building. This is in line with moderate theorists such as Taber (2011) that acknowledge the need for teacher-centric didactic approaches alongside student-centred constructivist approaches. As acknowledged with teacher participants that require the early intervention of the TE, an ELF, there needs to be at some point a reengagement with ILFs to ensure the continuation of learning so that TLs are "having a go and not just reading" (TL3) but putting "reading into practice" (TL3).

According to Hase (2019), there are four main qualities to a learning leader: The ability to deal with ambiguity; the capacity to foster management; the capacity to learn;

and, the ability to use open systems thinking. From this study, the findings show that TEs were perceived to have these qualities by TLs, but also that TEs acknowledged at least some of these traits in themselves. TEs were the "professionals" (TL6) "there to guide" (TL6); and to have TLs "kind of pick their brains and ask their advice" (TL7) and "to support and just to bounce ideas off" (TL8). The TE was perceived as a myriad of things, "a support . . . a resource . . . a conduit to be able to link things together . . . a mentor . . . a coach . . . a critical friend" (TE1). Depending on the need of the TL, the TE could be likened to the authority on all things K–6 Science and Technology through to a consultant for the highly self-directed learner. This follows the theoretical thought process of Grow's (1991) staged self-directed learning model (SSDL) whereby the TE's role is to align with the TL's stage of self-direction, which is based on their expertise and need. This study, through its findings presents the adult learner as a changeable, malleable learner. Similarly, the TE as a learning leader—handles ambiguity with flexibility; a release of control; and, an openness to experience (Hase, 2019). In this situation, the TL becomes the ELF influencing and interacting with the thoughts, feelings and actions of the TE, that is, their ILFs.

The professional learning (PL) context addressed in subsidiary question three is important for understanding the influence of the contextual boundaries on the adult learner and how to best work with these bounds for learning. There were professional necessities placed on the adult learning in this study because of "the new syllabus . . . the professional learning . . . also being in the leadership role (as science reference teacher)" (TL8); and these ELFs exerted a pressure. There are job responsibilities for compliance at state government level (for NESA), system (for Sydney Catholic Schools) and school level that require teachers to upskill in the NESA Syllabus for K–6 Science and Technology (2012). This was in order to teach the syllabus effectively to students, for compliance, and "for keeping us honest and making sure that we are doing the right thing and making sure that we are getting the message out there all of the time" (TL5). This connects with teacher accountability in the literature (Dubnick, 2006) as the external impetus to perform, regulate and manage teaching praxis, now identified in this study as an ELF. It has been discussed that without this pressure to change, the adult learners were unlikely to have initiated knowledge-building in K–6 Science and Technology, and others would not have sustained their learning. However, there is always a balance to be struck between internal learner forces (ILFs) and external learner forces (ELFs), in this example between teacher accountability and the autonomous decision-making in praxis that informs teacher agency. This study's findings support ideas presented in the literature that the teacher professional is a nuanced balance between teacher autonomy and teacher dependence (Nolan & Molla, 2019)—that is, the internal dependence of an ILF and the outward reliance of the ELF.

7.4 Summary

Chapter seven discussed the findings of this study by addressing each of the three subsidiary questions. These questions collectively showed the internal and external forces of influence on the adult learners in this study's context of teacher professional learning in K–6 Science and Technology; forces that are crucially required to be in interaction for learning. This vital interaction of internal learner forces (ILFs) and external learner forces (ELFs) is the relationship that replies to the main research question of the present study. The learning journey of the adult learner for the present study persists because of this relationship, and thus an understanding of how to maintain the interaction between ILFs and ELFs is just as imperative.

Chapter eight presents the conclusion to this study. It explores how the ILFs and ELFs of the adult learner are best utilised for successful teacher professional learning, and presents appropriate adjustments to the original conceptual framework of this study for this purpose. Also noted are limitations to the present study, and recommendations for further research.

Chapter 8: Conclusion

"Truth is ever to be found in simplicity, and not in the multiplicity and confusion of things."

Isaac Newton

Introduction

This concluding chapter evaluates the scope and purpose of the present study, alongside the significant findings. These findings resulted in new knowledge that is visually represented in the enhancement of the conceptual framework. Recommendations made in this chapter utilise the most significant findings in an aim to provide a platform on which they may be considered for successful adult learning in the teacher professional setting. In acknowledgment of the specificity of context in this study, limitations are also discussed. Finally, suggestions for further research are noted to compliment, support and build confidence in the applicability of this study's significant findings.

8.1 Scope and purpose of the study

This case study, interpretive in nature, sought to build understanding of the adult learner using the views of primary school teacher participants. This understanding contributes to the theoretical knowledge of adult learning. Teacher participant views put forward in semi-structured interviews and through document-based data sources resulted in data that were extrapolated towards greater utility for the teaching profession—that is, a pragmatic applicability for educational systems, individual schools, teachers educating and teachers undertaking learning. The premise is that once adult learning is better understood for this context, transferability may be possible to analogous professional learning (PL) settings. These settings could extend beyond the teaching profession into other professional realms as long as the forces acting upon the adult learner are comparable with the present study. For example, where there is learning required for professional compliance that must be directed, at least in part, by the educator or facilitator. For successful transferability of this study's findings there must be the opportunity for interplay between internal learner forces (ILFs) and external learner forces (ELFs).

It was the discovery of this relationship between ILFs and ELFs that enabled the main research question of this study to be resolutely addressed. By answering the three subsidiary questions, the relationship between learner factors was elucidated along with their influence on the adult learner, within the bounds of professional learning contextualised by K–6 Science and Technology. Collaboratively, these subsidiary question findings built a picture of the adult learner as a changeable learner constantly responding to ILFs and ELFs. It is the enduring interplay between ILFs and ELFs that establishes and allows for the continuity of learning for the adult learner in this study. The applicability of this interaction to existing and robust research on characteristics of the pedagogical and andragogical learner is critical to the significance of findings for this study, and their potential transferability.

8.2 Significance of findings

8.2.1 The pedagogy andragogy balance (PAB)

The relationship between ILFs and ELFs must be ongoing in a push and pull interaction. When an adult learner predominantly utilises pedagogical characteristics, they are in essence heavily relying on ELFs for their learning. These pedagogical ELFs include educator direction; educator evaluation; educator responsibility for learning; educator experience; prescribed subject matter for learning; and external rewards and pressures for motivation. The present study has established that these ELFs are not negative by nature; but can be useful forces that provide impetus to learn for the novice adult learner. Issues arise when these ELFs are too heavily utilised and relied upon at every stage of the learning journey, as learning is not sustainable without opportunities for intrinsic motivation and learner autonomy. Similarly, adult learners that identify with largely andragogical traits are contingent upon ILFs. These learners are self-directed; self-evaluate and are personally responsible for their learning; value their rich experience in the learning area over that of their educator; effectively analyse gaps in their learning and organise learning accordingly; and finally, they are internally incentivised and motivated to learn. As with pedagogical adult learners, the identification of the andragogical adult learner is useful for determining an appropriate learning direction. In the teaching profession, overreliance on self or ILFs crosses into the negative where colleague knowledge and experience is underutilised, and collaboration is curbed. Collaboration; the use of models and modelling; and, coaching and expert support are three well supported pillars of effective professional learning (Darling-Hammond et al., 2017). When a teacher remains in the realm of unalloyed autonomy and influenced only by ILFs, they run the risk of not benefitting from the richness of experience and knowledge that can come with a community of practice (CoP).

There is therefore the need for a pedagogy andragogy balance (PAB). Adult learners have to be challenged and must move beyond their preferred learner characteristics of either pedagogical or andragogical in the context of teacher professional learning. For predominantly pedagogical adult learners, this requires the use of ILFs, whereby self-confidence, self-efficacy and self-reliance are made more robust with ongoing professional learning. For example, when they learn a new way to teach the concept of night and day investigatively and they find success in the classroom with this new learning; confidence and self-efficacy improve. For principally andragogical adult learners, a similar opposition is necessary, but with ELFs. Their autonomy and self-reliance must be challenged in order for new learning to be taken on board. Andragogical adult learners find new learning by engaging with ELFs; for example, the knowledge and praxis of their colleagues.

8.2.2 The novice expert balance (NEB)

The relationship between ILFs and ELFs has an equivalent influence on the adult learner's stage of learning. The gamut from novice to expert learner is represented in this study with the stages of learning continuum (SoLC). Pedagogical adult learners more often than not acknowledge that they are novice learners. Novice adult learners build expertise over time and this allows them the opportunity to become more reliant on what they know, understand and can achieve in their rejuvenated teaching praxis—all ILFs. They begin their learning journey with great reliance on the external environmental factors, ELFs that provide impetus and support for their learning. These influential forces are important in the initial stages of learning; but are not enough for sustained adult learning. The teacher professional must at some point come to rely on self, even in a learning area that is not an acknowledged strength. Through learning via modelling; a building of knowledge; and, with the implementation of successful praxis in the classroom, the novice adult learner begins to move along the SoLC towards expertise. As they do this, self-efficacy, self-confidence and autonomy follow. In this study, teacher participants that fit this characterisation reported more and more ILFs as their learning journey progressed. They discussed more intrinsic motivation to learn about K–6 Science and Technology; a greater appreciation of what they could achieve in the classroom with their students; and, an improved understanding of where their learning fell short and how they could go about filling their own knowledge gaps—understood in the present study to be ILFs.

For the adult learner expert, a shift must be made towards the novice end of the SoLC. This does not mean that they unlearn what they know; or trivialise their strong knowledge base in the learning area. Rather, they seek or are introduced to a facet within the learning area in which opportunities exist for learning. One critical way this is achieved is through the identification of a niche or new area of learning for the andragogical learner—an area of learning in which they are novice and can once again benefit by ELFs, such as the knowledge and expertise of a facilitator. For any practising teacher, no matter their years of experience or expertise, there will always be gaps in knowledge that can be closed with professional learning. In this study, the most expert of teacher participants identified facilitation skills in professional learning as one area of need. The science reference teacher (SRT) role required that teacher learners (TLs) in this study facilitate professional learning (PL) for colleague teachers in their school. As such, for expert teachers in K–6 Science and Technology without experience in facilitating this was very novel learning—an example of where the adult learner was a novice once again relying on ELFs to move towards expertise. The interplay between ILFs and ELFs and how these forces influence learning for all adult learners in this study's context is presented in Figure 8.1.

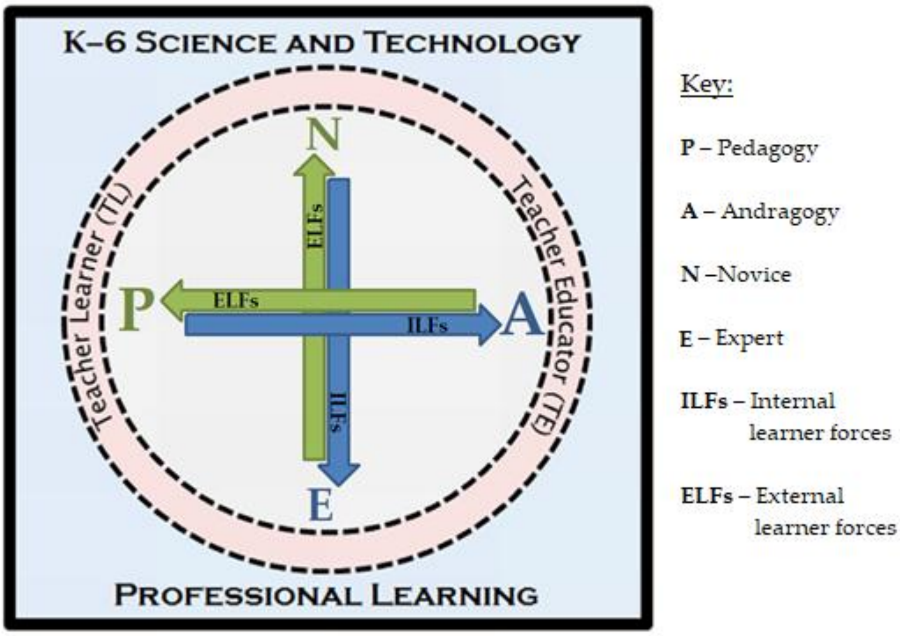


Figure 8.1 *Framework for the PAB and NEB in adult learning for teacher professionals*

8.3 Recommendations for professional learning

The framework for the PAB and NEB can be a useful tool for adult learning, most especially for the teaching profession. Adult learners about to begin a learning journey could be analysed against the framework, to establish their level of expertise and pedagogical or andragogical learner traits. This will allow facilitators of professional learning to establish whether ILFs or ELFs are preliminary influencers for the adult learner set to engage in learning. Similar to the administration of pre-tests for students in the classroom as a gauge of learner knowledge and understanding, a self-assessment is completed by the adult learner regarding their stage of learning and learner traits—a refined version of the document-based data sources in this study called the stages of learning continuum (SoLC) and principles of learning continuum (PoLC). Table 8.2 provides an example of an adult learner self-assessment of this description.

Table 8.1 *Adult learner self-assessment for professional learning*

In reference to learning for [e.g. K–6 Science and Technology] my characteristics as a learner best fit: *(please circle one response from each row)*	
Require educator to direct learning	Self-directed learning
Have little to no experience	Have rich and varied experience
Dependent on educator to organise and advance learning	Self-dependent to organise and advance learning
Require learning for the general subject area	Require learning for a task or problem
Motivated to learn by external rewards and pressures	Motivated to learn for personal and internal rewards and reasons

In reference to learning for [e.g. K–6 Science and Technology] my stage of learning is: *(please circle one response from the row)*				
Novice Little to no theoretical or practical knowledge	**Advanced beginner** Limited theoretical and practical knowledge	**Competent** General theoretical and practical knowledge	**Proficient** Above average theoretical and practical knowledge	**Expert** Advanced theoretical and practical knowledge

The successful use of such a self-assessment would be improved if the facilitator provided teacher learners (TLs) with a more detailed description of each of the characteristics of learning and the five stages of learning categories in order to improve accuracy of choice. This may be developed in more depth depending on the unique learning context, just as the SoLC was undertaken for the current study. Furthermore, this self-assessment may be adapted in other ways as long as the purpose behind its use is maintained, that is, to determine the perceived expertise of the learner and whether their position is in the pedagogical or andragogical trait profile. This will inform whether ILFs or ELFs are their primary influences and where shifts are required from the internal to the external, and vice versa.

Once determined, the starting point for a TL may be utilised by the educator in several ways. The educator now has knowledge of the pedagogical adult learners in the cohort who often also identify as novice. This allows facilitators of professional learning to scaffold and support these learners with ELFs appropriate to their current locus. As learners advance towards greater knowledge, understanding, and experience; facilitators and the learners themselves have more opportunity to be influenced by ILFs. This may be a new-found passion and appreciation for the learning area, or more intrinsic motivation to learn because of the success experienced along the learning journey. Self-assessment can also help identify the andragogical adult learners who are often more advanced in their stage of learning. These learners must find or be introduced to what is unknown, or little known to them, within the area of learning—to secure their engagement in learning and push them into the realm of greater reliance on ELFs. Knowlesian andragogical learners are adept in analysing gaps in their own knowledge base, and thus are a rich resource to aid in the educator's planning for professional learning (PL). Table 8.2 provides some examples where the pedagogical novice adult learner may engage with more ILFs and conversely for the andragogical expert adult learner to move towards a greater influence of ELFs. These examples are organised by Knowlesian learner categorises (shown in Table 3.1 of chapter three) such as *concept of the learner* and role of *learner's experience*. Table 8.2 is a snapshot, and certainly not an exhaustive list; what remains pivotal is the ongoing interplay between ILFs and ELFs. Practically speaking, there are certainly teacher learners (TLs) that may fall somewhere between the two realms. It is important that these learners have the opportunity to be supported to reinforce knowledge and skills, as well as recognise new learning opportunities.

Table 8.2 Suggestions for engaging adult learners in ILFs and ELFs learning interactions

For the pedagogical novice teacher learner:	**For the andragogical expert teacher learner:**
Pedagogical modelling of a worked example by teacher educator of sound teacher praxis for direct transfer by teacher learner to the classroom (Concept of the learner: Dependent) *ELFs (modelling of praxis) → ILFs (use of praxis)*	Teacher educator provides a problem for the teacher learner to solve in any way they deem appropriate. Teacher learner asked to present solution to other teacher learners for questions, comments and feedback (Concept of the learner: Self-directed) *ILFs (self-directed towards solution) → ELFs (collegial appraisal of solution)*
Teacher educator to provide one example of praxis for scaffold and support to the teacher learner and ask them to adapt it for their classroom (Role of learner's experience: Negligible) *ELFs (modelling of praxis) → ILFs (adaption of praxis)*	Teacher learner joins network of colleagues that share programs and praxis to compare and contrast their own experience with that of their others (Role of learner's experience: Rich resource) *ILFs (personal experience rich) → ELFs (colleague experience may also be enlightening)*

Teacher educator to introduce teacher learner to a group of colleagues for networking and resource sharing or encourage them to form a new network for experience building (Readiness to learn: Educator-directed) *ELFs (network apportionment) → ILFs (engagement with and knowledge building from newly joined or formed network)*	Teacher learner to identify particular learning gaps among the scope of learning discussed with teacher educator (Readiness to learn: Problem solving and knowledge gaps) *ILFs (self-assessment of knowledge gaps) → ELFs (teacher educator addresses knowledge gaps or learning opportunities)*
Teacher educator to set a task for the teacher learner to undertake and report back for accountability (Orientation to learning: Subject-centred) *ELFs (allocation of learning task)→ ILFs (completion of learning task)*	Teacher educator to provide teacher learner with greater detail on the scope of all learning in the professional learning program for transparency (Orientation to learning: Learning arises from need in life) *ILFs (expert learner) → ELFs (learning required for compliance)*
Teacher educator to utilise hands-on activities and practical demonstrations to motivate and engage teacher learners (Motivation: Extrinsic) *ELFs (intentionally selected learning experiences) → ILFs (increased enthusiasm and enjoyment)*	Teacher learner inquisitiveness leads to an innovative idea that they share with their network, which is later praised and used successfully by colleagues (Motivation: Intrinsic) *ILFs (curiosity) → ELFs (colleague admiration and appreciation)*

8.4 Limitations

The qualitative and descriptive nature of this case study renders it deeply effective in representing a specific context at a specific point in time; however, this impacts generalisability of findings. Instead, this study has always worked towards a level of transferability—the extent to which this occurs is left to the discretion of future researchers. Just as this study relied on specific studies to build the theoretical and conceptual frameworks, other researchers may find analogy in the present study and usefulness in its findings and recommendations. Generisability requires that findings be repeatable and demonstrable time and again, and furthermore universally applicable. This is well beyond the scope of this case study. The small sample size, purposively selected was always acknowledged as a limitation to generisability. Therefore, trustworthiness became the benchmark as supported by rich descriptions that were true to participant voice. This resulted in a focus on credibility of findings through persistent observation of study context by the researcher; potential transferability as decided by future researchers; an acknowledgement of trackable variance by the researcher and the contextualised nature of this study; and finally, confirmability, whereby this research is sufficient in detail with robust and justifiable methods of data collection and analysis.

Another potential limitation was the work role held by the researcher at the commencement of this study. The researcher facilitated learning for K–6 Science and Technology for science reference teachers (SRTs) on several occasions during 2015; and worked alongside teacher educators (TEs) from this study. From one vantage point this could be seen as limiting because the researcher was known to the participants and vice versa. However, this proximity allowed for observation of context for a substantial period of time which brought to the foreground the need to further understand adult learning in this situation. Without the engagement by the researcher in the context of this study, pivotal early musings would not have manifested into any type of research. This study contends that the depth of analysis and profound understanding of teacher participant context would have been deleteriously impacted by a researcher completely independent of the teaching profession.

8.5 Further research

There is potentially scope for applying the ILFs and ELFs interaction to comparable teacher professional learning contexts. This could be through a qualitative study that applies a form of the PAB and NEB to teacher professional learning, tracking in some manner adult learner success and attainment. Furthermore, there is also the capacity to utilise quantitative research strategies to determine the impact of ILFs and ELFs on the adult learner. Further research would either render this study's findings transferable across contexts through confirmatory future findings, or assign them as specific only to this case. The manner in which findings and conclusions were reported in this case also provides practical opportunities for future researchers to utilise at least elements of the present study. Adult learning is such a broad and theoretically dense research domain, which could be balanced by more practical opportunities to apply and analyse changes to praxis. Theory may be substantiated by fruitful, real-world applicability.

8.6 Final thoughts

If truth is found in simplicity, the present study is finalised by a single verity about the adult learner. It is neither nature nor nurture that singularly determines adult learning success. It is the interrelationship and constant interaction between the two. Nature denotes learner characteristics, traits, and identity; and nurture speaks to the external influences on the adult learner. Both are critical, and both should be acutely represented at various points in the adult learning journey. Change is the refrain that moves the adult learner between nature and nurture, between ILFs and ELFs, towards learning. Therefore, change must be accepted, embraced and championed to maintain the balance needed for success in learning for every adult learner.

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THE UNIVERSITY OF NOTRE DAME AUSTRALIA

INFORMATION SHEET

Dear teacher participant,

My name is Christine Kassis. I am a PhD candidate at The University of Notre Dame Australia and am enrolled in a Doctor of Philosophy – Education degree. As part of my course I need to complete a research project. This research may only take place upon ethics clearance from the University of Notre Dame and CEO Sydney.

The title of the project is: 'The adult learner: Nature or nurture? A case study of teacher educators and teacher learners'.

My research concerns influencing factors such as a new curriculum (the NESA K–6 Science and Technology Syllabus); teacher self-efficacy and technological pedagogical content knowledge (TPACK) on effective teacher professional learning in K-6 Science and Technology.
The purpose of the study is to ascertain if the learning of adult participants (Primary teachers) is influenced by certain factors and to what extent? This will attempt to shed light on the effectiveness of the professional learning engaged with; and what principles of learning are best employed in this and other similar professional learning contexts to maximise the benefit to teachers and eventually students.

Participants will take part in a 30–60 minute audio recorded and scribed interview, across one or two sittings. Two document-based data source sheets will also be completed during the interview. Information collected during the interview will be strictly confidential. You will be offered a transcript of the interview, and I would be grateful if you would comment on whether you believe we have captured your experience.

Participation is this study is completely voluntary. Before the interview I will ask you to sign a consent form which will be sent to you via email. If you are a willing participant in the study, I ask that you sign the consent form and email it to christine.kassis1@my.nd.edu.au as an indication of your willingness to participate in the study. After receiving the completed consent form you will be contacted by email. You may withdraw from the project at any time prior to the analysis of the data from the interview by sending an email to christine.kassis1@my.nd.edu.au.

The sample size is small, and as researcher all considerations will be taken for the ultimate goal of complete confidentiality. Four main ethical considerations will be employed - informed consent; the absence of deliberate deception; maintenance of privacy and confidentiality and accuracy.

Data collected will be stored securely in the University's School of Education for five years and securely in my home for seven years. No identifying information will be used and the results from the study will be made freely available to all participants.

The Human Research Ethics Committee of the University of Notre Dame Australia has approved the study.

Associate Professor Kevin Watson of the School of Education is supervising the project. If you have any queries regarding the research, please contact me directly or Dr Watson by phone on (02) 8204 4128 or by email at kevin.watson@nd.edu.au.

I thank you for your consideration and hope you will agree to participate in this research project.

Yours sincerely,

Christine Kassis

Tel: 04** *** ***   Email: christine.kassis1@my.nd.edu.au

If participants have any complaint regarding the manner in which a research project is conducted, it should be directed to the Executive Officer of the Human Research Ethics Committee, Research Office, The University of Notre Dame Australia, PO Box 1225 Fremantle WA 6959, phone (08) 9433 0943, research@nd.edu.au

Appendix 2: Interview schedule (teacher educator)

THE UNIVERSITY OF NOTRE DAME AUSTRALIA

INTERVIEW SCHEDULE (TEACHER EDUCATOR)

General information

Name
Age
Gender
Previous school
Number of years of teaching experience

Background knowledge in Science and Technology

1. You have ranked …………….. (teacher learner) as ……… (e.g. novice) on the 'stages of learning self-assessment'. Why would you say they fit into (chosen stage)?
2. How would you describe your Science and Technology background?
3. Did you engage in any form of science learning during your tertiary education?

NESA K–6 Science and Technology Syllabus (2012)

4. What are your perceptions of what constitutes a "good" science lesson?
5. What do you perceive to be the most important learning for teachers in reference to the new NESA K-6 Science and Technology Syllabus (2012)?
6. What is your perception of the influence of a new curriculum on teacher learners' principles of learning?

Teacher self-efficacy

7. How confident were you in your transition from teacher to teacher educator at the beginning of 2015?
- Were there changes to your confidence as the year progressed?
- If so, to what do you credit these changes?
8. Did you feel you had any vulnerability, such as a perceived lack of authority or expertise?
9. Has your self-efficacy in facilitating professional learning in Science and Technology changed in the last year?
- If so, to what do you attribute this change?
10. What influence does your self-efficacy have on your role as teacher educator?
- Do you perceive any influence on the teacher learners?
11. What are your perceptions of the teachers' self-efficacy in Science and Technology and the principles of learning they exhibit?

Technological pedagogical content knowledge (TPACK)

12. What in your opinion is the best way to teach Science and Technology?
- Has this always been how you have taught Science and Technology in your classroom?
13. When facilitating professional learning in Science and Technology describe the importance of:
- Content knowledge (what is being learned).
- Pedagogical knowledge (how it is taught).
- Technological knowledge (appropriate tools for learning).
14. What is your perception of the influence TPACK in Science and Technology has on the principles of learning the teacher learner exhibits?

Principles of learning continuum

15. How do you think you are viewed by the teacher learners in your Region? Has this transitioned along 2015?
16. How would you describe the teacher learners in your Region in reference to their autonomy in learning? Has this transitioned along 2015?
17. Do you feel as though the teacher learners are reliant upon your experience of Science and Technology for their own learning?
- To what extent?
- Has this transitioned along 2015?
18. What do you perceive to have been the main motivations of teacher learners to engage in professional learning in Science and Technology in 2015?
- Has this transitioned along 2015?
19. When facilitating professional learning for the teacher learners, what consideration (if any) did you give to the following:
- the adult audience of learners
- level of learner dependence on you as teacher educator
- your level of responsibility in the learning of the teacher learner
- the teacher learners' purpose for learning
- teacher learner extrinsic and intrinsic motivation in learning.
20. Do you think that "good teaching" is applicable to both adult and child students alike?
21. Do you consider your own principles of learning when facilitating professional learning?

Appendix 3: Interview schedule (teacher learner)

THE UNIVERSITY OF NOTRE DAME AUSTRALIA

INTERVIEW SCHEDULE (TEACHER LEARNER)

General information

Name
Age
Gender
Current school
Current teaching Stage
Number of years of teaching experience

Background knowledge in Science and Technology

1. You have ranked yourself as ……… (e.g. novice) on the 'stages of learning self-assessment'. Why would you say you fit into (chosen) stage?
2. How would you describe your Science and Technology background?
3. Did you engage in any form of science learning during your tertiary education?

NESA K–6 Science and Technology Syllabus (2012)

4. How would you describe your understanding of the NESA K–6 Science and Technology Syllabus (2012) at the beginning of 2015?
5. How would you describe your understanding of the NESA K–6 Science and Technology Syllabus (2012) by the end of 2015?
6. Do you feel that you are well equipped to teach the NESA K–6 Science and Technology Syllabus (2012)? Would your answer have been different at the beginning of 2015 prior to your professional learning?
7. How have your perceptions of a "good" science lesson changed/developed in 2015?

Teacher self-efficacy

8. How would you describe your level of confidence in the area of teaching science and technology at the beginning of 2015?
   - Has this transitioned at any point in the last year?
9. Has your self-efficacy in teaching Science and Technology changed in the last year?
   - If so, to what do you attribute this change?
10. How do you feel you could further improve your self-efficacy in Science and Technology?
11. What influence does your self-efficacy have on your classroom teaching?
    - Do you perceive any influences on student learning?

Technological pedagogical content knowledge (TPACK)

12. How would you describe your content knowledge in Science and Technology?
13. What in your opinion is the best way to teach Science and Technology?
    - Has this always been how you have taught Science and Technology in your classroom?
14. Do you feel confident in choosing ICT tools to teach Science and Technology?
    - Has this transitioned in the last year?

Principles of learning continuum

15. How would you describe your reliance on the teacher educator in your professional learning across 2015?
16. Do you feel as though your previous teaching and learning experience in Science and Technology was valuable to your professional learning in 2015?
17. Why were you motivated to participate in professional learning for Science and Technology in 2015?
18. How independent do you feel you are when engaging in learning in Science and Technology?
19. Do you prefer to rely on the teacher educator to guide your professional learning in Science and Technology?

THE UNIVERSITY OF NOTRE DAME AUSTRALIA

CONSENT FORM

The adult learner: Nature or nurture? A case study of teacher educators and teacher learners

Researcher: Christine Kassis

I, *(participant's name)* ________________________________hereby agree to being a participant in the above research project.

- I have read and understood the Information Sheet about this project and any questions have been answered to my satisfaction.
- I understand that I may withdraw from participating in the project at any time (in written form by sending an email to christine.kassis1@my.nd.edu.au) up until the data (interview) is analysed, without prejudice.
- I understand that all information gathered by the researcher will be treated as strictly confidential, except in instances of legal requirements such as court subpoenas, freedom of information requests, or mandated reporting by some professionals.
- I understand that a code will be ascribed to all participants to ensure that the risk of identification is minimised.
- I understand that the protocol adopted by the University Of Notre Dame Australia Human Research Ethics Committee for the protection of privacy will be adhered to and relevant sections of the *Privacy Act* are available at http://www.nhmrc.gov.au/
- I agree that any research data gathered for the study may be published provided my name or other identifying information is not disclosed.
- I understand that I will be audio-taped.

PARTICIPANT'S SIGNATURE:		**DATE:**	

RESEARCHER'S FULL NAME:			
RESEARCHER'S SIGNATURE:		**DATE:**	

If participants have any complaint regarding the manner in which a research project is conducted, it should be directed to the Executive Officer of the Human Research Ethics Committee, Research Office, The University of Notre Dame Australia, PO Box 1225 Fremantle WA 6959, phone (08) 9433 0943, email research@nd.edu.au