# Teaching Geoscience Out-of-Field with Digital Technologies: Understanding Agency through Positioning Theory

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Doctor of Philosophy

December, 2019

Melbourne Graduate School of Education

The University of Melbourne

Submitted in total fulfilment for the degree
of
Doctor of Philosophy

## Abstract

The professional rights and duties science teachers ought to attend to as skilled members of the profession are evident from roles specified by initial teacher education, registration authorities, subject-specific teachers' associations, education policy and state-mandated curriculum documents. Of particular interest are the assumptions made by stakeholders within and beyond the community of professional educators about both digital technologies and teachers' capacity to incorporate them into their practice. Research literature suggests that teachers' use of digital technologies varies considerably and depends on a number of factors (Ertmer & Ottenbreit-Leftwich, 2013; Inan & Lowther, 2010; Somekh, 2008; Waight, Chiu, & Whitford, 2014; Zhao & Frank, 2003). In addition, for multi-disciplinary subjects like general science the accepted reality is that teachers may be highly accomplished in some areas but not others (Carlsen, 1992; Kind, 2014; Nixon, Campbell, & Luft, 2016; Nixon & Luft, 2015; Sanders, Borko, & Lockard, 1993). Geoscience is a sub-discipline of science largely taught by non-specialists (King, 2008, 2013, 2015) or science teachers teaching out-of-field (OOF) (Hobbs, 2015).

This qualitative research sought a more empowering and useful understanding of teachers' lived experience teaching with digital technologies in the Australian state of Victoria. Positioning theory (Harré & van Langenhove, 1999) was the overarching philosophy and methodology for the research design. Ten science teachers from an inner-city school in Melbourne were invited to reflect on their lived experience teaching with digital technologies. Constructivist grounded theory coding procedures (Charmaz, 2014), pronoun grammar analysis (Mühlhäusler & Harré, 1990; Redman, 2013a; Redman & Fawns, 2010) and the positioning triad (Harré & van Langenhove, 1999) were the analytical tools used to methodically code data to better understand extent to which teachers perceived themselves to be permitted and/or empowered (Foucault, Martin, Gutman, & Hutton, 1988) to act autonomously before, during and after teaching geoscience with digital technologies.

Prior to offering teachers support to teach OOF with digital technologies, two notable conclusions emerged from the data analysis. First, teachers did not make connections between their institutional and subject-specific duties to utilize digital

technologies. Second, without a formal program of digital experiences for students *and* teachers' varying degrees of personal and professional history utilizing digital technologies, the sign systems (Foucault et al., 1988) were not yet in place for most of these teachers to identify the pedagogical possibilities for digital technology use. Notably early-career teachers who trained as scientists could not be assumed to intuitively draw on their transferrable skills to teach for technology-enabled learning (Brantley-Dias & Ertmer, 2013; Ertmer & Ottenbreit-Leftwich, 2013). In addition, most teachers did not readily identify their existing digital practices as transferrable and linked to teaching OOF.

Four teachers participated more extensively by teaching a year nine geoscience unit designed to support their personal and pedagogical growth to use digital technologies in the OOF area. External and internal factors that both strengthened and compromised teachers' evolving sense of personal agency are identified and explained. Notably, science teachers cannot be grouped as homogeneous users *of* and teachers *with* digital technologies. Teachers' interpretations of their professional rights and duties to utilize digital technologies must be understood for effective, differentiated professional growth to occur across both subject-specific and institutional expectations.

The range and complexity of competencies for which teachers are personally and professionally accountable are explained and the research is shown to make unique contributions to the fields of OOF teaching, digital technology use in education, better understanding the experiences scientists who became teachers and research methodology. The Explicit Personal Pragmatic Approach (EPPA) to professional learning is a three-dimensional model offered that illustrates the relationships between subject-specific and institutional expectations placed on teachers. The EPPA may also hold value if applied to other occupations where workplace professionals change roles and are required to continually refine their knowledge and skills in unfamiliar contexts. Finally, recommendations are made for implementing school-wide use of digital technologies which may have international implications, particularly in a time when a variety of stakeholders rely on teachers' digital technology use to help combat global health issues.

## Declaration

I, Emily Elizabeth Rochette, hereby declare that, except where specific reference is made to the work of others, the contents of this thesis are original. This work, submitted to The University of Melbourne in total for the fulfilment of the degree of Doctor of Philosophy, has not been submitted in whole or in part for any other qualification at this or another university. The work presented is my own except where specified in the text and acknowledgements. Excluding the titles of tables, figures and vignettes in addition to references, this thesis is fewer than 100,000 words as approved by the Research Higher Degrees Committee.

Emily Elizabeth Rochette

December 2019

## Acknowledgements

*Ever since the spider had befriended him, he had done his best to live up to his reputation. When Charlotte's web said SOME PIG, Wilbur had tried hard to look like some pig. When Charlotte's web said TERRIFIC, Wilbur had tried to look terrific. And now that the web said RADIANT, he did everything possible to make himself glow.*

*- White (2014, p. 24)*

I have vivid memories of my parents reading to me when I was a child. Looking at the page I wondered how those dancing shapes could become stories. It took me a long time to learn how to read and even longer to learn to write. I've had many teachers and I'm sure I'll have many more. With these thoughts and the quote from my favorite story I would like to express my gratitude to the teachers, of all ages, who helped craft this thesis.

First, I would like to thank my supervisors, Dr. Christine Redman and Dr. Paul Chandler, for your wisdom, support and time over the past five years. You have always challenged my thinking and helped shape my understanding of the complexities of teaching, learning and writing about the dynamic social world. I would like to offer my sincere gratitude to my participants, both teachers and students, who offered me their time and words. The narratives you have shared enabled me to better understand this noble profession.

Next, I would like to recognize the support I have received from by colleagues at The Melbourne Graduate School of Education, Riverside High (pseudonym) and beyond. Your ongoing encouragement has kept me in the right mindset to complete this thesis while working two jobs. Thank you for being my spring board for those moonshot ideas, acting as critical friends and checking in with coffees, breakfasts, lunches and dinners. 'It is not often that someone comes along who is a true friend and a good writer' (p. 249). I would like to express my gratitude to Dr. Susan White, my personal and, at times, very critical friend, who volunteered her time to teach me about geoscience and proofread this thesis.

In addition, I would also like to thank two of my high school teachers, Elisabeth von Bloedau and Susan Burpee. Your classes inspired me to become the scholar I am today. Finally, I express my heartfelt gratitude to my parents, who modelled reading, curiosity and wonder.

*We take to the breeze, we go as we please (p. 244).*

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# Chapter 1: Introduction

***Geoscience Domain:*** *What are the three types of rock?*

***Researcher:*** *Classic, punk and hard?* ¯_(ツ)_/¯

## 1.1 The Catalyst: Personal Experience

Five years ago, if you had asked me to name the three types of rock, I would have hesitated, laughed and then responded: Classic, punk and hard? The implications are significant. Although I was a professionally trained science teacher holding a bachelor of science, in chemistry and anthropology, I was traversing a new language environment and tasked to teach a topic with vaguely familiar concepts. Geoscience is the study of Earth's physical structures and processes acting on them (King, 2008). It is a sub-discipline of science that, internationally, has been documented as being largely taught by non-specialist general science teachers (King, 2008, 2013, 2015).

Recognizing this as an opportunity, I decided to harness my ignorance and satisfy my curiosity for online learning. I logged in to two massive open online courses (MOOCs) to learn about geoscience. Simultaneously, I reflected on my professional duties to utilize and incorporate digital technologies into teaching and learning sequences, professional requirements of teachers in Australia. I wondered how in-service science teachers managed this compulsory expectation while concurrently teaching an unfamiliar topic, a situation that other teachers of broad, multi-disciplinary subjects might also experience.

## 1.2 Professional Impetus for and Significance of the Research

This research seeks a more empowering and useful understanding of the complexity of the practices of science teachers in the Australian state of Victoria. Examination and analysis of the expectations placed on teachers through initial teacher education and certification (Australian Institute for Teaching and School Leadership [AITSL], 2015), professional standards (AITSL, 2011; Australian Science Teachers Association [ASTA], 2002), digital education policy (Alexander, Barnett, Mann, & Mackay, 2013; 2011; Department of Education, Employment and Workplace Relations [DEEWR], 2008; Department of Education and Early Childhood Development [DEECD], 2014) and state-

mandated curriculum documents (Australian Curriculum and Assessment Authority [ACARA], n.d.-a; Victorian Curriculum and Assessment Authority [VCAA], 2016d) point to the professional rights and duties teachers ought to attend to as skilled members of the profession. At the intersection of the science and digital technologies curricula these documents specify that teachers:

- Continually develop their professional capacity to utilize digital technologies throughout their career incorporating them into classroom practice and programs while working with, and eventually leading, colleagues (AITSL, 2011);

- Deepen their understanding of the contribution of and build students' skills toward utilizing digital technologies to support the advancement and communication of science in authentic contexts (ASTA, 2002);

- Refine their capacity to develop the knowledge, skills, behaviors and dispositions that equip their students to 'live and work successfully in the twenty-first century' by teaching information and communication technology (ICT) as a general capability through science inquiry (ACARA, n.d.-e); and

- Skillfully and effectively integrate content descriptions from the digital technologies curriculum into subject-specific learning areas (VCAA, 2016f)

The research literature, however, suggests that teachers' use of digital technologies varies considerably and, for some time, has been shown to depend on a number of factors (Ertmer & Ottenbreit-Leftwich, 2013; Inan & Lowther, 2010; Somekh, 2008; Waight et al., 2014; Zhao & Frank, 2003). Therefore, scaffolding teachers to explore the pedagogical possibilities with digital technologies and perhaps negotiate new roles for both themselves and their students begins with supporting them with initial steps toward change (Ertmer, 2016, 2017; Ertmer & Glazewski, 2015) and helping teachers 'understand how different instructional materials [...] support the effective teaching of specific content' (Brantley-Dias & Ertmer, 2013, p. 120). According to Ertmer and Ottenbreit-Leftwich (2010, 2013) and Ertmer, Ottenbreit-Leftwich, and Tondeur (2014) focus should be on:

1. **Contextual factors:** Ensuring teachers feel supported when facing external barriers to digital technology use;

2. **Cognitive factors:** Offering opportunities contributing to teacher professional growth by modeling the use of pedagogies for technology-enabled learning; and

3. **Affective factors:** Reflecting on teachers' beliefs about teaching, learning and attitudes about the potential value of technology-enabled learning

This means demonstrating how digital technologies transform the strategies and representations teachers use to teach specific content and then illustrating how technology impacts students' ability to understand and learn the content. Both of which may prove difficult when teaching areas of the curriculum outside a teacher's specialization.

Teaching out-of-field (OOF) is a contemporary and contentious label (Hobbs, 2015) that refers to teachers, either assigned or by choice, teaching subjects or year levels for which they have not undertaken specialist training. Despite professional standards indicating areas for teachers' professional growth, for broad, multi-disciplinary fields such as general science (Hobbs, 2015; Hobbs & Törner, 2019; Ingersoll, 1998; Price et al., 2019) the historically accepted reality is that teachers may be highly accomplished in some science areas but not others (Carlsen, 1992; Kind, 2014; Nixon et al., 2016; Nixon & Luft, 2015; Sanders et al., 1993). Notably there are many instances of teaching OOF. Although they are not of equal magnitude in terms of challenge, understanding them 'is essential to accurately assessing the quality and performance of teachers, schools and students' (Ingersoll, 2019, p. 27).

According to Shulman (1986b), 'we assume that most teachers begin with some expertise in the content they teach' (p. 8). For general science teachers this seems to be a problematic assumption perpetuated by initial teacher education and certification, professional standards and curricular expectations since teachers' confidence with disciplinary ideas and modes of inquiry impact the extent to which they feel OOF (Hobbs, 2013b). This research responds to an important area of exploration when establishing teachers' transferrable skills across sub-disciplines of science and identifying where professional learning can take place (Hobbs, 2014). The data gathered, analysis and findings have implications for better understanding the expectations and demands not only placed on teachers, but also any workplace professionals who may change roles and are required to continually refine their knowledge and skills in unfamiliar contexts.

## 1.3 Purpose and Research Questions

This research examines the intersection of the science and digital technologies curricula to better understand the lived experience of science teachers teaching OOF as they make sense of their professional duties and personal agency to fully, partially or outright reject these duties. As such, the seminal research question is:

> To what extent do secondary science teachers' perceptions of their agency change as they are supported to teach an out-of-field area of the curriculum with digital technologies?

Three subsidiary questions focused my investigation and research design:

1. How do secondary science teachers self-assess their uses of digital technologies in the classroom?

2. How do secondary science teachers perceive their capacity to teach geoscience with digital technologies?

3. How does participating in the delivery of a unit of work at the intersection of the geoscience and digital technologies curricula change teachers' beliefs about their sense of agency teaching an out-of-field area, if at all?

## 1.4 Methodology

Positioning theory (Harré & van Langenhove, 1999) was the overarching philosophy and methodology informing the research design. As such, this qualitative research adopted a constructionist epistemology and interpretivist theoretical perspective. In my reading, and so to my knowledge, positioning theory has not yet been utilized to better understand the lived experience of secondary science teachers teaching OOF topics.

Data collection for this research took place over seven months with 10 science teachers from Riverside High (pseudonym), an inner-city school in Melbourne. To varying extents these teachers participated by reflecting on their digital technology use before, during and after teaching a year nine geoscience unit. The teachers' data were triangulated with those from 28 year nine students and 22 colleagues attending the annual Science Teachers' Association of Victoria (STAV) conference to correlate the data and make sense of the possibilities to strengthen teachers' sense of personal agency to teach science with digital technologies.

Central to understanding an individual's perceptions of personal agency are mis-/matches in a participant's *discursive practices* (Harré & van Langenhove, 1999). These are referred to as 'the say and do,' what people state, claim and what they action. *Positions* arise from discursive practices and are reflective of the rights and duties individuals claim and ascribe to themselves and others. The extent to which positions are accepted or rejected is influenced by the history of interactions (Redman & Rodrigues, 2008) indicating power imbalances and signaling plots in *storylines*. *Storylines* emerge as an individual positions her/himself and others through written and non-/verbal symbolic exchanges. In chapter three, section 3.8, I explain how shifting storylines enabled me to monitor and track changes in teachers' sense of agency as they negotiated the local moral order, the system of rights and duties within which their intentional acts were performed. Figure 1.1, illustrates these relationships through the positioning triad.

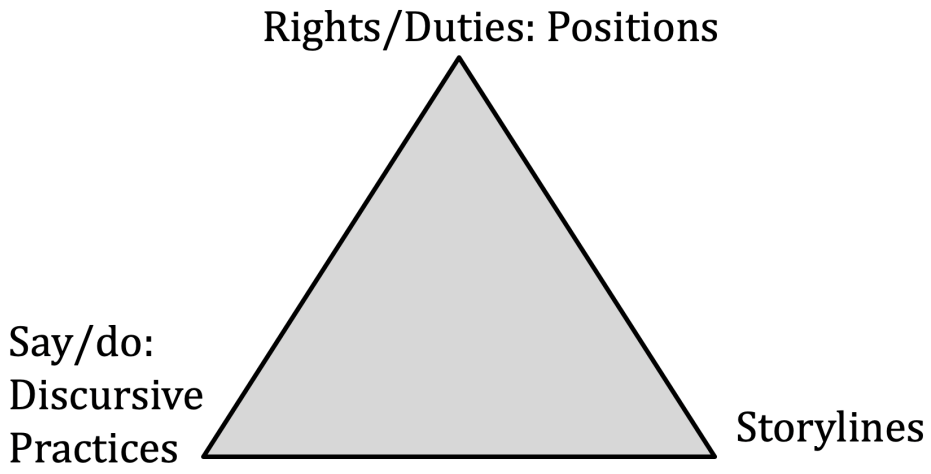



**Figure 1.1.1: The Positioning Triad Adapted from Harré and van Langenhove (1999)**

Constructivist grounded theory coding procedures (Charmaz, 2014), pronoun grammar analysis (Mühlhäusler & Harré, 1990; Redman, 2013a; Redman & Fawns, 2010) and the positioning triad (Harré & van Langenhove, 1999) were the analytical tools used to methodically code:

1. School documents;

2. Personal meaning making maps and collaborative interactive discussions (Giardiello, Parr, McCloud, & Redman, 2014);

3. Individual and focus group interviews; and

4. Questionnaires

Foucault's (1988) technologies of the self offered a framework to articulate the extent to which these teachers felt empowered to act.

### 1.5 Chapter Overviews

This thesis is comprised of four parts. Part I: Setting the Scene consists of two chapters. **Chapter two** presents the professional expectations of science teachers in the Australian state of Victoria and explains tensions between these expectations and findings from the research literature. A theoretical understanding of the agentic self is presented and opportunities for professional learning at the intersection of the science and digital technologies curricula are explained. **Chapter three** introduces and explains positioning theory (Harré & van Langenhove, 1999) as the overarching philosophy for the research design. The methodological framework, main research site, methods of participant recruitment, data collection and analysis are detailed and justified. A framework to evaluate the research design is presented to establish the rigor of the research and the chapter closes with an explanation of the limitations and ethical considerations.

Part II: Preparing to Teach Out-of-Field with Digital Technologies introduces the Riverside context to respond to subsidiary questions one and two. **Chapter four** exemplifies the analytical tools used to interpret 10 teachers' self-assessments of their digital technology use prior to teaching geoscience. These teachers demonstrated varying levels of empowerment (Foucault et al., 1988) to manipulate, produce and transform lessons with digital technologies. As such, they were grouped into categories along a continuum ranging from utilizing digital technologies for mostly teaching science content to teaching science inquiry skills. Unexpectedly, early-career teachers who trained as scientists were found to be placed at novice and apprentice levels of the continuum challenging a widely held assumption that scientific researchers can intuit their laboratory-

based technology skills to teach for technology-enabled learning (Brantley-Dias & Ertmer, 2013; Ertmer & Ottenbreit-Leftwich, 2013).

In **chapter five**, the historical evolution of Riverside's geoscience curriculum is scrutinized and a year nine curriculum document is closely analyzed to better understand the extent to which the state-mandated curriculum aligned with the enacted curriculum. Ten teachers' self-assessments of their personal capacities to teach geoscience with digital technologies were analyzed and the emerging categories organized into a continuum of awareness of digital technology use in geoscience. Unexpectedly most Riverside teachers did not seem to identify their existing digital practices as transferrable to geoscience.

If teachers are to become effective digital technology users, they require practical strategies for overcoming barriers (Ertmer, 1999) and models exemplifying the range of possibilities for computer use (Tondeur, Hermans, van Braak, & Valcke, 2008) such as detailed lesson plans and support to utilize the digital technologies in similar ways to their students. At Riverside, teachers' sense of personal agency to utilize digital technologies seemed to be compromised by both first and second-order barriers (Brickner, 1995; Ertmer, 1999). Both continua developed in chapters four and five served as useful frameworks to plan a unit of work intended to build the capacity of both early-career and experienced teachers to teach OOF from *technology integration* toward *technology-enabled learning* (Brantley-Dias & Ertmer, 2013; Ertmer & Ottenbreit-Leftwich, 2013). **Chapter six** details the considerations required for a unit of work developed to support these teachers to enact the intended curriculum.

Part III: Teaching Out-of-Field with Digital Technologies, Perceptions of Change exemplifies the analytical tools utilized to interpret competency and contrast Charlotte, Ethan, Rachel and Isabelle's perceptions of their sense of agency to teach with digital technologies before, during and after teaching OOF. These analyses enabled me to respond to subsidiary question three.

**Chapter seven** introduces Charlotte, an expert digital technology user who approached teaching prepared to experiment and utilized digital technologies to further develop students' inquiry skills. Surprisingly, while teaching OOF the resources offered provided an already agentic teacher the opportunity to strengthen her pedagogical capacity across the science and digital technologies curricula. For Charlotte professional learning

was perceived to be a personal, ongoing and dynamic process. However, her reflections indicated that even the most experienced and agentic teachers still require support to meet professional expectations, demands and requirements at borders between curricular intersections. Unfortunately, the local moral order (Harré & van Langenhove, 1999), which seemed to strengthen Charlotte's personal agency to experiment with digital technologies, simultaneously interrupted her continued professional learning in this OOF area.

**Chapter eight** introduces Rachel, a former career research scientist and apprentice digital technology user. Rachel's personal agency to utilize digital technologies seemed to be strengthened by social signs (Foucault et al., 1988) and the professional expectations within the Riverside local moral order (Harré & van Langenhove, 1999). However, her personal agency also appeared to be compromised by her beliefs about students' perceptions of technologies. While teaching OOF Rachel was enabled to explore technology-enabled learning (Brantley-Dias & Ertmer, 2013; Ertmer & Ottenbreit-Leftwich, 2013) in distinct pedagogical ways. Her personal agency seemed strengthened by her technological knowledge (Koehler & Mishra, 2009) and reflexive positioning (Harré & van Langenhove, 1999) of herself as a learner. Unexpectedly, Rachel indicated that her most significant area of growth resulted from the relationships she developed with colleagues through peer-to-peer mentoring and dialogic planning. Despite this growth, Rachel seemed to require additional avenues to explore the pedagogical possibilities with digital technologies through continued support.

**Chapter nine** focuses on Ethan who, like Rachel, was a former research scientist. As an early-career teacher, Ethan demonstrated that he felt accountable for student understanding of science and utilized digital technologies to efficiently plan lessons and teach science content. Although Ethan identified and, to a degree, expected his students to utilize digital skills in science, the accepted practices of the local moral order enabled him to feel he could abscond from the duty to teach students these skills. As a novice II digital technology user Ethan was able to manipulate (Foucault et al., 1988) and, to an extent, transform geoscience lessons, but he did not appear to act as an agent of change and required continued support to teach 'hidden' digital skill sets complimenting scientific epistemic practices.

Isabelle, like Charlotte, was an experienced teacher in her second decade of service. In **chapter 10** Isabelle is introduced as a novice I digital technology user. Isabelle's personal agency to utilize digital technologies was strengthened by a professional duty to cater for all learners and a sense of oughtness (Linehan & McCarthy, 2000) to utilize them in similar ways to her colleagues. However, Isabelle's lack of personal history with digital technologies appeared to have compromised the extent to which she was able to accurately assess her students' digital capacities and attend to a duty to teach digital skills. While teaching OOF, Isabelle's sense of agency appeared to be strengthened by social signs (Foucault et al., 1988) within the local moral order. Yet in an effort to be perceived as a competent teacher Isabelle negotiated her professional relationships in ways that seemed to prevent her from obtaining support and consequently limited her sense of personal agency to manipulate digital technologies and transform her practice.

In Part IV: The Explicit Personal Pragmatic Approach (EPPA) to Professional Learning, **chapter 11** responds to the overarching research question and explains the contributions the research makes to the fields of OOF teaching, digital technology use in education, understanding the experiences scientists who became teachers and research methodology. The findings point to a need for clearer pragmatic mandates for digital technology use so teachers feel at the center of their work and can know and be supported to understand and enact professional duties. The EPPA is a three-dimensional model illustrating the relationships between subject-specific and institutional expectations placed on teachers. This offering may not only be of value to the field of educational technology and teacher development for OOF teaching but also to other occupations where professionals are required to continually refine their knowledge and skills in unfamiliar contexts. The chapter concludes with recommendations for implementing school-wide use of digital technologies which may have international implications, particularly in a time when a variety of stakeholders rely on teachers' digital technology use to help combat global health issues.

# Part I: Setting the Scene

# Chapter 2: Literature Review

*Those who can do, do. Those who understand, teach.*
*- Shulman (1986b)*

## 2.1 Introduction

Chapter one explained my personal journey as an out-of-field (OOF) geoscience teacher endeavoring to develop a sense of self-efficacy (Bandura, 1982) to teach an area of the science curriculum of which I had little knowledge and minimal training but was expected to be able to teach. Satisfying a need and desire to learn, with curiosity I engaged in online learning and explored pedagogical possibilities for teaching geoscience. This research examines the intersection of the science and digital technologies curricula; therefore, it is necessary to understand what it means to be a practicing science teacher in a digital world traversing both personal capacity and professional expectations for teaching science. As such, this literature review is written in four parts:

1. Part I: The Expectations of Victorian Science Teachers;
2. Part II: The Expectations of Digital Technologies in Education;
3. Part III: Teaching Out-of-Field: The Geoscience Meaning Making Space;
4. Part IV: The Agentic Self: Knowledge, Beliefs, Attitudes and Behavior

## 2.2 Part I: The Expectations of Victorian Science Teachers

Davies and Harré (1999) explain that in research the development of a model for the social psychology of self has drawn on the traditional drama and the concept of role, where 'people are construed as actors with lines already written' (p. 41). Policies and contractual agreements express pre-determined lists of rights and duties by formally recording the static expectations of individuals assigned to roles. In this section, the complexity of what it means to be a science teacher in the Australian state of Victoria is unpacked by exploring the expectations placed on teachers, in terms of rights and duties, through initial teacher education and certification, professional standards and education policy including state-mandated curriculum documents.

### 2.2.1 Initial Teacher Education and Certification

In Australia, teacher registration requires a qualification (Weldon, 2015) recognized by state regulatory authorities such as the Victorian Institute of Teaching (VIT). Supporting federal, state and territory governments, the Australian Institute for Teaching and School Leadership (AITSL) (2018a) has designed standards and procedures for initial teacher education programs reflecting high expectations, collective accountability and a shared responsibility for program evaluation. In 2018, 358 accredited initial teacher education programs were offered by 48 providers across Australia (AITSL, 2018b). Graduates of initial teacher education programs are required to complete:

1. A three-year undergraduate degree in discipline-based knowledge and two-year graduate entry teaching qualification; or

2. Integrated or combined degrees of at least four years full-time equivalent comprising of discipline and professional studies; or

3. A four year full-time equivalent approved by jurisdictional regulatory authorities in consultation with AITSL (2018a)

In 2016, 40% of undergraduate entrants had an Australian Tertiary Admission Rank (ATAR) of 70 or lower (AITSL, 2018b). This means that teacher candidates academically outperformed, at most, 70% of students in their age group possibly calling into question the academic caliber of undergraduate students seeking to enter the teaching profession (Bahr, Pendergast, & Ferreira, 2018). However, Bahr et al. (2018) explain that less than half of the entrants into teacher education rely on the ATAR as an indication of their academic ability. Admission into graduate programs for secondary teaching requires a major study in one teaching area and 'preferably' a minor study in a second area (AITSL, 2018a). As such, graduate teachers are expected to have a breadth and depth of discipline-based content knowledge and pedagogy to meet professional standards and state-mandated curriculum requirements.

Despite these expectations and the attention drawn to the supply and demand of subject-specialists (Masters, 2015; Productivity Commission, 2017; Weldon, 2015; 2016), with the exception of the state of New South Wales, Australian teachers are registered without reference to year level or subject specialization (Price et al., 2019). As such, a certified in-service teacher with specialization in one discipline may be tasked with

teaching a non-specialist discipline. In addition, Porsch and Whannell (2019) point out that there is an assumption that 'teacher education programs positively influence teachers' competences, and subsequently their professional practices, which in turn leads to more effective student learning' (p. 185). In a mixed-methods study of 63 teacher educators and 52 student teachers, Barak (2017) explored the use of educational technologies to promote understanding of science teaching in middle schools and reported that teacher educators 'do not provide sufficient models for the promotion of reform-based practice via web 2.0 environments' (p. 283). Rowston, Bower, and Woodcock (2020) investigated 19 pre-service teachers with industry experience to explain how their technological capabilities, teacher-training and placement experience affected their perceptions about technology use and practice. Although interview data indicated that prior technological experience led to teacher confidence, resilience and self-regulation to utilize technologies, teachers' preconceived beliefs, insecurity about content knowledge and ineffective modeling of technologies during initial teacher education led to them to employ transmission-oriented pedagogies. Thus, graduate teachers making the transition to teaching from other fields, with only two years' developing their professional practice, may be presumed to be professionally competent beyond their capacity for effective instruction.

Where initial teacher education programs offer entry into teaching, professional standards and education policy expand on the expectations of teachers throughout their service. The next section introduces these professional expectations for all classroom teachers and then focuses on those specifically related to science teachers.

### 2.2.2 Teacher Professional Standards and Education Policy

The Australian Professional Standards for Teachers (AITSL, 2011) explicitly articulate the professional expectations of teachers and support the Melbourne Declaration to promote equity and excellence in Australian schooling and develop young people as successful learners, confident and creative individuals, and active and informed citizens (Barr et al., 2008). These standards were developed from and informed by six thousand teachers' perceptions of their professional expectations as well as descriptions of teachers' knowledge, practice and engagement used by professional associations and accreditation and registration authorities. In addition, they serve to inform national, jurisdictional,

system and school level performance and development frameworks to improve teachers' practice and student outcomes (AITSL, 2012). Table 2.1 presents the standards organized into three domains.

**Table 2.1: Australian Professional Standards for Teachers (AITSL, 2011)**

| Teaching Domain | Standards |
|---|---|
| **Professional Knowledge** | 1. Know students and how they learn<br>2. Know the content and how to teach it |
| **Professional Practice** | 3. Plan for and implement effective teaching and learning<br>4. Create and maintain supportive and safe learning environments<br>5. Assess and provide feedback and report on student learning |
| **Professional Engagement** | 6. Engage in professional learning<br>7. Engage professionally with colleagues, parents/carers and the community |

To meet the Australian Professional Standards for Teachers educators are expected to draw on professional knowledge, including research, to understand students' physical, social and intellectual needs as well as subject-based content and curriculum (AITSL, 2011). They are expected to plan for, develop and draw on a repertoire of effective strategies to scaffold literacy and numeracy and use information and communication technology (ICT) to contextualize and expand student learning. Teachers should be able to create inclusive and challenging learning environments, not only evaluating student learning but also planning and reflecting on the implementation of programs. These standards do not assume that once certified a teacher's learning journey is complete, stipulating that teachers have a duty to monitor their learning needs both individually and collegially within and beyond the classroom.

Although the Professional Standards for Teachers outline benchmarks for professional growth to ensure the quality of teaching and learning, much of a teacher's expertise is discipline-specific and standards for teaching must reflect the subject-specific character of professional knowledge:

> What accomplished teachers in science know and do is different from what accomplished teachers in other fields know and do (ASTA, 2002, p. 5).

In 2002, the Australian Science Teachers Association (ASTA), in consultation with practicing teachers, sought to design standards for highly accomplished teachers of science to reflect the complexity of knowledge and pedagogical reasoning underpinning excellence in science teaching. These standards are summarized in Table 2.2.

**Table 2.2: National Professional Standards for Highly Accomplished Teachers of Science (ASTA, 2002)**

| Teaching Domain | Highly Accomplished Teachers of Science... |
|---|---|
| **Professional Knowledge** | 1. Have a broad and current knowledge of science and science curricula, related to the nature of their teaching responsibilities<br>2. Have a broad and current knowledge of teaching, learning and assessment<br>3. Know their students well and understand the influence of cultural, developmental, gender and other contextual factors on students' learning |
| **Professional Practice** | 4. Design coherent learning programs appropriate for their students' needs and interests<br>5. Create and maintain intellectually challenging, emotionally supportive and physically safe learning environments<br>6. Engage students in generating, constructing and testing scientific knowledge by collecting, analyzing and evaluating evidence<br>7. Continually look for and implement ways to extend students' understanding of the major ideas of science<br>8. Develop in students the confidence and ability to use scientific knowledge and processes to make informed decisions<br>9. Use a wide variety of strategies, coherent with learning goals, to monitor and assess students' learning and provide effective feedback |
| **Professional Engagement** | 10. Analyze, evaluate and refine their teaching practice to improve student learning<br>11. Work collegially, within their school community and wider professional communities to improve the quality and effectiveness of science education |

The National Professional Standards for Highly Accomplished Teachers of Science stipulate that 'teaching science well is something that teachers learn to do over many years' (p. 6) and ASTA supports teachers to do so through online professional learning (ASTA, n.d.). Although teachers are expected to remain learners throughout their career, these

standards, outlined almost 10 years before the Australian Professional Standards for Teachers (AITSL, 2011), do not seem to acknowledge additional and distinct professional and administrative demands teachers face in their careers. The breadth of these demands may or may not directly relate to classroom teaching and as such could work to strengthen, stall or compromise teachers' professional capacity to meet discipline-specific professional standards. Furthermore, despite the National Professional Standards for Highly Accomplished Teachers of Science indicating areas for professional growth, the accepted reality is that teachers may be highly accomplished in some topic areas but not others (Carlsen, 1992; Kind, 2014; Nixon et al., 2016; Nixon & Luft, 2015; Nixon, Luft, & Ross, 2017; Sanders et al., 1993). Therefore, successful pedagogical practices from one topic may not be recognized and enacted as transferrable to another less familiar area.

The National Professional Standards for Highly Accomplished Teachers of Science *do* point out, however, that despite standards for professional certification aspiring to be context free, teachers adapt to the circumstantial situations within which they work. As such ASTA recommends that assessing teachers' attainment of these standards is based on 'rich descriptions of school context' (ASTA, 2002, p. 6). Scholars from different areas of education research have also pointed to the importance of understanding contextual factors, recent examples include Crook (2012); du Plessis, Hobbs, Luft, and Vale (2019); Leary et al. (2016); Mueller and Wood (2012); Tschannen-Moran, Salloum, and Goddard (2014); Vangrieken, Meredith, Packer, and Kyndt (2017). This research aims to provide a rich description of contextual factors including the history of practice, professional relationships, and support structures to possibly offer recommendations to foster teachers' capacity to meet discipline-specific standards in a less familiar topic area.

In addition to these professional expectations, the Australian Professional Standards also specify that teachers are expected to develop their professional capacity to utilize digital technologies throughout their career incorporating them into their classroom practice and programs while working with, and eventually leading, colleagues (AITSL, 2011). Similarly, the National Professional Standards for Highly Accomplished Teachers of Science stress the importance of understanding the contribution of and building students' skills toward utilizing digital technologies to support the advancement and communication of science in authentic contexts (ASTA, 2002).

Over many decades Victorian education policy has placed an increasing emphasis on digital technology use. In 2008, the Australian government funded the Digital Education Revolution (DER) to:

> [...P]rovide a once-in-a-generation opportunity to establish and enable a new future-directed vision for education in Australia and the role that digital technologies should play in delivering better educational outcomes for all school students. (DEEWR, Department of Education, Employment, and Workplace Relations, 2008, p. 3)

Over five years more than two billion dollars were pledged to provide laptops to secondary students, improve infrastructure to support use of the Internet and digital devices in schools, provide resources to develop teachers' and students' digital proficiency and enable parents to participate in their children's education. Yet, by 2013, the DER was no longer funded.

In 2014, the Victorian government released Unlocking the Potential, a four-year strategy to maximize learning opportunities through the use of digital technologies:

> From offering unprecedented access to high-quality interactive content and tools, to the development of digital skills, to enabling personalized learning, transforming assessment, reporting and feedback, and driving new forms of collaboration and communication, digital learning can benefit all learners (DEECD, 2014, p. 22).

These intended uses of digital technologies seem to sit at the intersection of intended institutional uses, 'transforming assessment, reporting and feedback,' and classroom uses, offering access to interactive content and tools to enable personalized, collaborative and communicative learning. Despite these claims, this policy also identified challenges within the Victorian context, which included building the capability and confidence of educators and leaders supporting them to embed digital technologies into their practice in ways that are learning centered, not technology-driven.

Although Unlocking the Potential highlighted the challenges teachers may face to implement digital technology use in their classrooms and offered a plan for action, there seemed to be the assumption that policy is effectively implemented in schools. Another assumption was that teachers collectively have the capacity to bridge their administrative and professional duties to utilize digital technologies. Finally, without reflecting on the complexity of teaching multi-disciplinary learning areas, such as science or the humanities,

teachers seemed to be grouped as homogeneous users of digital technologies. As such, the next section explains the curricular expectations placed on science teachers working at the science and digital technologies curricular intersection.

### 2.2.3 Curricular Expectations: The Australian and Victorian Science Curricula

In Australia, state governments have controlled curriculum decisions for over a century (Craig Campbell & Proctor, 2014). Yates and Collins (2010) explain that from 1975 to 2005 curriculum policy has shifted from emphasizing subject-based content knowledge toward capabilities, 'procedural knowledge of future value to students across all aspects of their lives' (p. 97). In 2009, the federal government oversaw the Australian Curriculum, Assessment and Reporting Authority (ACARA) to establish a common curriculum from foundation to year 10. Across primary and secondary schooling, students are expected to learn topics from eight learning areas integrating seven general capabilities and three cross-curriculum priorities. Table 2.3 summarizes the structure of the Australian Curriculum (ACARA, n.d.-a).

**Table 2.3: Structure of the Australian Curriculum**

| Learning Areas | General Capabilities | Cross-Curriculum Priorities |
|---|---|---|
| 1. English<br>2. Mathematics<br>3. Science<br>4. Humanities and social science<br>5. The arts<br>6. Languages<br>7. Health and physical education<br>8. Technologies | 1. Literacy<br>2. Numeracy<br>3. Information and communication technology (ICT)<br>4. Critical and creative thinking<br>5. Personal and social capability<br>6. Intercultural understanding<br>7. Ethical understanding | 1. Sustainability<br>2. Asia and Australia's engagement with Asia<br>3. Aboriginal and Torres Strait Islander histories and cultures |

Adapted from (ACARA, n.d.-a)

Based on the School Science Education National Action Plan 2008-2012 (Goodrum & Rennie, 2007), the objective of the science learning area was to develop students' science literacy to become effective citizens (Corrigan & Marangio, 2018) and includes three strands:

1. **Science Understanding:** Content knowledge from biology, chemistry, Earth and space sciences and physics that enables students to predict, explain and apply science to new situations;

2. **Science Inquiry Skills:** Proficiency to question and predict, plan and conduct investigations, process, analyze, evaluate and communicate data and information; and

3. **Science as a Human Endeavor:** Understanding the nature and development of science and the use and influence of science in society (ACARA, n.d.)

The information and communication technology (ICT) general capability has been integrated into the science inquiry skills strand. Table 2.4 presents the content descriptions for these capabilities across years seven to 10. Teachers are expected to develop the knowledge, skills, behaviors and dispositions that equip their students to 'live and work successfully in the twenty-first century' (ACARA, n.d.-e). Although these content descriptions provide signposts for teachers to understand where digital technologies can support development of science inquiry skills, teachers are assumed to have the knowledge of and capacity to utilize digital technologies for these purposes.

**Table 2.4: Developing Science Inquiry Skills through the ICT General Capability**

| Year(s) | Content Description |
|---|---|
| **7** | **Planning and Conducting:** Measure and control variables, select equipment appropriate to the task and collect data with accuracy (ACSIS126) |
| **7 and 8** | **Processing and Analyzing Data and Information:** Construct and use a range of representations, including graphs, keys and models to represent and analyze patterns or relationships in data using digital technologies as appropriate (ACSIS129, ACSIS144)<br><br>**Communicating:** Communicate ideas, findings and evidence-based solutions to problems using scientific language, and representations, using digital technologies as appropriate (ACSIS133, ACSIS148) |
| **9 and 10** | **Planning and Conducting:** Select and use appropriate equipment, including digital technologies, to collect and record data systematically and accurately (ACSIS166, ACSIS200) |

(ACARA, n.d.-d)

Apart from Victoria and New South Wales, the Australian Curriculum has been adopted by all other states and territories. In 2015, the Australian Curriculum was incorporated into the Victorian Curriculum by the Victorian Curriculum and Assessment Authority (VCAA) to reflect Victorian standards and priorities (VCAA, 2016d). Of note is that government and Catholic schools in the state of Victoria were required to implement the Victorian Curriculum as of 2017, other non-government schools, however, have a choice of either implementing the Australian or Victorian curricula.

The Victorian Curriculum is presented as a learning continuum, yet teachers are expected to meet content descriptions comparable to the Australian Curriculum. For instance, at levels nine and 10 teachers are expected to scaffold students to:

> Select and use appropriate equipment and technologies to systematically collect and record accurate and reliable data, and use repeat trials to improve accuracy, precision and reliability (VCAA, 2015b, VCSIS316).

Notable structural changes within the Victorian Curriculum include science as a human endeavor having been merged with the science understanding strand. In addition, the literacy, numeracy and ICT general capabilities have been incorporated into all eight learning areas without separate curricular treatment (Foster, 2015). Furthermore, Victorian teachers are also expected to integrate content descriptions from the technologies (VCAA, 2016f) into subject-specific learning areas.

The digital technologies curriculum complements aspects of the science curriculum (VCAA, 2016e) and consists of three strands: digital systems, data and information, and creating digital solutions (VCAA, 2016b). As such, science teachers are expected to equip students with a skill set including the collection, organization, storage, analysis and presentation of scientific data and the use of simulations and animations to support conceptual understanding and test predictions about phenomena that cannot be explored first-hand (VCAA, 2016e). These expectations seem to mirror the ICT general capabilities that teachers are already expected to incorporate into science, but may abstract other digital skills that teachers working in a networked society may already have the capacity to teach. These skills could include teaching students how to control, manage and secure data in networked digital systems as well as scaffolding students to collaborate online while managing privacy and security. These situations serve to exemplify the complexity of

implementing curriculum policy where, in some cases, state-mandated curriculum can both strengthen and abstract teachers' understanding of what to teach.

### 2.2.4 Conclusion

This section explained the development and expectations of pre-determined lists of duties assigned to science teachers from theoreticians and policy makers. Initial teacher education programs, professional standards, policy and state-mandated curriculum documents place high expectations on Victorian science teachers even though they are not professionally registered as subject specialists (Price et al., 2019). On paper, practicing science teachers are expected to have the capacity to incorporate digital technologies while attending to their administrative and professional duties to enhance both science understanding and inquiry skills.

A large body of literature, however, suggests that teachers' choices to use digital technologies depend on a number of factors (Ertmer & Ottenbreit-Leftwich, 2013; Inan & Lowther, 2010; Somekh, 2008; Waight et al., 2014; Zhao & Frank, 2003) including workplace context (Ertmer, 1999; Leary et al., 2016; Tondeur, Devos, van Houtte, van Braak, & Valcke, 2009) and their personal and pedagogical beliefs in relation to digital technology use (Ertmer, 1999, 2005; Ertmer & Ottenbreit-Leftwich, 2010; Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; Ertmer et al., 2014; Ertmer, Ottenbreit-Leftwich, & York, 2006; Hermans, Tondeur, van Braak, & Valcke, 2008; Levin & Wadmany, 2006; Mama & Hennessy, 2013; Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010; Petko, 2012; Prestridge, 2012; Tondeur, Hermans, et al., 2008; Tondeur, van Braak, Ertmer, & Ottenbreit-Leftwich, 2017) and science education (Chen, Morris, & Mansour, 2014; Jones & Leagon, 2014; Kind, 2016; Mansour, 2009, 2013; Markic & Eilks, 2012). Therefore, the next sections shift focus to explain two complexities in a science teacher's lived experience. By exploring the expectations of digital technologies and the out-of-field (OOF) teaching experience tensions will be highlighted between what science teachers are professionally held accountable for through their roles and what they are personally able to do.

## 2.3 Part II: The Expectations of Digital Technologies in Education

Part I explained the development of and expectations placed on Victorian science teachers to utilize digital technologies in their classrooms as specified by the roles informed by teachers, theoreticians and policy makers. In doing so some of the expectations placed on digital technologies were also introduced. Harré (2002b) explains that non-living, material objects, through their intended use, have practical roles assigned to them. Yet material objects also carry meaning such that they are capable of interacting with human beings and thus have many roles open to them that can alter the actions of the individuals using them. Selwyn (2014) calls for an understanding of educational technology as ideology arguing that academic endeavors into educational technology use tend to be positive projects driven by beliefs and rhetoric that digital technologies ultimately improve education. Here, three positive ideologies are introduced to interrogate the lived-experience of science teachers expected to teach with them: techno-fundamentalism, learner-centered learning and the efficiencies of education.

### 2.3.1 Techno-Fundamentalism

Techno-fundamentalism (Vaidhyanathan, 2011) is an unquestioning faith in the power of digital technologies to ultimately improve education and presumes that learning is taking place and driven by technology (Selwyn, 2015). Consider the following from Beyond the Classroom: A New Digital Education for Young Australians in the 21st Century (Alexander et al., 2013), italics have been added for emphasis:

> We need to harness the *transformative potential* of digital technology to support new approaches to *innovative learning* centered around the development of 21st Century Learning skills (p. 4).

Many justifications for the use of digital technologies in education seem to center on these beliefs (Selwyn, 2014). However, convincing evidence of improved learning outcomes due to digital technology use remains elusive (Lim, Zhao, Tondeur, Chai, & Tsai, 2013; Livingstone, 2012; Mama & Hennessy, 2013; Munro, 2010) and 'frequently overemphasizes the influence of technology' (Oliver, 2011, p. 373).

Despite popular, political and academic discourse heralding the transformative potential of digital technologies, a number of scholars have advocated for an examination

and evaluation of the intentions *for* and enactment *of* digital technology use (Lim et al., 2013; Livingstone, 2012; Selwyn, 2009, 2011, 2014, 2015; Selwyn & Cooper, 2015; Tondeur, van Braak, & Valcke, 2007; Voogt, 2008; Watters, 2014, Webb, 2013, Wheeler, 2015) . The Organization for Economic Co-operation and Development (OECD) (2015) has reported that countries investing heavily in information and communication technology (ICT) for education show no significant improvements to students' achievement in reading, mathematics or science. Drawing on data collected from the 2013 International Computer and Information Literacy Study (ICILS) (Fraillon, Schulz, Friedman, Ainley, & Gebhardt, 2015) and the Australian National Assessment Program (NAP) (Fraillon et al., 2017; Fraillon, Schulz, Gebhardt, et al., 2015), Fraillon (2019) draws attention to the realities about digital literacy in schools, in particular that the use of ICT has yet to transform classroom pedagogy and that student digital literacy does not appear to be continuing to increase.

Media reports also seem to indicate that there is no shortage of critics rejecting the claims of the techno-fundamentalists. According to John Vallance, former principal of the academically esteemed Sydney Grammar School, money spent integrating computers in class is a 'scandalous waste' producing little measurable benefits (Bita, 2016, para. 1). Vallance continued by expressing concern that digital technologies gave teachers and the community the 'illusion of having prepared a lesson plan' (para. 17). More recently, Deputy Premier of Victoria and Minister for Education, James Merlino (2019), announced that from term one in 2020, mobile phones will be banned for all students in Victorian state primary and secondary schools to 'help reduce distraction, tackle cyber bullying and improve learning outcomes for students' (para. 1). Assuming that technology is a proxy for learning (Watters, 2014) the techno-fundamentalist ideology may compromise the extent to which teachers identify and enact successful pedagogical practices that may be transferrable from the non-digital to the digital space. However, these reports from the media do not seem to acknowledge that teaching is a reflective profession where teachers may struggle to negotiate their professional duties in terms of what it means to be a teacher driving students' learning.

Teaching in technology-rich environments means that science teachers could assume a duty to build their broad range of professional knowledge (Webb, 2013) by

exploring their personal capacity to utilize the affordances of digital technologies that students carry with them. For instance, those outside the science classroom may not realize that acceleration can readily be measured by students using mobile phones with free or commercial applications. Students studying motion could easily collect and record data on their phones while modeling the forces experienced during collisions. Both Vallance's comments and the state government's ban seem to have assumed that teachers are unable or unwilling to draw on their professional knowledge to critically incorporate digital technologies with pedagogical strength resulting in action that may compromise teachers' sense of agency to meet state mandated curricular requirements to teach inquiry skills with digital technologies.

Wheeler (2015) offers a perspective that seems to sit at the intersection of the critics and the techno-fundamentalists. He explains that teachers may fail to capitalize on the use of digital technologies because they limit their practices to anachronistic mindsets. This perspective seems to deny teachers a sense of agency to assume professional duties to explore the pedagogical possibilities for digital technology use. At the same time, he explains that simply introducing technology into the classroom will not improve education; teachers must understand how technologies can be employed to improve pedagogies. Assuming that teachers know of and have the personal capacity to utilize digital technologies *is* problematic. Information technology is a subject that has one of highest instances of being taught by teachers without specialization in this area (Weldon, 2016). Yet science teachers are expected to seamlessly integrate digital technologies into their regular teaching practice, a significant complexity in multi-disciplinary subjects where teachers are highly accomplished in some topic areas but not others.

### 2.3.2 Learner-Centered Learning

*Learner-centered learning*, or student-centered learning, is another positive ideology explored by Selwyn (2014). It is associated with progressive educational ideals and social constructivist or sociocultural modes of learning from the Vygotskian (1978) tradition. Digital technologies utilized for learner-centered learning support non-authoritarian forms of engagement and pedagogies that emphasize meaning making, interpretation, learner autonomy and power (Selwyn, 2014). Although educational reforms may claim learner-

centered learning to be the most effective way to prepare students for the 21st century (Voogt, 2008), the beliefs that digital technologies 'herald distinctively new *and* improved social arrangements in comparison to preceding 'pre-digital' times' still remains suspect (Selwyn, 2014, p. 5).

Teachers with constructivist beliefs tend to be active users of digital technologies (Ertmer & Glazewski, 2015; Tondeur, van Braak, et al., 2017). Waight et al. (2014) call for more research into the nuances of digital technology use in the sub-disciplines of science reporting that teachers who engaged students in inquiry approaches tended to use digital technologies in their practice. However, the technologies themselves cannot be claimed to inspire shifts in pedagogy from the traditional to learner-centered. For some time the literature has suggested that digital technologies are being used for low-level, teacher-centered tasks (Russell, Bebell, O'Dwyer, & O'Connor, 2003; Tondeur et al., 2007) disconnected from best practice (Ertmer, 2005; Ertmer & Ottenbreit-Leftwich, 2010; Hermans et al., 2008; Prestridge, 2017; Tondeur, Pareja Roblin, van Braak, Voogt, & Prestridge, 2017; Tsai & Chai, 2012). Although traditional pedagogies seem to remain dominant (Mama & Hennessy, 2013), the constructivist/traditionalist dichotomy is not as clearly defined as previously thought (Ertmer & Ottenbreit-Leftwich, 2013; Ertmer et al., 2014; Hermans et al., 2008; Tondeur, Hermans, et al., 2008). In addition, teachers' beliefs about the nature of science do not always translate into constructivist practices (Chen et al., 2014). For instance, Mansour's (2013) case studies of four science teachers demonstrated that those holding traditionalist beliefs employed traditionalist pedagogies whereas teachers holding constructivist beliefs or a mixture of the two experienced tension enacting their beliefs.

Almost 10 years ago Ottenbreit-Leftwich et al. (2010) called for research into shifting teachers' digital technology use toward student-centered practices. Brantley-Dias and Ertmer (2013) and Ertmer and Ottenbreit-Leftwich (2013) distinguished between *technology integration*, increased frequency of digital technology use, and *technology-enabled learning*, employing pedagogies to support students' content-based learning through the use of digital technologies. In this research I draw on these distinctions to differentiate between the appropriation of digital technologies and emphasize the quality of pedagogy when technologies are harnessed for technology-enabled learning. Utilizing

Google Earth, for instance, in ways that seek to empower both teachers and students to learn *with* and *through* digital technologies by gathering real time data and challenging students to reason like scientists is of higher quality than appropriating them for drill and skill type activities.

### 2.3.3 The Efficiencies of Education

Another positive ideology Selwyn (2014) explains is *the efficiencies of education*, linked to market-driven economies where digital technologies are heralded to instill businesslike, organizational efficiencies of educational institutions (Selwyn, 2011). For instance, Compass, a web-based learning management system used in many Australian schools, is reported to 'drive operational efficiency, improve learning outcomes and enable better communication' (Compass Education, 2019). These are claims that can be seen to have strong appeal to many stakeholders including administrators, teachers, students, and parents who may assume rights and duties associated with being offered and using a learning management system, yet the needs and desires of administrators are ultimately reflected by this use (Watters, 2014) .

Although teachers' capacity to negotiate their administrative and professional subject-specific duties may be strengthened with the use of a learning management system, unless they have been invited into the planning processes, these technologies may not be utilized as innovatively as intended (Tondeur, van Keer, van Braak & Valcke, 2008). Over 10 years ago, Dede (2008) explained that, pedagogically, learning management systems limited what could be taught to web-based behaviorist instruction and more recently Selwyn (2014) has suggested that learning management systems may lack the affordances that permit individuals collective empowerment. Although these claims may no-longer hold, Dede's (2008) clarification that educational technologies do not cluster neatly into discrete categories is worthy of reflection especially as teachers negotiate their administrative duties which may not be perceived to be linked to their professional duties in the classroom.

### 2.3.4 Conclusion

This section has explored three positive ideologies about digital technology use in education. Drawing on peer-reviewed literature, books written by education technology scholars and media reports tensions between the intended use of digital technologies and some aspects of teachers' lived experience were explained. In addition, areas of tension for specialist and non-specialist teachers were alluded to, yet what it means to be a specialist teacher is complex, especially for multi-disciplinary subjects like science and the humanities (Crisan & Hobbs, 2019; Hobbs, 2015; Hobbs & Törner, 2019; Ingersoll, 1998). As such, section 2.4 explores the out-of-field teaching experience.

## 2.4 Part III: Teaching Out-of-Field: The Geoscience Meaning Making Space

Part I explained the professional expectations placed on science teachers through their roles specified by initial teacher education programs, professional standards, policy and state-mandated curriculum documents. In Part II the positive endeavors for digital technology use were explained and reflected on. An underlying assumption for the use of digital technologies in education seems to be that science teachers, even at the earliest stage of their career, possess the personal capacity and assume the professional duties to teach at the intersection of the science and digital technologies curricula. Davies and Harré (1999) explain that 'role' is a static concept and developing a social psychology of the self means reflecting on an individual's personal agency as s/he casts her/himself to play these roles in particular settings. This section explores teaching out-of-field (OOF), a complexity within the lived experience of many general science teachers internationally, and explains why the context of geoscience is worthy of study.

### 2.4.1 Out-of-Field Science Teacher Versus Science Teacher Teaching Out-of-Field

The term 'teaching out-of-field' (TOOF) has been described as education's 'dirty little secret' (Brodbelt, 1990, p. 282) and was made popular with the work of Ingersoll (1998, 1999, 2002) in the United States. Teaching out-of-field is a contemporary and contentious label (Hobbs, 2015) that refers to teachers, either assigned or by choice, teaching subjects or year levels for which they do not have specialization. Among nations where published research exists, including Australia, Germany, Ireland, the United

Kingdom, the United States and Indonesia (Price et al., 2019), the phenomenon of TOOF has been shown to have implications for teacher knowledge and practice (Carlsen, 1992; Crisan & Hobbs, 2019; Kind, 2014; Nixon et al., 2016; Nixon & Luft, 2015; Ríordáin, Paolucci, & Lyons, 2019; Sanders et al., 1993), identity (Hobbs, 2012, 2013b, 2014; Olitsky, 2007), student outcomes (Porsch & Whannell, 2019), policy (Productivity Commission, 2017; Vale & Drake, 2019), leadership practices (du Plessis, 2015, 2017; du Plessis, Carroll, & Gillies, 2015; du Plessis, Gillies, & Carroll, 2014; du Plessis et al., 2019), the quality of initial teacher education programs (Coral Campbell, Porsch, & Hobbs, 2019; Hobbs & Campbell, 2014) and teacher professional development (du Plessis et al., 2014; Faulkner, Kenny, Campbell, & Crisan, 2019; Kenny, Hobbs, & Whannell, 2019). However, the literature surrounding OOF teaching does not seem to conclude whether the phenomenon is a deficit or an opportunity.

Drawing on data from the 2013 Staff in Australia's Schools survey (McKenzie, Weldon, Rowley, Murphy, & McMillan, 2014), Weldon (2016) explained that 10 percent of general science teachers are considered OOF. For Weldon, teaching in-field means:

1. Teachers have studied a subject for at least one semester at second-year tertiary level with no tuition in subject-specific teaching methodologies; or

2. Teachers have met the subject criteria above *and* were instructed in subject-specific teaching methodologies

Defining in-field teaching in this way seems to value teachers' experiences with discipline-based content and methods of inquiry. Having a major and teaching certification may also be useful for policy groups advocating high standards for recruitment of specialist teachers (Ingersoll, 2019). In the state of Victoria, however, school leaders are responsible for advertisement and appointment of teaching staff (Price et al., 2019). At the discretion of the principal, in response to hiring or timetabling complications for example, a teacher can legitimately teach any subject and year level (Hobbs & Törner, 2019).

Teachers respond to OOF teaching allocations in a variety of ways (Hobbs, 2013b) and the border between in and OOF teaching can be difficult to identify (Ingersoll, 2019). TOOF can be described metaphorically as a boundary crossing event (Hobbs, 2013a, 2013b, 2014) between a teacher's familiar practices in in-field subjects and unfamiliar practices of OOF subjects where s/he may not recognize the transferability of successful pedagogical

practices. In addition, boundaries can be porous and teachers may reject the OOF label but perpetuate poor or unreflective practice as self-identified subject teachers (Hobbs, 2013b, 2014; Ríordáin, Paolucci, & O'Dwyer, 2017).

The literature surrounding OOF teaching does not seem to conclude whether the phenomenon is a deficit or an opportunity. Blog posts such as: Out-of-Field Teaching is Out of Control in Australian Schools (du Plessis, 2019) and claims that OOF teaching 'inevitably results in heightened levels of student disengagement, lower than anticipated achievement of student learning outcomes, and an increasing lack of confidence among teachers about their ability to teach effectively'(Caldis, 2017, p. 13) may reflect the experience of some OOF teachers, but not all. Drawing on previous work with the Teacher Identity In and Across Subjects Project (Darby, 2010), Hobbs' (2013a) study of 23 teachers, leadership and support staff across three rural Victorian schools explained that there are many factors influencing a teacher's appropriateness to teach OOF including contextual factors, support mechanisms and personal resources. Furthermore, TOOF can offer opportunities for identity expansion and reconceptualization of practice when teachers are supported at their point of need.

In addition, Weldon's (2016) definitions of in-field teaching may be problematic for broad, multi-disciplinary fields such as science and the humanities (Crisan & Hobbs, 2019; Hobbs, 2015; Hobbs & Törner, 2019; Ingersoll, 1998) where teachers, despite being identified as in-field, are unlikely to be specialists in all sub-disciplines of science. Section 2.2.3 explained that in the state of Victoria, science teachers are expected to teach across biology, chemistry, Earth and space sciences and physics. Teaching across the sub-disciplines of science has been researched for some time. For example, Carlsen (1992) reports that a novice biology teacher tended to assert control over conversations when teaching unfamiliar science content. Sanders et al. (1993) explain that when experienced teachers taught in unfamiliar sub-disciplines, at times, they acted as novice teachers but where able to draw on their pedagogical content knowledge as a framework to teach across both areas. Nixon and Luft (2015) report a similar finding for early-career biology teachers teaching chemistry. The subject matter knowledge of chemistry teachers with more classroom experience was more 'coherent, chemistry-focused and sophisticated' than

teachers without this experience (Nixon et al., 2016, p. 1636), a finding previously supported by Kind (2014).

These conclusions highlight the need for pragmatic approaches that must be in place for OOF teachers to be supported to successfully attend to the professional duties for which they are held accountable. For the purpose of this research a distinction must be made between *out-of-field (OOF) science teacher* and *science teacher teaching out-of-field (TOOF)*. *OOF science teacher* refers to a teacher who does not have a specialization in any of the four sub-disciplines of science. These are the 10 percent of OOF science teachers identified by Weldon (2016) . *Science teacher TOOF* is a teacher who, although deemed a subject specialist, is teaching units of science for which s/he does not have subject specialization. For example, I am a science teacher TOOF as a chemistry specialist with duties to teach Earth and space sciences at levels seven to 10 of the Victorian Curriculum.

Understanding these distinctions may call one to question whether any science teacher could be considered in-field. Although not all instances of TOOF are of equal magnitude, understanding them 'is essential to accurately assessing the quality and performance of teachers, schools and students' (Ingersoll, 2019, p. 27). Shulman (1986b) explains 'we assume that most teachers begin with some expertise in the content they teach' (p. 8) an assumption perpetuated by initial teacher education and certification, professional standards and curricular expectations of science teachers. Yet this assumption may be problematic because teachers' confidence with disciplinary ideas and modes of inquiry have bearing on the extent to which they feel OOF (Hobbs, 2013b), an important area of exploration when establishing teachers' transferrable skills across sub-disciplines of science and identifying where learning can take place (Hobbs, 2014).

### 2.4.2 Science Teachers Teaching Out-of-Field: The Geoscience Meaning Making Space

In the state of Victoria, general science teachers are expected to teach science understanding and inquiry skills across four sub-disciplines of science: biology, chemistry, Earth and space sciences and physics. Earth science refers to the study of the Earth's dynamic structure within and on its surface (ACARA, n.d.-d; VCAA, 2015a) and encompasses geology, meteorology, oceanography, soil and environmental science (King, 2011). *Geoscience* (King, 2008), a contemporary term and extension of geology, is the study

of the solid Earth including the physical structures and the processes acting on them. In this section, the complexities of teaching geoscience are explained. Of note is that when 'Earth science' has been used in the literature, I have continued to use this term. Since geoscience is a sub-discipline of Earth science, here 'Earth science' can be assumed to mean geoscience.

King (2015) has summarized the position of geoscience education worldwide. Currently geoscience is a small, compulsory part of national science and geography curricula and may be available as additional or optional courses. Geoscience is becoming increasingly more prominent in schools internationally (King, 2008, 2013), however with the exception of Japan, Korea and Taiwan, geoscience is largely taught by general science teachers TOOF (Dawson & Moore, 2011; King, 2001, 2008; Lewis & Baker, 2010). Eisner (2002) explains that curriculum change is not analogous to installing a mechanical device, 'it is an adaptive process in which both classrooms and materials undergo change' (p. 41).

In England and Wales 10 years after introducing an Earth science component in the National Curriculum for Science, teacher knowledge of Earth science content continued to remain poor (King, 2001). Trend (2005) has shown that children have a high interest in current environmental changes affecting the future of humanity and in the geological events of the past, present and future. In the most recent Trends in International Mathematics and Science Study (TIMSS), Australian year eight students were found to perform significantly higher in biology and Earth science content domains compared to chemistry and physics (Thomson, Wernert, O'Grady, & Rodrigues, 2017). Secondary students' may even place more educational value on Earth science than their teachers (Betzner & Marek, 2014), yet data from 27 teachers and 243 senior secondary students in the state of Western Australia suggest that a lack of content knowledge from lower secondary science contributes to students' perceptions of Earth and environmental science concepts as difficult, boring or irrelevant (Dawson & Carson, 2013).

After reviewing 20 years of literature, Osborne, Simon, and Collins (2003) concluded that teacher variables are the most significant factor in determining students' attitude toward science. Geoscience tends to be viewed as less rigorous by some educators (Lewis & Baker, 2010; Underwood, 2008) and may be offered to students who are 'unmotivated and unable to do *real* science like chemistry and physics' (Lewis, 2008, p.

446). Thomas, Ivey and Puckette (2013) question how teachers who have not had authentic geoscience experiences themselves can provide these learning opportunities for their students. In England and Wales, Jenkins' (2000) survey exploring the effects of the National Curriculum for Science on various elements of teachers' work indicated that chemistry teachers seemed to hold resentment toward Earth science. Some of these teachers believed that Earth science topics were taught at the expense of chemistry, presented difficulties for designing practical work and led to insecurity as teachers taught beyond their specialism. Unfortunately, when content knowledge is deemed to be of less value and learning demand perceived to be slight, teachers may devote less time to certain topics (Mortimer & Scott, 2003; Pajares, 1992).

However, geoscience is a modern, scientific enterprise in which cutting edge technologies yield evidence about the structure and history of the Earth. It is an historical interpretive science (Dodick & Orion, 2003; Frodeman, 1995; Thompson, Praia, & Marques, 2000) that is engaging if students are scaffolded to understand the story of geoscientists' work. King (2008) proposes five strands that make geoscience a distinct curriculum subject:

1. The methodologies of geoscientific reasoning encompass retrodictive thinking and draw on large and incomplete datasets;

2. The holistic systems perspective consists of the passage of chemicals in Earth's biogeochemical cycles;

3. The requirement for high-level geoscientific spatial abilities or three-dimensional thinking;

4. The understanding of different perspectives of time including the geological time scale spanning over four billion years; and

5. The methodologies and attributes of geoscientific fieldwork through observing, recording and analyzing datasets to understand multi-faceted field contexts (pp. 188-189)

As such, geoscientific epistemic practices are distinct from the predictive nature of chemistry and physics (Baker, 1996, p. 41). Therefore, an 'in-field' general science teacher may struggle to teach geoscience topics for which s/he has had little experience. Yoon and Peate's (2015) mixed-method study of 300 American undergraduate students suggests that

some secondary students' school experience has had limited influence on their conceptual understanding of the Earth and space sciences, possibly due to the low status of these topics and a declining number of qualified teachers. After applying a qualitative approach to studying expert and novice Earth science teachers' problem-solving skills, Barba and Rubba (1993) recommend caution when assigning minimally trained teachers or teachers trained in other disciplines to teach Earth and space science.

Crisan and Hobbs (2019) point out that 'the school subject will be a simplified form of the discipline, according to how curriculum designers see fit to present a discipline to pupils' (p. 155). In a school these curriculum designers are subject teachers and when they are TOOF, even the 'simplified form of the discipline,' teachers may not identify or draw on transferrable skills from their in-field specialization and/or possess the capacity to model and develop students' geoscientific epistemic practices. Google Earth, for example, is a computer software available to the public but also used by geoscientists to explore geospatial representations while collecting and displaying data. Although Google Earth has the potential to be utilized in schools for similar purposes and is becoming increasingly popular with educators, classroom activities can be short lived and typically involve passive participation by students (Almquist, Blank, & Estrada, 2012).

There seems to be a disconnect between the pedagogical possibilities for studying geoscience, young people's interests and the educational experiences offered to them. Bridging these dimensions and young people's value of geoscience knowledge has implications for learning opportunities, cognitive development and teachers' professionalism (Trend, 2005). Hobbs and Törner (2019) explain that the challenge for the OOF teacher is to 'adapt what they know and can do to new subject areas; and then apprentice themselves to the new specialization' (p.4). They explain:

> In an ideal world, the teacher would take the time to immerse themselves in the content, understand its histories and basic tenets, practice the disciplinary ways of knowing and doing, learning the teaching approaches and learning theories that reflect reformist or at least contemporary 'best practice,' and practice and reflect on theories and teaching approaches implemented (p. 4).

Unsurprisingly, educators participating in the Teaching and Learning International Survey (TALIS) (OECD, 2014; OECD, 2019) reported feeling better prepared for teaching when formal training included specific content, pedagogy and classroom practice. In the Earth

and space sciences, Betzner and Marek (2014) found that teachers with more credit hours enjoyed teaching these topics and were more confident in their teaching self-efficacy.

How can OOF teachers apprentice themselves in new specializations assuming they accept a professional duty to do so? Textbooks may be the first place teachers turn to when developing content knowledge and many teachers seem to rely on them to provide both content and pedagogical knowledge (Kesidou & Roseman, 2002). Responses to King's (2001) survey from the National Curriculum for Science indicated that teachers typically consulted textbooks written for 11- to 16-year-old students. In Australia, survey results from 486 schools suggest that most teachers utilize a textbook in junior science lessons and respondents emphasized the benefits of textbooks to support beginning and non-specialist teachers (McDonald, 2015).

However, King's (2010) more recent survey of 51 textbooks used to teach Earth science in England and Wales found poor coverage of the National Curriculum for Science and an average of one error or alternative conception per page. The literature on geoscience alternative conceptions is vast (Clark, Libarkin, Kortz, & Jordan, 2011; Driver, Squires, Rushworth, & Wood-Robinson, 2015; Francek, 2013; King, 2000, 2010, 2012; Kusnick, 2002; Marques & Thompson, 1997). Despite the fact that textbook authors tend to be less familiar with Earth science concepts, 'textbooks are frequently the hub around which school programs revolve' and 'the choice of textbook is a significant factor in the diffusion of ideas in the curriculum' (Eisner, 2002, p. 43).

Overall, the Australian Curriculum and the VCAA's adaptation of it outline more specific content descriptions and achievement standards for teaching Earth science than the previous Victorian Essential Learning Standards (VELS) (VCAA, n.d.-a; VCAA, n.d.-b). The theory of plate tectonics was absent from VELS science. At the same time, schools are permitted flexibility when implementing the Victorian Curriculum with respect to policies, schedules and programs that meet the educational needs of students while challenging them cognitively (VCAA, 2015e). Although the adaptability of the intended curriculum appears to exist to benefit students, unless the enacted curriculum is closely monitored situations may emerge counteracting the equity of the science curriculum offered to students.

For instance, the science understanding content descriptions at levels nine and 10 of the Victorian Curriculum could both be taught at year nine, to students typically aged 14-15 years old. This means that plate tectonics and patterns of geologic activity on Earth (VCAA, 2015b, VCSSU127) are taught in the same year as global systems (VCAA, 2015b, VCSSU128), the interactions of the atmosphere, biosphere, hydrosphere and lithosphere. Decisions like this may be justified as science educators seek to design year 10 programs with greater focus on biology, chemistry and physics, subjects which traditionally attract more enrolments (Dekkers & de Laeter, 1997, 2001; VCAA, 2019) as students prepare for tertiary studies and read for their Victorian Certificate of Education (VCE). Although, in the early 2000's, Earth science education was characterized by a shift toward the systems approach (Kali, 2003), this could have been 'at the expense of the materials, structure, resources and historic approach to geoscience curricula' (Vallender, 2010, p. 46). Crowding the curriculum in this way risks students developing a superficial understanding of geoscience and without equal exposure to and depth of knowledge across science disciplines students may be prevented from making informed subject selections for future science study.

After reviewing seven years of articles from the *Journal of Research in Science Teaching*, Lewis and Baker (2010) found, among other factors, little research advancing geoscience education in terms of science literacy. Schaffer (2012) has proposed that the limited research in Earth science education may be a reason why there is a lack of support for it as a subject. Teachers' experiences from the literature seem to foreshadow areas where support is required to offer Victorian science teachers opportunities for professional growth to teach geoscience topics. For these reasons, geoscience was the meaning-making space chosen to study teachers' perceptions of their agency to utilize digital technologies in science.

### 2.4.3 Conclusion

Chen et al. (2014) explain that students' deep understanding for and appreciation of the complexity of science begins with teachers who must understand that scientific knowledge is connected to other fields, revised with new evidence, faces disagreement among scientists and must be justified by multiple sources and experimentation. To reach

these understandings, teachers must scaffold students through activities modeling this complexity which requires substantial organizational and planning skills, engaging and motivating students, and connecting learning activities to curriculum standards. Sections 2.3 and 2.4 explained two complexities that general science teachers face as an accepted reality of their lived teaching experience:

1. A mismatch between the expectations of digital technologies and their enacted educational uses; and

2. The challenge of teaching geoscience OOF

These sections seem to highlight an opportunity for teacher professional growth. Scholars have explained the importance of planning for experiences that attend to the personal and professional needs of teachers (Darling-Hammond, Hyler, & Gardner, 2017; Kenny et al., 2019; Korthagen, 2017; Ríordáin et al., 2017) which may have implications for identity expansion (Hobbs, 2013a) and career development (du Plessis, 2013) through the reconceptualization of what it means to teach OOF. What does it mean to reconceptualize one's teaching practice and habits; and how is it intertwined with teacher identity? Part IV draws on the literature to present a framework for understanding the agentic self as teachers negotiate their personal capacity and professional duties to utilize digital technologies in their classrooms.

## 2.5 Part IV: The Agentic Self: Knowledge, Beliefs, Attitudes and Behavior

Part I introduced the professional expectations placed on science teachers evident in initial teacher education programs, professional standards, policy and state-mandated curriculum. These roles were fraught with assumptions about teachers' personal capacity to teach at the intersection of the science and digital technologies curricula and the extent to which these duties may be assumed. Parts II and III reflected on the lived experience of science teachers through the literature, explaining the expectations placed on digital technologies and the institutional and social complexities of the out-of-field teaching experience.

Understanding teaching from teachers' perspectives, however, means acknowledging and reflecting on 'the beliefs with which they define their work' (Nespor,

1987, p. 323) and the extent to which teachers perceive themselves to be permitted and/or empowered (Foucault et al., 1988) to act autonomously. In this section Shulman's (1986b, 1987) pedagogical content knowledge (PCK) and Koehler and Mishra's (2009) technological pedagogical content knowledge (TPACK) are presented and explained to define teachers' knowledge at the science and digital technologies curricular intersection. I draw on Foucault's (1988) technologies of the self and the literature to distinguish between beliefs, attitudes and behavior to offer a language through which to explain teachers' reflections about their personal agency to teach geoscience with digital technologies. Finally, some of the theories and models of technology adoption that incorporate beliefs, attitudes and behaviour are presented and discussed.

### 2.5.1 Defining Teacher Knowledge at the Science and Digital Technologies Intersection

Drawing attention to the interconnection between the cognitive and affective domains Clandinin and Connelly (1987) explain that researchers utilize different terms such as beliefs, perspectives and practical knowledge to refer to the same things. This section seeks to begin differentiating between these terms within the context of this research. Of the many knowledge domains teachers are expected to use to inform their practice, I draw on Shulman's (1986b) original work and Koehler and Mishra's (2009) extension of it to define teacher knowledge at the intersection of the science and digital technologies curricula.

Shulman (1986b) proposed three categories of teachers' content knowledge:

1. Subject matter content knowledge;
2. Curricular knowledge; and
3. Pedagogical content knowledge

In summary, *subject matter content knowledge* encompasses not only facts or concepts, but also understanding the epistemic practices of the domain. Goldsmith (2011) explained his case-based approach for teaching introductory geology to undergraduate students:

> [G]eologists did not read the theories of plate tectonics, seafloor spreading, or deep time in a book and then go out to apply them to the Earth. We explored the Earth and used the results of those explorations to create theories (p. 125).

A teacher displaying subject matter content knowledge in geoscience, for instance, would be able to articulate the theory of plate tectonics including how, through collection and analysis of data using increasingly sophisticated technologies, scientists' understanding of tectonic plate movement resulted in a paradigm shift in the late 1960s.

*Curricular knowledge* includes the range of programs that have been designed for teaching subjects, the materials used to do so and the knowledge of when and how to utilize the curriculum and/or materials at particular times and places. Science teachers applying their cross-curricular understanding of the Victorian Curriculum (VCAA, 2016d) might scaffold students to make connections between their study of geomorphological hazards in the humanities and plate tectonics in science by using questions from the Geoscience Concept Inventory (Libarkin & Anderson, 2006; Libarkin, Anderson, Deeds, & Callen, 2006). In this way, classroom teachers working with education researchers might contribute to an emergent domain of scholarship understanding students' perceptions of the Earth in classrooms (Libarkin, 2014).

*Pedagogical content knowledge* includes teachers' knowledge of the topics to be taught and 'the ways of representing and formulating the subject that make it comprehensible to others' (Shulman, 1986b, p. 9). By posing essential questions, *Where is the world's tallest mountain?* for example, and utilizing case studies, Goldsmith (2011) modelled the scientific method used in geoscience and reported undergraduate students making improvements to their higher-order thinking. In the secondary school setting, this might mean teachers exploring the literature related to students' geoscience alternative conceptions and designing pedagogical approaches to scaffold students toward a more scientific understanding of geoscience. Mills, Tomas, and Lewthwaite (2016) and Mills, Tomas, Whiteford and Lewthwaite (2018) employed a conceptual change approach with 52 year nine students constructing stop-motion videos about tectonic plate movement. They report improvement in students' conceptual understanding and that teacher-student dialogue and student-student dialogue was integral to supporting students toward developing more sophisticated ideas.

Shulman's (1986a, 1986b, 1987) pedagogical content knowledge has been described as the 'missing paradigm' (1986b, p. 6), one of many knowledge bases required for teachers to perform their work. Pedagogical content knowledge has a long history in

science education through the study science teachers' subject matter knowledge (Bartos, Lederman, & Lederman, 2014; Kind, 2009a; Nixon, Hill, & Luft, 2017), research into sub-discipline specific pedagogical content knowledge (e.g. Avraamidou & Zembal-Saul, 2010; Mavhunga & Rollnick, 2013; Rollnick & Mavhunga, 2016; van Driel, Verloop, & de Vos, 1998), teachers' experience at different stages of their careers (Chan & Yung, 2018; Clermont, Borko, & Krajcik, 1994; Lee & Luft, 2008; Schneider & Plasman, 2011) and induction into teaching (Luft et al., 2011) all of which has resulted in the evolution of models (e.g. Gess-Newsome, 2015; Grossman, 1990; Magnusson, Krajcik, & Borko, 1999) and strategies for science teachers to explicitly articulate their pedagogical content knowledge (Loughran, Berry, & Mulhall, 2012). Some researchers have called attention to the ambiguity of the construct while others highlight its usefulness (Abell, 2008; Gess-Newsome, 2015; Hashweh, 2013; Kind, 2009b). The purpose of studying science teachers TOOF in geoscience, however, is not to offer another sub-discipline specific model for pedagogical content knowledge, but to utilize geoscience as the meaning making space to better understand how science teachers make sense of their experiences while teaching with digital technologies.

Lee and Fortner (2005) surveyed 51 participants from the third International Geoscience Education Conference to explore preferred approaches to teaching geoscience. Australian participants cited Internet-based approaches as the most important. In addition, the mission statements of the geoscience sector highlight a need for technologically savvy school leavers' contributions to the nation's success. Geoscience Australia, the government's advisor on geology and geography, places emphasis on science and technology to 'understand the Earth for the benefit of Australia' (n.d.-a, para. 1). According to the Minerals Council of Australia (n.d.): 'Australia's minerals industry is innovative, technologically advanced, capital intensive and environmentally and socially progressive' (para. 2). The Productivity Commission (2017), the Australian government's advisory body on micro-economic policy as well as other social and environmental issues, also advocates for a focus on skills formation to improve Australia's labor market. The report *Shifting the Dial: Five Year Productivity Review* explains that at a 'fundamental level all workers will need the skills to interact with digital technology' (p. 87).

These statements from the wider community seem to echo the expectations placed on science teachers to teach with digital technologies. However, these professional expectations assume that teachers have the personal capacity to utilize digital technologies to develop students' capabilities with modern scientific practices. Feig (2010) has reported that networked computing presents opportunities for geoscience instructional innovations yet Watters (2014) cautions the use of the term innovative when coupling technology with education because students tend to be viewed as consumers of digital media rather than learners. As such, there seems to be another distinct body of professional knowledge teachers are required to utilize while supporting their students to learn procedural and conceptual knowledge with and through digital technologies. Here, I draw on Koehler and Mishra's (2009) technological pedagogical content knowledge (TPACK) as a distinct body of knowledge (Voogt, Fisser, Pareja Roblin, Tondeur, & van Braak, 2013) to provide a descriptive language that enables better examination and understanding of teachers' knowledge at the intersection between content, pedagogy and technology. The TPACK framework is illustrated in Figure 2.1.

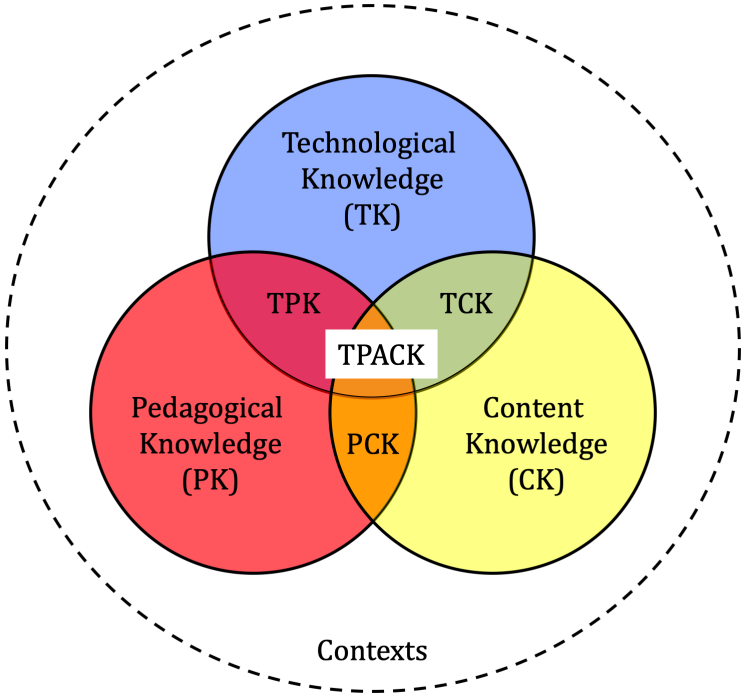



**Figure 2.1: The TPACK Framework, adapted from Koehler and Mishra (2009)**

*Pedagogical knowledge (PK)* is defined as a teacher's knowledge about the processes and practices of teaching. It is the knowledge that pre-service teachers are expected to develop during initial teacher education programs and that in-service teachers are professionally required to build and draw on throughout their career. *Content knowledge (CK)* consists of knowledge about the subject matter to be learned or taught. This knowledge is developed throughout a teacher's formal and informal education including professional learning opportunities s/he assumes the duty in which to participate. Consistent with the work of Shulman (1986b, 1987) *pedagogical content knowledge (PCK)* sits at the intersection of PK and CK and has been described as a teacher's interpretation of the subject matter and understanding of how to represent it to students. These distinctions are important to note in the OOF teaching context. Section 2.4.1 explained that teachers' successful pedagogical practices in one specialist area may not be identified as transferrable to other subject areas as they cross borders into unfamiliar content knowledge (Carlsen, 1992; Kind, 2014; Nixon et al., 2016; Nixon & Luft, 2015; Sanders et al., 1993).

*Technological knowledge (TK)* has been described as 'notoriously difficult' to define (Koehler & Mishra, 2009, p. 64) because it is in a state of constant flux. Koehler and Mishra have compared TK to Fluency of Information Technology (FITness) (National Research Council, 1999) where individuals:

> [...] 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 (p. 64).

Acquiring TK is a developmental process that spans beyond computer literacy as individuals utilize digital technologies for a variety of tasks and develop distinct ways to accomplish tasks.

At the intersection of TK and PK, Koehler and Mishra (2009) define *technological pedagogical knowledge (TPK)* as a teacher's understanding of how teaching and learning can change when particular technologies are used in particular ways. *Technological content knowledge (TCK)* sits at the intersection of a teacher's TK and CK and encompasses knowledge about how technology and content influence and constrain each other. These

are the types of knowledge that initial teacher education programs, professional standards, policy and state-mandated curriculum documents expect teachers to not only acquire but also strengthen throughout their career. These expectations, however, may erode when science teachers teach OOF and geoscience-specific TPK and TCK remain abstract.

Of note, is that this research does not seek to develop a sub-discipline specific TPACK for geoscience, but draws on these knowledge components to provide a language to examine and better understand teachers' perceptions of their experiences. The next section exemplifies how these knowledge components could be scaffolded for teachers to possibly strengthen their capacity to teach geoscience with digital technologies while modelling the methodologies of geoscientific fieldwork.

### 2.5.2 The Challenge of Bridging the Domains of Teacher Knowledge: Fieldwork

The field in geoscience is the equivalent of the laboratory in chemistry. As such, teaching outdoors and developing the PCK to do so could be considered best practice. There are many types of fieldwork experiences for educators to plan, yet de Barros, Almeida and Cruz's (2012) survey of 16 Portuguese teachers suggests that although teachers identified problem solving experiences as best practice, direct observation fieldwork was commonly implemented. In the United Kingdom, Orion's study (1996) of five academic tutors and 39 students found that pre-service teachers left their post-graduate initial teacher education program with high levels of confidence in their indoor teaching abilities but expressed lower confidence to teach outdoors. After in-service training in the pedagogical practices modelling geoscientific fieldwork, 103 Portuguese secondary school students indicated that teachers used fieldwork as a means to confirm previously acquired information (Marques, Praia, & Kempa, 2003). With little training and experience in geoscientific epistemic practices themselves science teachers TOOF may struggle to offer authentic fieldwork activities engaging students in the synthetic thinking enacted by geoscientists.

Koehler and Mishra (2009) explain that TPACK is the basis for teaching effectively with technology and knowing how it can:

1. Be utilized in constructive ways to teach content;

2. Help redress difficulty in students' understanding or application of concepts; and
3. Be used to build on existing knowledge or develop new epistemologies (p. 66)

Google Earth is a software that has been used more prominently in classrooms and although it can enable teachers to invite students into the epistemic practices of geoscientists through collection and analysis of data, these affordances do not seem to be regularly utilized by classroom teachers (Almquist et al., 2012). In their study of over 300 undergraduate students Bitting, McCartney, Denning, and Roberts (2018) found that completing Google Earth exploration activities offering direct experience with phenomena significantly strengthened students' conceptual understanding of geoscience. The benefits from using Google Earth to interpret Earth's structure, however, has been found to depend on the user's grasp of geoscience content knowledge and technological knowledge.

Giorgis' (2015) five-year study of 75 undergraduate students' three-dimensional visualization skills indicated that students with limited geological knowledge benefitted less from utilizing Google Earth. In a qualitative study of 10 pre-service teachers in Finland, Ratinen and Keinonen (2011) reported that while using Google Earth for problem-based learning, teacher candidates had inadequate technological knowledge and required continued support to interpret maps and analyze data, yet exhibited improved geographical thinking skills. These examples seem to indicate the complex interplay between the knowledge domains in TPACK and caution against a technology fix to teaching an OOF area of the curriculum.

Ríordáin et al. (2019) explain that teacher educators supporting OOF teachers must maintain a focus on not only developing teachers' content knowledge but also the skills and practices for competent teaching. They stress that professional learning must be strategically planned, emerging in response to the individual and evolving needs of teachers where they experience similar learning activities to their students. These assertions are also supported by literature in Earth science education (e.g. Hagevik, 2011; Penuel & Gallagher, 2009; Penuel et al., 2009). Baker et al. (2015) call for research into educators' professional learning with geospatial technologies. Perhaps scaffolding teachers' use of geospatial technologies through indoor classroom experiences might strengthen their confidence and capacity to teach geoscientific thinking.

The *Cyber-Enabled Earth Science Exploration (CE3)* curriculum (Almquist et al., 2012; Blank, Almquist, Estrada, & Crews, 2016; Blank, Plautz, Almquist, Crews, & Estrada, 2012), developed through the University of Montana in the United States, offers both teachers and students opportunities to participate in digital fieldwork experiences. This curriculum begins a unit of plate tectonics with natural disasters and ends with the theory of continental drift, a succession that is in direct contrast to the traditional presentation of these topics where continental drift is explored first then applied to natural disasters. The purpose of this sequence is to help students experience similar processes of discovery that geoscientists made with developing technologies (Almquist et al., 2012) and, when made explicit, could challenge teachers' pedagogical content knowledge.

In the CE3 practical activities, both teachers and students are scaffolded to develop the technological content knowledge for utilizing Google Earth with explicit instructions included in field notebooks. In addition, students develop more sophisticated computer skills through successive activities by collecting both qualitative and quantitative data to make interpretations and present evidenced-based reasoning about the processes acting on the Earth as required by both the Australian and Victorian curricula (ACARA, n.d.-d; VCAA, 2015d). Used in nine classrooms in the United States Blank et al. (2016) found that the CE3 curriculum not only advanced students' understanding of the topics, but also developed their science identity and reasoning abilities. In this way, programs like the CE3 curriculum could possibly be utilized to scaffold science teachers to build their capacity to meet the professional expectations in an OOF area.

Shulman's (1986b, 1987) PCK and Koehler and Mishra's (2009) TPACK were used to define and explain teacher knowledge at the science and digital technologies curricular intersection. By unpacking non-digital fieldwork experiences and comparing them to the pedagogical possibilities for utilizing digital technologies, TPACK has been shown to offer a language to examine and explain the professional landscape Victorian science teachers are required to navigate across the knowledge domains of content, pedagogy and technology. The choice to utilize digital technologies and the extent to do so, however, are dependent on teachers' interpretations of their personal capacity and professional duties to do so. The next section introduces and explains Foucault's (1988) technologies of the self to

understand the extent to which teachers may feel empowered to enact these interpretations.

### 2.5.3 The Technologies of the Self and Barriers to Digital Technology Use

Foucault's earlier work focused on the 'history of the different ways humans develop knowledge about themselves' (Foucault et al., 1988, pp. 17-18), but his later work turned to the question of 'how the self constituted itself as a subject' and how humans used technologies to create and refine the self (Burkitt, 2002, p. 219). Of note is that the term technologies used in the Foucauldian sense does not refer to digital technologies. Foucault identified four major technologies:

1. **Sign systems:** Permit individuals to use signs, meanings, symbols or signification;
2. **Production:** Permit individuals to produce, transform and/or manipulate objects;
3. **Power:** Determine the conduct of individuals; and
4. **Self:** Permit individuals, by their own means or with the help of others, to effect operations on their bodies, souls, thoughts, conduct and ways of being to transform themselves (p. 18)

Foucault's technologies rarely function separately and each 'implies certain modes of training and modification' meaning that individuals not only acquire certain skills but also attitudes (Foucault et al., 1988, p. 18). Aristotle's *phronesis*, practical rationality or wisdom, and *praxis*, the attitude that involves doing, transaction and practical activity, are central to the hermeneutics of the self (Burkitt, 2002). Thus, for Foucault a technology is defined as:

> [A] form of practical action accompanied by practical reason, which aims to instill in the body habitual actions – either moral virtues (that is, the right ways of acting in a situation) or technical skills – and, later, to give people the reflexive powers to reason about their virtues or skills, providing them with the capacity to refine, modify or change them (p. 224).

Phronesis and praxis thus occupy a moral domain informing teachers' professional practice as they interpret the local moral order (Harré & van Langenhove, 1999), the system of rights and duties within which intentional acts are done.

Applied to teaching and learning, the technologies of the self can be understood as a continuum beginning with the interpretation of signs: Prior to teaching a sequence of lessons, a teacher reads an assessment task to better understand the learning outcomes. She discovers that students are required to utilize Microsoft Excel to analyze data. The assessment task signifies that the use of Excel must be taught. Next, the teacher draws on her personal capacity to utilize Excel and begins to transform a paper-and-pencil graphing exercise for use in the digital space. In the classroom, she is empowered to teach the modified lesson and problem solve when unanticipated issues arise. Finally, as she comes to understand the new affordances of the technology, the teacher may begin to seek out and incorporate Excel into other lessons, possibly developing her own skills in the process.

Burkitt (2002) reminds us that each technology is associated with a certain kind of domination but also production. Here, I propose that individuals may be dominated and as a result dis-/empowered from the external and/or internal experience depending on how the self is reflexively modified. To illustrate this point, I draw on Ertmer's work from the late 90's and early 2000s which remains relevant to understanding teachers' present lived experience. Ertmer (1999) explains that for teachers to become effective users of digital technology, pragmatic strategies must be in place including:

- Developing a vision for effective technology use;
- Identifying and implementing curricular opportunities to bring teachers' beliefs and values to the surface as they modify their practice;
- Obtaining resources and addressing constraints to access, time, training and support;
- Managing resources and classroom activities; and
- Evaluating technology investments and classroom practices

These strategies may seem to be an obvious extension of the expectations placed on Victorian science teachers explained in Part I and, when enacted, may serve to empower teachers to manipulate digital technologies in ways that strengthen their capacity to produce and transform lessons with them. However, implementing strategies like these

requires an understanding of both extrinsic and intrinsic barriers that compromise teachers' digital technology use.

Extrinsic to teachers are first-order barriers, including a lack of 'access to computers and software, insufficient time to plan instruction and inadequate technical and administrative support' (p. 48). Confronting these barriers involves making changes within the local moral order that may otherwise compromise teachers' sense of agency to utilize digital technologies. This means increasing access to resources including hardware, software and technical support while adjusting workplace practices for teachers to become more effective or efficient technology users. The Digital Education Revolution (DEEWR, 2011) may have resulted in reducing many first-order barriers through improvements to infrastructure, provision of hardware, software and, to an extent, technical support, however structuring planning time for teachers remains at the discretion of individual workplaces. From a survey of 25 award-winning teachers who utilized digital technologies in learner-centered, constructivist environments, Ertmer et al. (2006) cautioned:

> [E]ven if teachers have access, support, and time, it does not necessarily mean that they will integrate technology in meaningful ways (p. 55).

Waight et al. (2014) surveyed 153 American science teachers about their digital technology use and found that teachers were more likely to use hardware than software. Instructional tools, SMARTboards and clickers, and laboratory tools, sensors and data loggers, tended to be used by physics teachers, teachers teaching through inquiry approaches and those who had received professional learning to utilize the technologies. Addressing first-order barriers alone leaves underlying beliefs unchallenged (Brickner, 1995) which still prevent teachers from using digital technologies (Ertmer et al., 2014).

Second-order barriers are intrinsic to teachers and include beliefs about 'teaching, computers, established classroom practices and unwillingness to change' (Ertmer, 1999, p. 48) and may be the true 'gate-keepers' to teachers' technology use (Ertmer et al., 2012). These barriers are value-laden and may act to compromise or strengthen a teacher's sense of oughtness (Linehan & McCarthy, 2000) and empowerment to act. Making changes to second-order barriers means confronting teachers' beliefs about current practices leading to new goals, structures or roles (Brickner, 1995; Ertmer, 1999) often perceived as 'risky' and 'difficult' to achieve (Ertmer, 2005, p. 26).

Here, I use the term *social signs* as form of sign system (Foucault et al., 1988) arising from the social interactions between teachers which may strengthen or challenge their perceptions of second-order barriers. For example, a teacher may be apprehensive about incorporating new datalogging equipment into her practice, but when a colleague shows her how easy it can be used and explains value added to the learning experience, she may assume the duty to try using datalogging equipment in her classroom. The teacher is responding to social signs challenging an intrinsic barrier. According to Ertmer and Ottenbreit-Leftwich (2013) 'the best way to bring more teachers on board is *not* by eliminating more first-order barriers, but by addressing the second-order barriers of attitudes and beliefs' (p. 177). Therefore, a distinction must be made between beliefs and attitudes and their relation to behavior change.

### 2.5.4 Defining Beliefs, Belief Systems and Values

Teachers' choice to use digital technologies depends on their personal and pedagogical beliefs about them (Ertmer, 1999, 2005; Ertmer & Ottenbreit-Leftwich, 2010; Ertmer et al., 2012; Ertmer et al., 2014; Ertmer et al., 2006; Hermans et al., 2008; Levin & Wadmany, 2006; Mama & Hennessy, 2013; Ottenbreit-Leftwich et al., 2010; Petko, 2012; Prestridge, 2012; Tondeur, Hermans, et al., 2008; Tondeur, van Braak, et al., 2017). However, the term belief is a 'messy construct' that must be defined and differentiated from similar constructs (Pajares, 1992, p. 307). Of note is that here I have incorporated some reflections from research participants to offer apt examples of the types of beliefs explained. They are presented in *italics*.

According to Kagan (1992) a program promoting growth through belief change must require participants to:

> [...] make their pre-existing personal beliefs explicit; it must challenge the adequacy of those beliefs; and it must give novices extended opportunities to examine, elaborate, and integrate new information into their pre-existing belief system (p. 77).

This research draws on two working assumptions explained by Kagan:

1. Much of a teachers' professional knowledge can be regarded as belief; and

2. A teacher's knowledge of the profession sits at the intersection of context, content and self (pp. 73-74)

Rokeach (1968) defines a belief as: '[...] any simple proposition, conscious or unconscious, inferred from what a person says or does' (p. 113), their discursive practices (Harré & van Langenhove, 1999), and may be preceded by: I believe that ... The content of a belief can be:

1. **Descriptive:** *I believe intrinsically that human beings are learning creatures.*

2. **Evaluative:** *I think it's [geoscience is] important to learn.*

3. **Prescriptive:** *I'm a believer in offering kids as many opportunities to capitalize on their talent and interests.*

Although beliefs are acknowledged to contain a cognitive component (Rokeach, 1968), Pajares (1992) explains that the boundary between knowledge and belief can be difficult to define. Based on the work of Abelson (1979) and the Teacher Belief Study (Nespor, 1985), Nespor (1987) differentiates beliefs from knowledge based on six structural features of beliefs:

1. **Existential presumptions:** Teachers' perceptions about student ability, maturity and motivation that are embodied by the student and beyond the control and/or influence of teachers

2. **Alternativity:** Teachers' perceptions of ideal situations that differ significantly from current situations, but nevertheless serve to inform practice

3. **Affective and evaluative:** Teachers' perceptions about the domain based on personal preferences within the belief system

4. **Episodic storage:** Aspects of beliefs that are informed by teachers' experiences and events in which the cultural and institutional sources of knowledge are transmitted to them

5. **Non-consensuality:** Aspects within the belief system which are in dispute and are not open to evaluation or critical examination in the same way knowledge systems are

6. **Unboundedness:** The loosely-defined boundaries of belief systems whereby individuals subjectively read belief-based meanings into situations.

Aspects of Nespor's (1987) structural features can be found in the types of belief identified by Rokeach (1968), unpacked in Table 2.5. Figure 2.2 illustrates the placement of these beliefs within the belief system.

## Table 2.5: Rokeach's (1968) Types of Belief

| Type of Belief | Description | Example |
|---|---|---|
| **A: Primitive, 100% Consensus** | • Learned by direct encounter<br>• Reinforced by unanimous social consensus | **Physical world:** I believe this is a chair.<br><br>**Social world:** I believe this is my father.<br><br>**Self:** I believe my name is... |
| **B: Primitive, 0% Consensus** | • Learned by direct encounter<br>• About existence and self-identity<br>• Maintenance is independent of the belief being shared by others | **Self-enhancing ($B^+$):** *[T]echnology can-sometimes a program doesn't work or you get glitches here and there so that's probably why I tend to stay away from that kind of stuff. Not that I don't know how to use it, I know how to use all that.*<br><br>**Self-deflating ($B^-$):** *[M]y use of it [digital technology] is probably rudimentary compared to theirs [students'].* |
| **C: Authority** | • Develop from Type A beliefs when individuals discover that a belief is not shared by everyone<br>• Help the individual come to terms with her/his perceptions of the world | *Interviewer: Do you think the students know how to use the technologies for school purposes?*<br><br>*Participant: Um, yeah. Yeah. Do-do you think that they don't? I don't (sighs) some of the things are not that they don't know how to use the technology, some of the things are that they're lazy.* |
| **D: Derived** | • Derived secondhand through identification of and trust in an authoritative source<br>• Provide a sense of group identity | Ideological beliefs that originate from religious or political institutions<br><br>Beliefs about Earth and space from the work of scientists |
| **E: Inconsequential** | • Matters of taste originating through direct experience<br>• Maintenance is independent of social consensus<br>• Few connections to other beliefs and have little to no consequence to maintain beliefs about self-identity and self-esteem | *So, the data loggers that we have here are good because you just plug it in and it works.* |

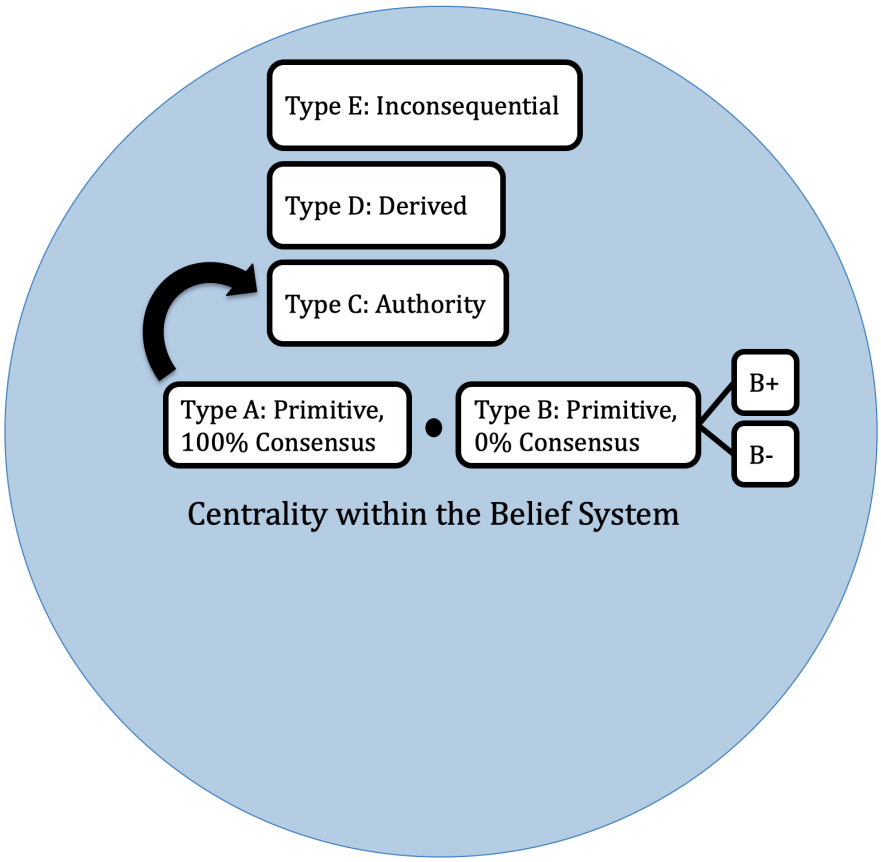



**Figure 2.2: The Belief System Adapted from Rokeach (1968)**

Rokeach (1968) based his analysis of beliefs on three assumptions:

1. Not all beliefs are equally important to the individual;

2. Centrally located beliefs within the belief system have greater connections to others and are more difficult to change; and

3. If central beliefs are changed, the more widespread the repercussions to the belief system (p. 3)

For Rokeach (1968) a value is a single belief that:

> [...] transcendentally guides actions and judgements across specific objects and situations, and beyond immediate goals to more ultimate end-states of existence (p. 160).

Although beliefs are important in teachers' work, Biesta, Priestley, and Robinson (2015) explain that 'the promotion of teacher agency does not just rely on the beliefs that individual teachers bring to their practice, but also requires collective development and

consideration' (p. 624). Extending Lave and Wenger's (1991) legitimate peripheral participation, Linehan and McCarthy (2000) explain the importance of interactive engagement in the community of practice and how values seem to inform action. As an individual assumes personal and professional duties through her/his discursive practices, for example by seeking opportunities to be *learner* and *teacher of* digital skills, the moment-to-moment oughtness in prosaic acts can enable understanding of how a participant's 'selfhood emerges and is enacted in particular moments' (Linehan & McCarthy, 2000, p. 452). Values are centrally located within the belief system and embody a sense of oughtness about how to behave or attain a worthy end-state of existence.

Rokeach (1968) does not claim that five types of beliefs are adequate to address all beliefs within a belief system and any stimulus activates only a portion of an individual's belief system. For this research, the most important beliefs are types B, C and E because they evolve from teachers' perceptions of their identity and self-efficacy (Bandura, 1982) as they negotiate their personal capacity and professional duties to utilize digital technologies while teaching OOF. Changes to these beliefs, made evident through teachers' discursive practices, may indicate changes to values and possibly to attitudes and behaviors.

### 2.5.5 From Beliefs to Attitudes and Behavior: An Agentic Change Process

Clandinin and Connelly (1987) have sought to understand 'the personal' (p. 487) and how it relates to pedagogical action. They describe teachers' personal practical knowledge as 'experiential, embodied and reconstructed out of the narratives of a teacher's life' (p. 490). For Rokeach (1968) beliefs act as predispositions to actions and consist of cognitive, affective and behavioral components. An attitude is defined as:

> [A]n enduring package of interrelated beliefs that describe, evaluate and advocate action with respect to an object or social situation (p. 132).

Behavior is a function of the interaction between attitudes toward objects and situations. Rokeach explains that an attitude toward an object may not behaviorally manifest due to the situation in which the attitude-object is encountered. This is consistent with the literature demonstrating that teachers' pedagogical beliefs do not mirror their practices

(e.g. Chen et al., 2014; Ertmer, 2005; Ertmer et al., 2012; Ertmer et al., 2014; Hermans et al., 2008; Mansour, 2013; Tondeur, Hermans, et al., 2008).

For instance, science teachers might believe that teaching graphing with Microsoft Excel is a useful skill for students to learn, a type A belief. Cognitively and affectively they may express type $B^+$ self-enhancing beliefs about being able to manipulate (Foucault et al., 1988) Excel for this purpose. Yet, in an effort to alleviate an already crowded science curriculum these teachers could relinquish their duties and defer to the mathematics faculty to teach Excel. Thus, an individual's choice to act or not is dependent on her/his knowledge and interpretation of the social setting including personal beliefs about the extent to which s/he is permitted to act. Here, the static concept of role is challenged when the attitude, the *say*, does not match the behavior, the *do*, and an individual's perception of her/his personal agency emerges (Harré & van Langenhove, 1999).

Rokeach's (1960) approach to understanding belief systems is cognitive, yet the affective influence on cognition is also acknowledged. The affective domain (Krathwohl, Bloom, & Masia, 1980), presented in Table 2.6, and the technologies of the self (Foucault et al., 1988) provide a useful language to understand how possible changes in teachers' beliefs and attitudes may be internalized to become part of an individual's identity.

**Table 2.6: Krathwohl et al.'s Taxonomy of the Affective Domain**

| Internalization | Levels of the Taxonomy | Description |
|---|---|---|
| **Higher internalization** ↑ **Lower internalization** | Characterization | Having a growing complexity, becoming a philosophy on life |
| | Organization | Organizing behavior and feelings into a structure |
| | Valuing | Going out of one's way to respond to the phenomenon |
| | Responding | Responding to the phenomenon with a positive feeling |
| | Receiving | Being willing to attend to the phenomenon<br>Being aware of the phenomenon, able to perceive it |

Modified from Krathwohl et al. (1980)

For Foucault *self* is a reflexive pronoun that conveys identity (Foucault et al., 1988) and Krathwohl et al. (1980) explain that internalization is a process by which values successively become part of individuals as they are tentatively to completely adopted. Teachers may internalize the use of digital technologies in their classrooms by receiving and responding to an initiative to utilize them. This level of internalization seems to be similar to Foucault's (1988) technologies of sign systems where individuals utilize signs and meanings to manipulate objects. At the level of valuing teachers may begin to take pedagogical risks with digital technologies in ways that reflect their personal capacity to do so and professional duties to craft their practice. Here, internalization aligns with Foucault's technologies of sign systems, production and power as teachers draw on signs and meanings to transform and produce objects. At the levels of organization and characterization internalization seems to be similar to Foucault's technologies of the self.

Burkitt (2002) explains that self is of comprised of habitus, capacity and knowledge. Informed by Aristotle, Dewey and Mauss, *habitus* is:

> ... a mode of habitual action marked by mastery of techniques of the body, which are modes of doing something in the world, of effecting an action that may or may not have a particular end product (p. 229).

Burkitt (2002) takes care to explain that *habitus* informs choice in that when individuals choose to act, their choice depends on prior disposition toward practical action in given situations. Drawing on the work of Sève (1978), Burkitt (2002) highlights that capacities are more than skills developed through apprenticeship, they are 'the *product of* and the *subjective conditions for* activity' (p. 230). Capacities depend on acts, the product of a history of activities, and involve 'the *knowledge* of what one has done and how to use or extend that ability to produce a desired consequence for the future' (p. 230). Burkitt points out that both habitus and capacity operate within particular social contexts which constitute '*both* the motives and the faculties for styles of action' (p. 233).

Ertmer (2017) explains that building teachers' capacity to utilize digital technologies begins with building their confidence by engaging them in the change process. According to Chen et al. (2014) experiences providing science teachers with 'content knowledge, teaching strategies, and an opportunity to apply both in an authentic setting can have a powerful influence on teachers' self-efficacy' (p. 376) and when teachers

'believe they are equipped with the necessary skills and knowledge they are more apt to engage their students in more complex science activities' (p. 380). Values that are internalized become standards for guiding actions, developing and maintaining attitudes, justifying one's own and others' actions and morally judging self and others (Rokeach, 1968). Of note is that values may inform an individual about when, if and how to act yet unless an individual perceives s/he is permitted to do so, one's sense of agency may be compromised. Here habitus and capacity meet positioning theory (Harré & van Langenhove, 1999), explained in detail in chapter three, where the history of interactions informs an individual's perceptions of her/his personal agency and identity at that time and place.

Krathwohl et al. (1980) explain that internalization may suggest conformity or non-conformity. Foucault (1988) and Burkitt (2002) use *power* to explain technologies which 'determine the conduct of individuals and submit them to certain ends of domination' (p. 18). In section 2.5.3 I proposed that domination may act from the individual's external to internal experience depending on how the self is reflexively modified. Instead of using *power*, I will use *empower* to explain the varying extents to which teachers in this research were possibly enabled to reflectively craft their pedagogies to teach an OOF area of the science curriculum with digital technologies.

### 2.5.6 Beliefs, Attitudes and Behaviors and Technology Adoption

There has been extensive study about technology adoption resulting in a variety of theories and models. These include the Theory of Reasoned Action (Fishbein & Ajzen, 1975), Technology Acceptance Model (Davis, 1985; Davis, Bagozzi, & Warshaw, 1989), Motivational Model (Davis, Bagozzi, & Warshaw, 1992), Theory of Planned Behavior (Ajzen, 1991), Model of Personal Computer Utilization (Thompson, Higgins, & Howell, 1991) , Innovation Diffusion Theory (Moore & Benbasat, 1991), Social Cognitive Theory (Compeau & Higgins, 1995) and a number of hybrid models (e.g. Taylor & Todd, 1995; Venkatesh & Davis, 2000) including the Unified Theory of Acceptance and Use of Technology (Venkatesh, Morris, Davis, & Davis, 2003). Although this research does not seek to measure the likelihood of success for teachers' adoption of technologies, some of these models warrant explanation because they incorporate constructs related to the research including

beliefs, attitudes and behaviors. As such, this section introduces and interrogates the Theory of Reasoned Action (TRA), Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT).

The TRA, illustrated in Figure 2.3, evolved from social psychology and has been employed across a variety of domains to predict and explain behavior. As such, it is an appropriate theory for studying the determinants of technology use (Davis et al., 1989). According to the TRA an individual's intention to perform a behavior is a determinant of their action. Two constructs contribute to a person's behavioral intention (Fishbein & Ajzen, 1975):

1. **Attitude toward behavior:** The positive or negative feelings about enacting the behavior (p. 216); and

2. **Subjective norm:** Perceptions about whether the majority of people an individual holds in esteem feel s/he should or should not enact the behavior (p. 302)

Attitude toward behavior is evaluative and determined by an individual's beliefs about and possible consequences of enacting the behavior. It seems to be similar to Krathwohl et al.'s (1980) internalization where feelings can be operationalized along a continuum from receiving to characterization. The subjective norm is informed by one's normative beliefs, those concerning the expectations of an individual, and motivation to attend to those expectations. Both attitude toward behavior and the subjective norm could be compared to aspects of positioning theory (Harré & van Langenhove, 1999). For positioning theorists, the history of interactions, including perceptions about expectations, shape the repertoire of acts individuals may draw on to negotiate the social situation.

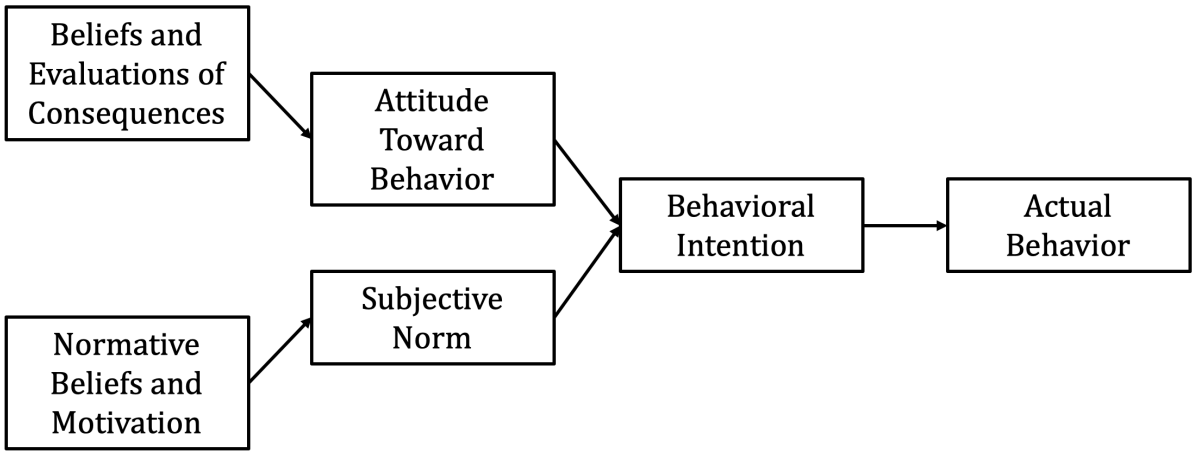



**Figure 2.3: The Theory of Reasoned Action, adapted from Fishbein and Ajzen (1975)**

Illustrated in Figure 2.4, the TAM is an adaptation of the TRA originally designed for the context of information systems (Davis, 1985) and applied to a diverse set of technologies and users to predict on-the-job use and acceptance of technology (Venkatesh et al., 2003). A key purpose of the TAM is 'to trace the impact of external factors on internal beliefs, attitudes and intentions' (Davis et al., 1989, p. 985). Davis (1989) explains two beliefs that are determinants of behavior:

1. **Perceived usefulness:** An individual's beliefs about the extent to which a technology would enhance job performance; and

2. **Perceived ease of use:** An individual's beliefs about the extent to which technology use is free from effort and encompasses a sense of self-efficacy (p. 320)

The TAM is similar to the TRA where an individual's use of technology is determined by behavioral intention, yet unlike the TRA behavioral intention is informed by attitude toward the technology and more so by its perceived usefulness.

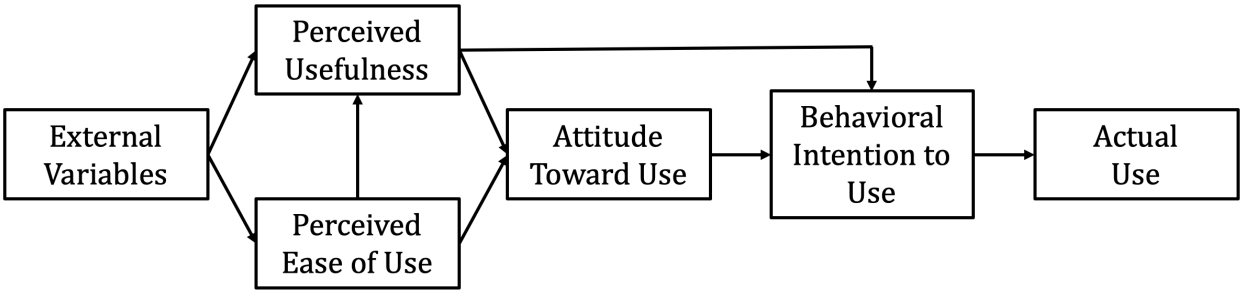



**Figure 2.4: The Technology Acceptance Model, adapted from Davis et al. (1989)**

Notably, perceived usefulness is tied to enhancement of job performance which may not apply to teaching where job performance may be viewed differently by distinct stakeholders. For instance, teachers may be viewed as performing well when administrators can confirm that grades are entered into the learning management system on time. However, for teachers their evaluations of job performance may be more personal where success is assessed through a sense of satisfaction from learning how to use and employ a new technology in the classroom. Davis (1989) draws on the literature to explain that 'affect toward a behavior need not fully incorporate affect toward any rewards due to performance outcomes [...] yet positively valued outcomes often increase one's affect toward the means to achieving' them (p. 987).

In addition, the TAM proposed by Davis (1985) does not include the subjective norm. Davis et al. (1989) explain that its exclusion is due to the 'uncertain psychometric status' (p. 986) of the subjective norm. For research adopting a quantitative approach, this decision seems to have merit. However, teaching is a relational profession where shared narratives of successes and failures of technology use in the classroom and colleagues' expectations of themselves and each other may influence decisions about whether or not and to what extent technologies are adopted.

Venkatesh et al. (2003) have summarized the eight theories and models of technology adoption listed at the beginning of this section. Drawing on data from four organizations over a period of six months the theories and models were shown to explain between 17 to 53 percent of the variance in user intentions to utilize technology. Venkatesh

and colleagues then developed the UTAUT to consolidate the theory and research about technology adoption, see Figure 2.5. This model is comprised of four constructs moderated by gender, age, experience and voluntariness of use:

1. **Performance expectancy:** The extent to which an individual believes that a technology will lead to gains in job performance;

2. **Effort expectancy:** The degree of ease associated with the use of the technology;

3. **Social influence:** The extent to which an individual perceives that others held in esteem believe s/he should use the technology; and

4. **Facilitating conditions:** The extent to which an individual believes that existing organizational and technical infrastructures exist to support the use of the technology (pp. 447- 453)

The authors then tested UTAUT against other theories and models of technology adoption finding it to outperform previous models in determining acceptance and use of technology. Although UTAUT addresses the limitations of TAM by accounting for individual differences affecting technology adoption, it may not capture the complexities of the educational context (Straub, 2009).

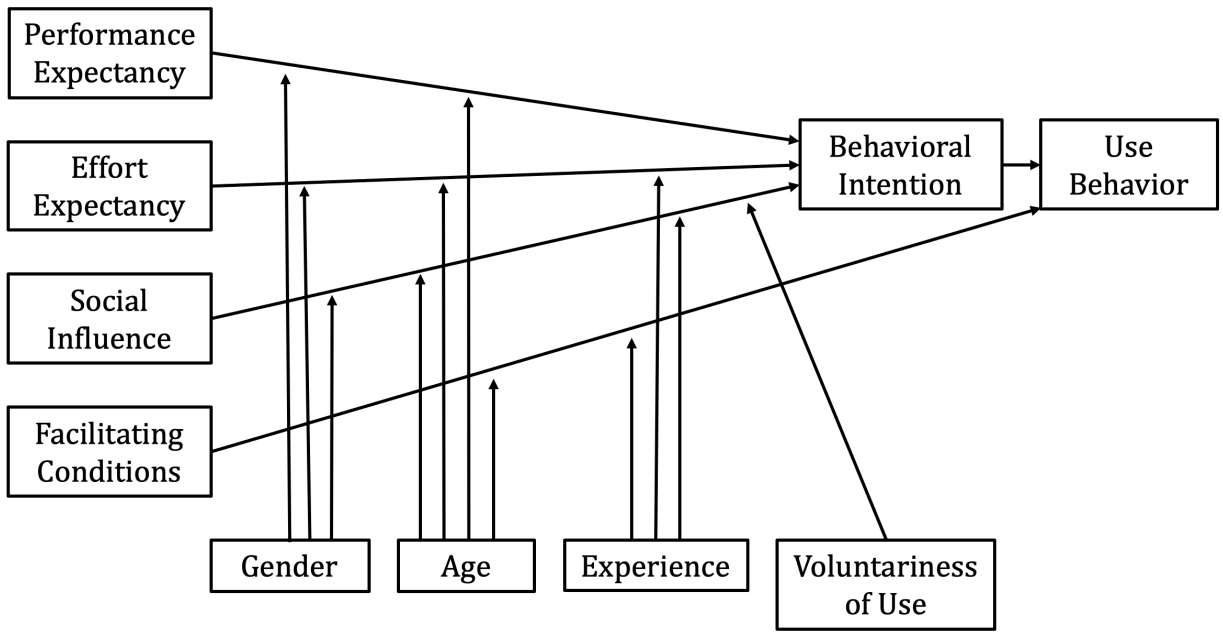



**Figure 2.5: The Unified Theory of Acceptance and Use of Technology, adapted from Venkatesh et al. (2003)**

Similar constructs related to performance expectancy and social influence were discussed above through the TAM's perceived usefulness and the TRA's subjective norm. Effort expectancy seems encompass Rokeach's (1968) beliefs about self and second-order barriers to technology incorporation (Ertmer, 1999) such as beliefs about personal capacity to learn and be able to use technology. Depending on a teacher's beliefs in the organizational and technological infrastructure, facilitating conditions may speak to easing first-order barriers to technology use. However, there seems to be an assumption that if the facilitating conditions exist, moderated by experience and age, technology users will enact the behavior. This assumption does not appear to account for instances where technology use does not clearly fall within mandated versus voluntary borders. For instance, a school's leadership team may encourage the use of specific digital technologies, yet teachers, as trained professionals, may assert a right to choose which technologies to use in the private classroom space: *I know the support exists, but I choose not to access it because I prefer to employ tried and trusted existing practices.*

Reflecting on the TRA, TAM and UTAUT has provided a space to understand how constructs such as beliefs, attitudes and behavior have informed theories and models for technology adoption and illustrate the complexity of introducing and utilizing digital technologies within the context of teaching and learning. Other scholars have made similar conclusions (e.g. Chang, Lieu, Liang, Liu, & Wong, 2012; Scherer, Siddiq, & Tondeur, 2019). Scherer et al. (2019) explain that although the TAM seems to dominate the landscape of education research, it fails to conceptualize acceptance and integration of technology in classrooms. They postulate that teachers may be likely to adopt new technologies once they are able to perceive them as relevant to subject-specific goals and highlight TPACK as a useful framework toward achieving this. For these reasons, rather than rely on an existing model of technology adoption I have chosen to utilize the language of TPACK to specifically unpack the knowledge and practice surrounding digital technology use in the classroom.

### 2.5.7 Conclusion

Part IV has presented a theoretical understanding of the agentic self, differentiating between constructs that seem to be used interchangeably in the literature. Shulman's

(1986b) original work and Koehler and Mishra's (2009) extension of it were utilized to define teacher knowledge at the geoscience and digital technologies curricular intersection. Acquiring knowledge does not necessarily equate to putting it into practice (Brantley-Dias & Ertmer, 2013; Voogt et al., 2013). For teachers TOOF '[a] number of factors, such as teaching backgrounds, subject commitments and beliefs about teaching and learning, mediate a teacher's capacity to interpret the traditions [of practice], and degree of autonomy to challenge or move forward from those traditions' (Crisan & Hobbs, 2019, p. 165). Therefore, distinctions were made between beliefs, attitudes and behavior and their influence on each other were explained. The section concluded with a discussion of prominent theories and models of technology adoption to further examine the complexity of digital technology use in the context of teaching and learning.

## 2.6 Conclusion

This literature review was constructed to frame the background to the research and locate and connect it to the relevant thinking, research and data available. In Part I the pre-determined lists of expectations assigned to science teachers from theoreticians and policy makers were presented and the inherent assumptions about teachers explained. Parts II and III explored the expectations of digital technologies and out-of-field (OOF) teaching, two complexities possibly faced by teachers in their lived experience as they negotiate the science and digital technologies curricular intersection. Tensions between what science teachers are professionally held accountable for through their roles and what they are personally able to do were highlighted. Finally, Part IV presented a theoretical understanding for the agentic self that could be utilized to understand teachers' perceptions of change.

Science teacher education must honor teachers' subject matter knowledge, their local and practical knowledge and the sociocultural contexts framing their work (Abell, 2007). The Productivity Commission (2017) explains that to improve the school workforce addressing high levels of OOF teaching will not only require specialized recruitment efforts but also specific professional learning for 'existing teachers willing to acquire the knowledge and teaching skills in the relevant disciplines' (p. 90). This means understanding where teachers TOOF are challenged (Hobbs, 2013a) including the context

within which they face these challenges (du Plessis et al., 2019). Ertmer (1999; 2005), Leary et al. (2016), Tondeur et al. (2009) and Tondeur, van Braak, et al. (2017) have made similar assertions for successfully implementing digital technologies into teachers' practice.

To conclude his study of Foucault's technologies of the self, Burkitt (2002) reminds us that '[...] the human self appears to us, not so much as it was made to be, even though it is a product of certain technologies, but in terms of what it can do' (p. 235) and he calls attention to the need for:

> [N]ew techniques of the body and self in order to break the old ossified habits of action, thought, and emotional dispositions that are hindering our development or our relations with others (p. 236).

Rather than mandate teachers change their pedagogy and technology use, a more impactful strategy may be to offer teachers support to teach across geoscience and digital technologies while at the same time aligning the intended use of digital technologies from theoreticians, policy makers and teachers with those of school leaders, ICT coordinators, students and parents. Since teaching OOF seems to have become an accepted reality in science education and teachers are expected to incorporate digital technologies into their regular practice, studying the experiences of science teachers TOOF may yield recommendations that could be applied to teaching other multi-disciplinary subjects. The following chapter explains the overarching philosophy and methodology for the research design.

# Chapter 3: Methodology

> *The self is something which has a development; it is not initially there, at birth, but arises in the process of social experience and activity...*
>
> *- Mead (1934)*

## 3.1 Introduction

Chapter two raised and reviewed many of the contentious issues surrounding the professional expectations of science teachers utilizing digital technologies in the Australian state of Victoria alongside the out-of-field (OOF) teaching experience. This research sought to better understand and explain science teachers' perceptions of their digital technology use before, during and after teaching an OOF geoscience unit. The seminal research question was:

> To what extent do secondary science teachers' perceptions of their agency change as they are supported to teach an out-of-field area of the science curriculum with digital technologies?

This question is underpinned by the assumption that making sense of teachers' discursive practices (Harré & van Langenhove, 1999) is challenging and complex. Discursive practices consist of verbal and non-verbal symbolic exchanges informed by teachers' beliefs and their sense of personal and professional agency as they are reasoned, enacted and shared. As such discursive practices are seen and heard in what teachers say and do.

This chapter explains the philosophical and methodological framework to justify utilizing positioning theory (Harré & van Langenhove, 1999) as the overarching philosophy and methodology for this research. A question-driven approach (Maxwell, 2013; Punch & Oancea, 2014; Shavelson & Towne, 2004) informed the methodological design to better understand teachers' perceptions of their choices (Schatzki, 2002) as they negotiated complex local structures (Jovchelovitch, 1996; Mansour, 2009) to explain how their beliefs have become reified and discursively active (Davies & Harré, 1990; Harré, 2002a).

The chapter begins by explaining the philosophical and methodological framework. Comparisons are made between the epistemologies and theoretical perspectives of positioning theory and constructivist grounded theory (Charmaz, 2014) to justify the use of constructivist grounded theory coding procedures to analyze data through the positioning

triad. Then, I introduce the main research site, Riverside High (pseudonym), explain participant recruitment and the data collection and analysis process. The chapter closes by offering a framework to evaluate the research design and identify the limitations and ethical considerations.

## 3.2 Locating Self in Qualitative Research

I am a science teacher working and studying within the social world where my participants spend the majority of their day. I understand that qualitative studies may be considered 'partial-renderings [...] from within the standpoints of the life experience of the researcher' (Erickson, 2004, p. 54). I acknowledge that I bring an interpretive framework shaped by my professional lived experience to evoke and analyze my participants' reflections.

The relationship between the researcher and what is studied, however, is also recognized as shaping the inquiry (Denzin & Lincoln, 2011; Flick, von Kardoff, & Steinke, 2004). As a researcher, I sought to understand the meanings participants ascribed to their lived experience (Creswell, 2009, 2013). Focusing acute attention on the language and non-verbal symbolic exchanges my participants utilized to make sense of the world enabled me to draw evidence about the range of possible meanings of actions and events and how these meanings may have evolved (Redman, 2013b).

What we know and understand of people arises from their 'acting from within a culture' and our relationships with participants help us not report on what we think they are but 'on what they actually are' (Shotter, 2013, p. 133). As such, meaning is understood to be dynamic and actively co-/re-constructed through my participants' conversations with each other and me. This challenged me to confront my assumptions as both a teacher and researcher to interpret phenomena in terms of the meanings my participants brought to them (Denzin & Lincoln, 2011). For these reasons a qualitative paradigm was adopted.

## 3.3 Philosophical Worldviews

Philosophical worldviews may be less apparent than explicit theories guiding qualitative studies, however they inform choice of theory guiding the research design (Creswell, 2013) and influence selection of methodology and methods of data collection

(Corbin & Strauss, 2008). Since worldviews, and their inherent assumptions, are embedded in the researcher's beliefs, actions and accounts of the inquiry process (Lincoln & Guba, 1985b) they are worthy of discussion.

Patton (2002) reports there is 'no definitive way to categorize the various philosophical and theoretical perspectives that have influenced and [...] distinguish types of qualitative inquiry' (p. 79). In this section, I will draw on the work of Kamberelis and Dimitriadis (2005b) to unpack my philosophical worldviews across four analytic strata (Crotty, 1998). Epistemology and theory, discussed below, inform the methods of data collection, analysis and triangulation, explained in sections 3.6 to 3.9.

### 3.3.1 Constructionist and Constructivist Epistemologies

Epistemology is the relationship between knowledge and how people construct it (Guba & Lincoln, 1994; Kamberelis & Dimitriadis, 2005b). In this section, I explain constructionist and constructivist epistemologies to introduce positioning theory as the overarching methodology and to begin defending the choice to utilize constructivist grounded theory coding procedures in the data analysis.

Positioning theory has its roots in social constructionism (Harré & van Langenhove, 1999; Howie & Peters, 1996), a concept credited to Berger and Luckmann (1971) who proposed that understanding reality requires inquiry into how it is constructed by individuals in social situations (van Langenhove & Bertolink, 1999). For social constructionists descriptions of the world are possible and numerous; they align with an individual's identity and the socio-temporal contexts within which descriptions are formulated at a moment in time (Harré & van Langenhove, 1999). For this research identity refers to the social, historical and cultural perceptions an individual has of her/himself at a moment in time during conversation with others.

In the literature, the terms 'constructionism' and 'constructivism' often appear to be used interchangeably and there are multiple definitions of constructivism (Guba & Lincoln, 1994). According to Flick (2004a) a common element is their examination of the 'relationship to reality by dealing with constructive processes in approaching it' (p. 88). Individuals construct and co-construct the realities in which they participate by gaining multiple views of a phenomenon located within the connections and constraints of the

social world (Charmaz, 2014; Creswell, 2013; Denzin & Lincoln, 2011; Guba & Lincoln, 1994). Charmaz (2014) has affirmed that the constructionist ontological perspective aligns with constructivist grounded theory analyses.

### 3.3.2 Interpretive Theoretical Perspective

Constructivist inquiry not only 'promises to deliver on some set of local or context-grounded truths, it is also the processes of interpretation' (Guba & Lincoln, 2005, p. 205) because reality is socially constructed (Charmaz, 2014; Creswell, 2009, 2013; Guba & Lincoln, 1994; Lincoln & Guba, 1985a). In this research, interpretation of reality occurred on two levels.

On one level, all research is interpretive since it is guided by the researcher's beliefs about how the world should be understood and studied (Mills, Bonner, & Francis, 2006). Theoretical models emerging from the analysis of participants' data are not an exact portrayal of the world but an interpretation of it (Charmaz, 2014; Guba & Lincoln, 1994; Schwandt, 2000). By adopting a qualitative paradigm, I recognize that I am acting as data interpreter. I interpreted my participants' speech and actions through my researcher's lens and inevitably through my deep-seated pedagogical beliefs.

On another level, Schwandt (2000) suggests that action is meaningful and 'requires that one interpret [...] what the actors are doing' (p. 191) with an aim to reconstruct self-understandings. Positioning theory is concerned with performance style; the way people do things and the meanings ascribed to their actions (Harré & Moghaddam, 2003). Two principles of positioning theory speak to the interpretive perspective of this research:

1. Action, what people say and do, hinges on judgment; and

2. What people are is a product of interpersonal interactions including what a person is able to do, physically and temperamentally; has done, is doing or will do; and is permitted or forbidden to do (Harré, 2015; Harré & Slocum, 2003; Harré & van Langenhove, 1999)

Positioning theory offers a more useful way to understand people's actions than considering a person through their role, a static concept.

The interpretive perspectives of grounded theorists are similar to positioning theorists. Grounded theory evolved largely from the pragmatist philosophical tradition

(Strauss, 1991) where reality is considered to be indeterminate and fluid. Pragmatism informed Blumer's (1969) symbolic interactionism:

> [H]uman beings interpret or 'define' each other's actions instead of merely reacting to each other's actions. Their 'response' is not made directly to the actions of one another but instead is based on the meaning which they attach to such actions (p. 19).

Symbolic interactionism focuses on a dynamic relationship between action and meaning in which individuals actively create and mediate meaning (Charmaz, 2014).

Positioning theory paired with constructivist grounded theory coding procedures will be unpacked in section 3.8 to show how these interpretive perspectives provide a framework to understand participants' interpretations of the social, cultural and historical facets of the local moral order, the system of rights and duties within which intentional acts are done (Davies & Harré, 1990; Harré & Slocum, 2003; Harré & van Langenhove, 1999).

### 3.4 Purposive Sampling of Participants and the Main Research Site

Unlike experiments with controlled laboratory conditions, context in qualitative research is crucial to developing understanding (Patton, 2002). Context-dependent knowledge has been said to be 'at the heart of expert activity' (Flyvbjerg, 2011, p. 303) and Charmaz (2014) explains that a 'combination of insider knowledge and detailed study can yield profound analyses' (p. 63).

I purposely chose a government school in inner-city Melbourne, Australia as the main research site. Conducting research at Riverside High (pseudonym) enabled me to draw on my established professional relationships with the administrative staff, teachers and students. At the time of data collection, I had been a classroom teacher at Riverside for six years and I remained in this role until the submission of this thesis. Throughout my time, I developed a deep understanding of the school culture and history. As such, I had access to data sources that may have remained out of reach to scholars outside this community (G. J. Anderson, 1998; Charmaz, 2014) and my fellowship with participants may have enabled them to feel comfortable reflecting on their experiences.

Prior to the implementation of the Australian Curriculum (ACARA, n.d.-c) followed by the Victorian Curriculum (VCAA, 2016a) teachers at Riverside had very little to no

habitus teaching geoscience and therefore no known way of resourcing for these state-mandated requirements. At the time, geoscience had yet to earn its way into the curriculum as a topic approached with the rigor of biology, chemistry and physics. In addition, Riverside had a bring-your-own-device (BYOD) program, however no specific device was mandated for students which had possibly complicated the introduction of digital technologies into the science classroom.

Since Riverside teachers seemed to be navigating terra incognita at this curricular intersection, I believe that Riverside thus presented a specific context to examine and study these teachers' experiences. In addition, part of the research agenda was to work toward effectively building teachers' capacities to teach science with digital technologies by offering support and resources to understand the extent to which these teachers may have experienced personal and professional growth. As such I sought to foster my continued commitment to government education in this small way.

Understanding that these new geoscience units were still beginning to take shape, I also sought to offer teachers opportunities to reflect on the practices of others outside the Riverside community. I purposely sampled a small group of science teachers attending the Science Teachers' Association of Victoria (STAV) conference. Teachers with at least five years' experience were deemed more likely to have taught geoscience units and able to offer informed perspectives.

### 3.5 Participant Recruitment

In 2016, I formally met with the principal of Riverside High to request consent for the research. All plain language statements (PLSs) and consent forms (CFs) were provided to the principal. With the support of the Science Coordinator, I explained the purpose of the research during a science faculty meeting. Ten teachers volunteered to participate to varying extents. Three participating teachers facilitated the recruitment of student participants. I was introduced to these students as both a teacher and researcher and I was offered time to explain the research and invite students to participate. The teachers and I distributed parent and student PLSs and CFs. These were collected two weeks later to offer parents and students time to make informed decisions about participation. Twenty-eight year nine students volunteered to participate to varying extents.

Recruitment of science teachers outside Riverside High occurred at the STAV conference where teachers were invited to respond to an online questionnaire. At the conference, I offered two workshops introducing the Cyber-Enabled Earth Exploration Curriculum (Almquist et al., 2012; Blank et al., 2016; Blank et al., 2012), a resource that Riverside teachers were scaffolded to use while teaching geoscience. Presenting these workshops connected me to the conference attendees not only as a researcher but also as a practicing teacher. Before the questionnaire began, a PLS introduced the purpose of the research and explained that completing the questionnaire would signal consent. Twenty-two conference attendees volunteered to complete the questionnaire, 19 of whom had more than five years' teaching experience.

### 3.6 Methods of Data Collection

The interpretive and subjective nature of this research required me to draw on multiple sources of evidence to generate the Explicit Personal Pragmatic Approach (EPPA) to professional learning, a model grounded in participants' reflections of their lived experience (Charmaz, 2014; Urquhart, 2013). Meaning making is of central interest to constructivists because it shapes action or inaction (Guba & Lincoln, 2005) as individuals interpret the world through their social, historical and cultural lenses (Shotter, 1993, 2013). Charmaz (2005) explains that understanding:

> [...] what things mean to people makes what they do with them comprehensible [... and] how people act toward things in their worlds indicates their relative significance (p. 521).

In positioning theory meaning making becomes evident through participants' discursive practices, speech and gesture, which are indicative of the normative frames through which people are thinking, feeling, acting and perceiving (Harré, Moghaddam, Cairnie, Rothbart, & Sabat, 2009). Mortimer and Scott (2003) explain:

> According to the sociocultural perspective, if you wish to investigate the ways in which people typically *think* about the world around them, the place to start is to investigate the ways in which they *talk* and communicate about the world (p. 10).

The methods of data collection invited participants to co-construct understandings (Charmaz, 2006) and were intended to offer them the opportunity to reflect on their experiences both:

1. Privately by constructing personal meaning making maps and responding to questionnaires; and

2. Publicly though participating in collaborative interactive discussions, semi-structured interviews and focus groups informed by private reflections, classroom observations and document research

### 3.6.1 Questionnaires

Questionnaires are the most widely used procedure to obtain information (Opie & Sikes, 2004) and efficiently gain a general understanding of phenomena (O'Toole & Beckett, 2013). Two questionnaires were designed for this study:

1. Student Questionnaires I-V, Appendix A; and

2. STAV Conference Attendee Questionnaire, Appendix B

Year nine participants were invited to complete five weekly online questionnaires as they studied geoscience at Riverside. Students were provided the opportunity to assess their digital technology use by responding to Likert-type and open-ended questions. The questionnaires drew on the language from Bloom's Revised Taxonomy (Krathwohl, 2002) to prompt students' reflections. This language complimented Riverside's curricular initiative to explicitly teach metacognitive language and skills. These questionnaires allowed me to track changes in students' self-assessments, develop further focus group and interview prompts and to triangulate teachers' perceptions of their experiences.

To understand how Riverside teachers' practice differed to those outside the main research site, STAV conference attendees were invited to briefly share some their geoscience pedagogical content knowledge by responding to Likert-type and open-ended questions. These responses were collated and utilized to prompt Riverside teachers to reflect on their own practices during individual interviews.

### 3.6.2 Focus Groups and Interviews

Semi-structured interviews and focus groups were key to understanding participants' multiple realities (G. J. Anderson, 1998; Charmaz, 2014; Patton, 2002; Peräkylä & Ruusuvuori, 2011) and the emergent themes in the data (Punch & Oancea, 2014). Interviews and focus groups facilitated in-depth exploration of areas in which participants have substantial experience (Charmaz, 2014) while offering time for them to reflect, 'negotiate and reformulate their self-narratives' (Barbour, 2014, p. 320).

Personal meaning making maps (PMMMs) and collaborative interactive discussions (CIDs) are not only pedagogical tools that support teaching practice (Giardiello, McCloud & Redman, 2014), but also act as powerful data collection tools that offer participants time to reflect on and explicitly articulate perceptions about their lived experience. During focus groups, teachers and students were invited to create PMMMs and CIDs that aimed to 'cultivate new kinds of interactional dynamics' (Kamberelis & Dimitriadis, 2005a, p. 903) and form the basis for individual interviews.

<u>Interviews and Personal Meaning Making Maps (PMMMs)</u>

PMMMs support constructivist approaches to gathering participants' epistemological beliefs (Giardiello et al., 2014) and they can empower participants to share personal narratives. PMMMs capture perceptions at particular times in particular places and supported me to begin data collection with a deep respect for teachers' and students' experiences they deemed personally significant.

Participants constructed PMMMs during two focus groups at Riverside High. The first consisted of ten science teachers responding to the written prompt *digital technologies used in science class*. In the second focus group six students responded to the prompt *digital technologies we use in science class*. Responses to these prompts could include words, phrases or diagrams. Figure 3.1 exemplifies a PMMM constructed by Olivia, a Riverside science teacher. As the curriculum designer, part of the research agenda was to possibly extend both teachers' and students' capacities to utilize digital technologies in science. Data from PMMMs helped inform my understanding of participants' capacities prior to designing the digital experiences for both teachers and students in the geoscience unit.

**Figure 3.1: Olivia's Personal Meaning Making Map from July, 2016**

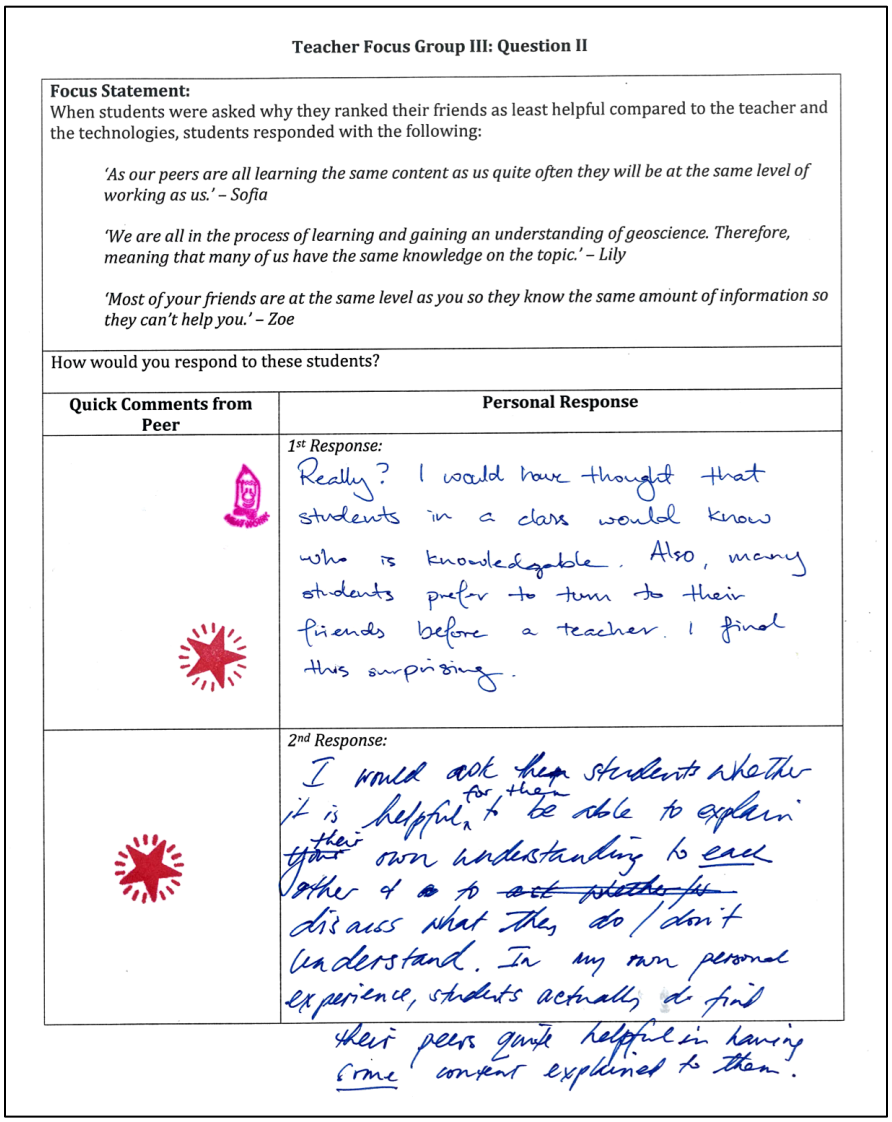
The data gathered from PMMMs elicited sensitizing concepts (Blumer, 1969) illuminating tentative lines of inquiry (Charmaz, 2014). I attempted to capture an accurate understanding of participants' perceptions by inviting them to participate in follow up interviews. These audio-recorded, transcribed interviews were designed to support participants to elaborate on their experiences and clarify their use of language by defining meanings from their 'lexicon of experience' (p. 97). The PMMMs were revisited a second time during a final individual interview for each teacher. These interviews were the most crucial to identifying and furthering an understanding of any possible change in participants' beliefs about their digital technology use.

Focus Groups and Collaborative Interactive Discussions (CIDs)

Focus groups are not only educative spaces, but also can be used to gather data that may otherwise be inaccessible (Kamberelis & Dimitriadis, 2011). In addition, focus groups can provide a group dynamic of 'endemic prompting and probing' (O'Toole & Beckett, 2013, p. 132). Each focus group began with a CID to establish equitable participation (Creswell, 2013) and trust between members of the group as they shared their perspectives.

CIDs are similar to PMMMs in that they are temporal, contextual and can be used as a means to usher participants' private thoughts into the public space. First, participants were provided with substantive statements from a body of knowledge derived from the literature, questionnaires, classroom observations or prior focus groups. These statements invited participants to reflect on the issue and share their beliefs by responding to a focus question. Participants recorded their reflections on the CID template and then passed it to another member of the group. Each participant read and responded to their peer with a quick comment then recorded their personal reflection. Quick comments took the form of mutually agreed upon symbols to prompt further elaboration and record the sense of feltness (Shotter, 1993, 2013).

CIDs were used during five focus groups with two teacher participants and during five focus groups with six student participants. Figure 3.2 exemplifies a CID constructed by Riverside science teachers, Ethan and Charlotte. In the quick comments section, a red star indicated that Charlotte agreed with Ethan, the pink pencil signified that she found his personal response interesting. Ethan agreed with Charlotte's personal response.



**Teacher Focus Group III: Question II**

**Focus Statement:**
When students were asked why they ranked their friends as least helpful compared to the teacher and the technologies, students responded with the following:

*'As our peers are all learning the same content as us quite often they will be at the same level of working as us.' – Sofia*

*'We are all in the process of learning and gaining an understanding of geoscience. Therefore, meaning that many of us have the same knowledge on the topic.' – Lily*

*'Most of your friends are at the same level as you so they know the same amount of information so they can't help you.' – Zoe*

How would you respond to these students?

| Quick Comments from Peer | Personal Response |
|---|---|
| | *1st Response:* Really? I would have thought that students in a class would know who is knowledgable. Also, many students prefer to turn to their friends before a teacher. I find this surprising. |
| | *2nd Response:* I would ask them students whether it is helpful for them to be able to explain their own understanding to each other & to discuss what they do/don't understand. In my own personal experience, students actually do find their peers quite helpful in having some content explained to them. |

**Figure 3.2: Collaborative Interactive Discussion from October, 2016**

### 3.6.3 Observation

Observation is an established method of data collection in education research (Punch & Oancea, 2014) and compliments other methods by contributing evidence that would not otherwise be obtained (Maxwell, 2013). Observation was used to triangulate data from PMMMs, CIDs and interviews to understand 'how social processes are constructed and constrained by the physical and social environments in which they are practiced' (Starks & Trinidad, 2007, p. 1375).

I observed participating teachers' classes as often as permitted by the timetable. While observing, I recorded memos about the progress of the lessons. To compliment my

observations audio-visual recordings were made while students utilized Microsoft Surface computers. Software installed on these computers recorded students' facial expressions and screen manipulations as they worked to complete online activities. These observations not only enabled me to develop and challenge my own assumptions about what happened in the classroom but also helped me to make sense of participating teachers' perceptions and served to indicate matches or mismatches between their discursive practices.

### 3.6.4 Document Research

Documents are rich data sources (Punch & Oancea, 2014). In case study research, they can be utilized to 'furnish descriptive information, verify emerging hypotheses [and] offer historical' insights (Merriam, 1988, p. 108) and documents also have value for generating theory (Charmaz, 2014). Although not all documents are created for research purposes, Prior (2008) suggests that researchers look beyond what documents contain to what they say and do. In addition to state-mandated curriculum documents, Riverside curriculum planning documents were utilized to understand how the intended curriculum was interpreted and enacted within the Riverside context.

### 3.6.5 A Note on Audio-Visual Recordings and Transcription

Constructivist epistemologies (Guba & Lincoln, 2005) emphasize active and reflective participants yet field notes alone could not efficiently and accurately capture the tone and tempo of participants' dialogue or silences (Charmaz, 2014). Audio-visual recordings were essential to preserving a record of interviews, focus groups and observations.

I transcribed and reviewed all audio-visual recordings for accuracy using MAXQDA qualitative data analysis software as described by Corbin and Strauss (2008). Apart from recording participants' words, pauses of three seconds or more were also transcribed using the notation '.....' to indicate the participant was silent for five seconds. Each second of silence was represented by a full stop. Utterances including 'um, uh, like, you know' and moments of hesitation were transcribed as well. Silences, use of paraverbals and moments of hesitation seemed to indicate that participants were traversing unfamiliar language environments as they reflected on 'the unique what-ness of previously unencountered

*things*' in their lived experience (Shotter, 2013, p. 150). All transcripts were disseminated to participants who were offered the opportunity verify the accuracy of the transcriptions.

### 3.7 Data Collection Process

This research was conducted in six phases. Over seven months data were collected through phases I to V, illustrated in Figure 3.3. The arrows signal phases of the research that informed others.

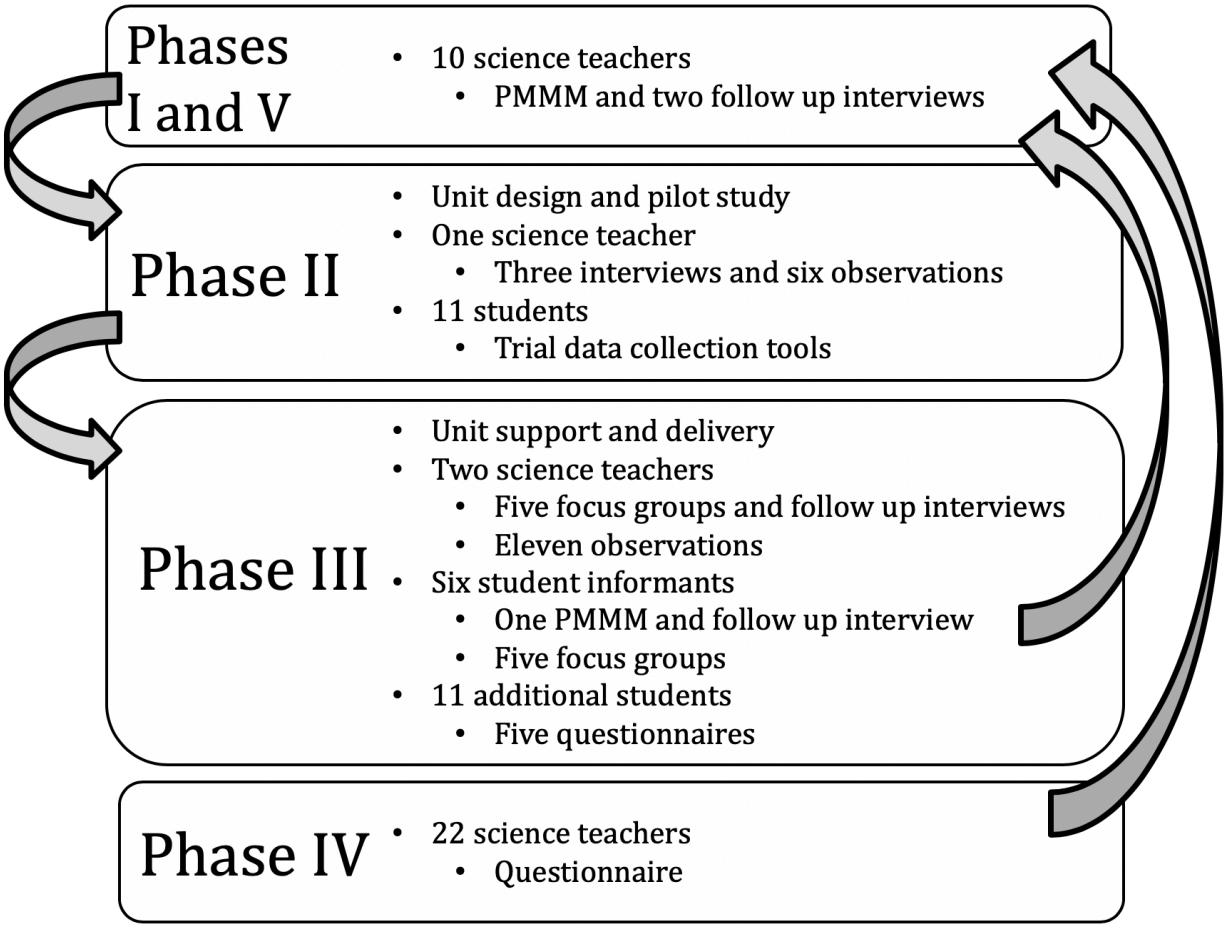



**Figure 3.3: Sequence of Data Collection**

Phase I began in late July 2016 and lasted approximately one month. During a science faculty meeting Riverside teachers were offered professional learning to introduce them to the use of PMMMs in the science classroom. Ten of these teachers consented to participate in the research and they completed a PMMM and follow up interview.

Phase II began in August 2016. Rachel, a teacher participant from phase I, volunteered her year nine science class to pilot a seven-week geoscience unit of work taught through the use of digital technologies. The design of this unit was informed by teachers' perceptions of their digital technology use and analysis of curriculum planning documents. I was invited to observe Rachel's class six times over the course of the unit and offered both technical and pedagogical support when needed. Rachel participated in three interviews throughout this time and offered invaluable insights to improve the unit. For instance, Rachel was new to using both Google Drive and Google Earth. Her reflections prompted me to make instructional videos as an additional support for teachers utilizing these digital technologies in phase III.

Eleven students from Rachel's class consented to trial the data collection tools designed for students. These students provided valuable feedback about the language and structure of the data collection tools. This feedback shaped the final questionnaires and structures for the CIDs used in phase III. Five of these students piloted the Surface computers and video recording software as they worked to complete online activities. This video data has been utilized to triangulate Riverside teachers' reflections of digital technology use in their classes.

Phase III began in October 2016 and lasted seven weeks. Charlotte and Ethan, teacher participants from phase I, volunteered their time and year nine classes to reflect on utilizing digital technologies in geoscience. Of note, is that Isabelle, another teacher from phase I, taught the unit alongside Charlotte and Ethan, but professional duties prevented her from participating to the same extent as them. I was invited to observe Charlotte's class eight times and Ethan's class three times. As a teacher at Riverside, I was asked to substitute for both Ethan and Charlotte's class once when these teachers were attending to other professional duties. Charlotte and Ethan also participated in five focus groups and a follow up interview after each focus group.

Four of Charlotte's students and 13 of Ethan's students consented to complete five questionnaires throughout the seven weeks. Of these students, six volunteered to participate in a focus group to construct a PMMM, follow up interview, five focus groups using CIDs as well as audio-video recording while completing digital activities throughout

the unit. These data were utilized to triangulate teachers' perceptions of digital technology use in their classes.

Phase IV was completed on November 25, 2016 at the STAV conference. Consent was obtained from conference coordinators and attendees were invited to complete a questionnaire at their convenience. Twenty-two teachers volunteered to complete this questionnaire. Nineteen had more than five years' experience and their responses were sufficient to inform phase V of the research.

Phase V began in December 2016 and lasted approximately two weeks. Data from phases I, III and IV were used to inform a final follow up interview with the 10 Riverside science teachers who participated in phase I. The purpose of these interviews was to clarify my interpretations of teachers' digital technology use and their perceptions of the intended and enacted geoscience curricula.

In 2018, two years after the completion of phases I to V, Ethan, Rachel and Charlotte, volunteered for a final follow up interview. The purpose of these interviews was to better understand how participating in this research may have contributed to these teachers' professional growth, if at all.

## 3.8 Data Analysis Overview

Positioning theory (Harré, 2012; Harré & van Langenhove, 1999) and constructivist grounded theory methodology are epistemically and theoretically complimentary to each other as explained in section 3.3. Researchers adopting a grounded theory approach are provided with a set of guidelines used to build explanatory frameworks from the personal reflections of participants (Charmaz, 2014). These guidelines include simultaneous data collection and initial coding, constant comparison, memo writing, theoretical sampling and refinement of emergent theory. As such, positioning theory was used in conjunction with these guidelines to inform data analysis.

### 3.8.1 The Positioning Triad

Positioning theory can be utilized to interpret the moment-to-moment evolution of teachers' perceptions of past, present and future events indicating 'the relationships that a teacher has to outside influences that come from the broader institutional setting' (Redman

& Coyle, 2013, p. 271). In grounded theory social and psychological processes are interpreted as data collection evolves and events are explained by the individuals experiencing them (Charmaz, 2014; Glaser, 1978). Analyzing participants' discursive practices, the say and do, through the lens of positioning theory indicates the normative frames through which people think, feel, act and perceive as positions and storylines emerge (Harré et al., 2009). Figure 3.4 illustrates the relationship between discursive practices, positions and storylines. Drawing on the work of Herbel-Eisenmann, Wagner, Johnson, Suh, and Figueras (2015), Tait-McCutcheon and Loveridge (2016) point out that the relationships between elements of the triad are dynamic, despite being represented by a static shape.

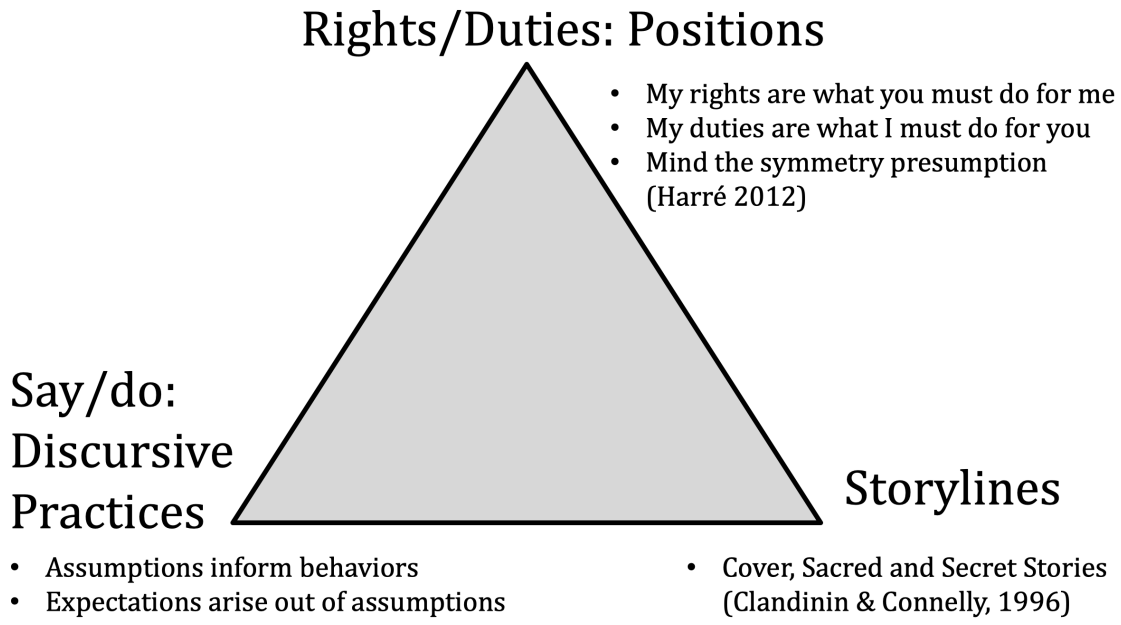



**Figure 3.4: The Positioning Triad, adapted from Harré and van Langenhove (1999)**

During conversations individuals perform *discursive practices* through the speaking or writing of words and non-verbal symbolic exchanges (Davies & Harré, 1990; Harré & van Langenhove, 1999). The intended outcome of an utterance or action, the illocutionary force (Austin, 1975), depends on how the discursive practice is perceived by others involved in the conversation at that time and place. In addition, words or actions can occupy more than one conversation (Harré & Slocum, 2003; Harré & van Langenhove,

1999) exhibiting distinct perlocutionary forces (Austin, 1975), the effects of utterances either intended or unintended.

Both illocutionary and perlocutionary forces are actively constructed and contested (Louis, 2008). For example, I might ask the class: 'In an earthquake-prone area, do you think it's safer to live at the top or the bottom of a hill?' A student volunteers a response and I reply: 'That's interesting, can you tell me more?' My intention is for the student to offer further explanation. However, she turns to a peer and says: 'That means I'm wrong!' The student's interpretation of my utterance results in reticence, an undesired perlocutionary act.

Discursive practices give rise to dynamic *positions* which indicate power imbalances that are connected to perceptions of agency, identity and beliefs. Referring to research in mathematics education, Herbel-Eisenmann et al. (2015) point out possible ambiguities in the use of the terms 'position' and 'positioning' demonstrating that positioning theory can be criticized for not explaining 'the sources from which people draw as they position each other' (p. 186). To offer clarity, they refer researchers to more recent work by Harré (2012) and recommend describing positions by emphasizing the rights and duties individuals claim and ascribe to themselves or others. As individuals are positioned they interpret the system of rights and duties within which intentional acts are done, the local moral order (Davies & Harré, 1990; Harré & Slocum, 2003; Harré & van Langenhove, 1999), and possess a limiting repertoire of acts to negotiate the social episode (Harré & Moghaddam, 2003).

Positions, whether accepted or rejected, signal plots in *storylines* that have been influenced by the history of interactions (Redman & Rodrigues, 2008). Storylines not only reflect an individual's rights and duties but also her/his interpretations of others' rights and duties (Redman, 2013a). Herbel-Eisenmann et al. (2015) explain that conceptual 'fuzziness' (p. 185) about positions/positioning and storylines can complicate their relationship. They highlight a need for explanation and operationalization of these terms. This apparent ambiguity is understood as an opportunity to draw on theoretical perspectives that can further illuminate the phenomenon under study.

I use cover, sacred and secret stories (Clandinin & Connelly, 1996) to illustrate how storylines may be operationalized to better understand the professional landscape teachers navigate. Cover stories are promoted by school administrators to the wider

community: ***Our school provides technologically advanced learning spaces***. Sacred stories are the theory-driven view of practice shared by teachers, policy makers and theoreticians: ***The technologically advanced learning spaces should be used to improve student outcomes***. Secret stories are about classroom practice that can indicate tension with the cover and/or sacred stories: ***I'm unsure how to use technology to improve my students' outcomes***.

How do material objects like digital technologies influence and inform storylines? Harré (2002b) explains that a non-living, material object is capable of interacting with humans either actively or passively and that an object is:

> [...] transformed from a piece of stuff definable independently of any storyline into a social object by its embedment in the narrative (p. 25).

Material objects have particular affordances (Gibson, 1979) and as such they can exist as multiple social objects 'each identified by its role in a narrative' (Harré, 2002b, p. 27). An affordance is a material disposition specified in human terms, it is spatially and temporally located (Gibson, 1979). Harré (2002b) explains that material objects have multiple affordances and influence storylines by:

1. Serving as carriers of meaning;
2. Being potent in a special way in the context of a story;
3. Having practical roles not included in their original specifications;
4. Changing categories within a story; and
5. Impeding actions that are presented as proper within the story (pp. 25-26)

Since material objects can act to influence and inform storylines in multiple ways, the term 'role,' used above, might be replaced with 'position' because material objects may be positioned and re-positioned as having certain affordances depending on how and by whom they are utilized. Of note, however is that without a sense of self, non-living material objects are unable to reflexively position themselves. Repositioning material objects in a storyline can only arise out of the personal agency expressed by the individual/s utilizing them for different purposes at certain times and in certain places. In this way material objects may be utilized by individuals to position and reposition self and others such that new storylines emerge.

In the classroom, an individual's contradictory beliefs about her/his or a group's collective rights and duties and personal identity shape what it means to be a teacher or a student (Davies, 1990). The relationships between the positioning triad provided a framework for a fine-grained analysis of the data. Codes indicating teachers' perceptions of their own and their students' rights and duties were grounded in the data to understand the possibilities and permissions that might be afforded to participants as new positions became available to them. In this way the positioning triad has guided me to interpret participants' perceptions of their experiences as they taught geoscience using digital technologies.

### 3.8.2 From Data to Model: The Process of Analysis

This research emerged from my belief that in education researchers' theoretical understandings of best practice are informed by teachers' professional knowledge and that teachers' pedagogical capacities can be enhanced through theoretical understandings. At the outset, I sought to construct a model grounded in and representing my participants' reflections of their lived experience. Figure 3.5 illustrates the constructivist grounded theory coding procedures (Charmaz, 2014) utilized in conjunction with the positioning triad to analyze my participants' data.

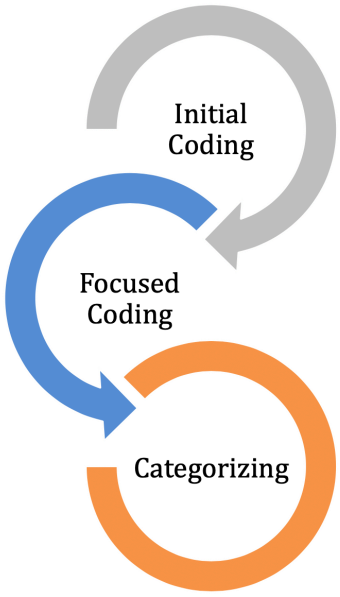



**Figure 3.5: Data Analysis from Initial Coding to Categorizing**

Charmaz (2014) explains that codes 'explicate how people enact or respond to events, what meanings they hold, and how and why these actions and meanings evolved' (p. 113). Initial coding began with examination of transcripts and written text from PMMMs, CIDs, observation notes and documents. The data were examined line-by-line and coded as gerunds to summarize each piece of data focusing on action. Examples of initial codes include: *having technology available makes class more meaningful, wondering how to use technology effectively* and *wondering if podcasting enables students to learn more*. Coding the data in this way enabled me to define implicit meaning, make comparisons between participants' experiences and drew attention to data that needed clarification.

Positioning theory was utilized as a lens through which to code beyond the descriptive and make analytic sense of the data. To better understand Riverside teachers' perceptions of digital technology use in an OOF area, initial codes were organized into three groups based on teachers' positioning of the digital technologies, self and their students. The initial codes exemplified above were grouped together because they appeared to be primarily about the digital technologies themselves. After organizing the initial codes in this way, I utilized pronoun grammar analysis (Redman, 2013a; Redman & Fawns, 2010) to raise these groups of initial codes to focused codes telling an analytic story (Charmaz, 2014). *Approaching digital technologies with caution* was the focused code distilled from the initial codes *having technology available makes class more meaningful, wondering how to use technology effectively* and *wondering if podcasting enables students to learn more*.

Informed by positioning theory, pronoun grammar analysis (Mühlhäusler & Harré, 1990) is an analytical tool that aids in the fine-grained analysis of textual data (Redman & Fawns, 2010). In communication participants' moment-to-moment language choices, intentional or unintentional, indicate perceptions of their rights and duties within the local moral order (Harré & van Langenhove, 1999). Using pronoun grammar analysis and constant comparison (Charmaz, 2014), I focused attention on participants' use of pronouns, phrases, qualifying words and paraverbals to track shifts in storylines within and between conversations.

Table 3.1 identifies and explains the significance of the language features utilized to track positioning changes and shifts in storylines as Riverside teachers reflected on the use

of digital technologies in science. Of note is that qualifying words may have culturally specific meanings and thus need to be examined and explained within the social context of the conversation (Mühlhäusler & Harré, 1990).

**Table 3.1: Language Features and Significance to Positioning**

| Language Feature | Examples | Possible Meaning* |
|---|---|---|
| **Pronoun** | I, me, my | Indicate that ideas under discussion are most likely personally located in the speaker's narrative and may signal personal belief and commitment to ideas. |
| | You | Communicates that a speaker is perhaps distancing themselves from ideas under discussion, but can also be indicative that the speaker is explaining a past event or anticipating a future scenario. |
| | We | Reflexively positions a speaker seeking to be recognized as being part of a group and indicates possible authority as s/he assumes the right and duty speak on behalf of group members. |
| | They | May communicate a speaker's lack of empowerment as s/he distances her/himself from the group. |
| **Phrase** | You know | Can be used to reflexively position oneself as aligned with ideas and also position the listener to be in agreement by conveying a sense of oughtness (Linehan & McCarthy, 2000). For this research, 'you know' can indicate that the participant granted me, a teacher-researcher, the right to tell her/his story. |
| **Qualifying Words** | Guess, just, kind of, maybe, might, perhaps, possibly, somehow, sort of or suppose | Indicate a possible sense of uncertainty or lack of personal commitment to ideas under discussion. |
| | Actually, basically, certainly, obviously or really | Attempts to imply actual confidence or certainty and a degree of personal commitment to ideas under discussion which may or may not exist. |
| **Paraverbals** | Like, oh, okay, um, uh and moments of hesitation | Hold the conversation as the speaker thinks about or seeks control of a place in it. |

* Developed together with Christine Redman and Paul Chandler

As individuals are defined and redefined the self becomes a product of and in the community (Redman & Rodrigues, 2008) and 'pronominal grammar provides a window to the relationship between selves and the outside world' (Mühlhäusler & Harré, 1990, p. 207). Thus an individual's affiliation or disaffiliation in a group (S.-L. Tan & Moghaddam, 1999) and possible changes in her/his beliefs and attitudes may be better understood.

Categorization is an iterative process in which themes and patterns in the data are raised to an analytical concept (Charmaz, 2014). From the focused codes, I aimed to conceptualize how teachers' positionings of the digital technologies, themselves and their students were related before, during and after teaching geoscience. Memos are crucial in grounded theory studies (Charmaz, 2014; Glaser, 1978; Strauss & Corbin, 1990) and I used them throughout data collection and analysis to capture, shape and code promising theoretical directions. I also drew on Rokeach's (1968) five types of belief and Foucault's (1988) technologies of the self, explained in chapter 2, to provide a shared language to better understand an individual's sense of her/his personal agency.

After I developed tentative theoretical categories, Ethan, Rachel and Charlotte volunteered to be re-interviewed in 2018. Through theoretical sampling (Charmaz, 2014) I was further able to refine the properties and dimensions of the theoretical categories. Understanding that professional growth is dynamic, theoretical categories are expressed as gerunds and serve as metaphors explaining how these teachers perceived their professional practice at the time and place of their reflections.

## 3.9 Criteria for Evaluating the Research

What constitutes sound education research is a debated and contested issue involving judgments about research and education (Yates, 2004). Naturalistic studies cannot be evaluated along the same criteria as those adopting a positivist epistemological stance (Guba, 1981; Lincoln & Guba, 1985b). As such, the terms 'credibility' and 'transferability' are used to justify the rigor of this research.

### 3.9.1 Credibility

Lincoln and Guba (1985b) suggest five techniques in research design that minimize researcher bias and maintain credibility:

1. Prolonged engagement;
2. Persistent observation;
3. Triangulation;
4. External checks; and
5. Refinement of working hypotheses

Prolonged Engagement and Persistent Observation

Prolonged engagement and persistent observation are key to establishing trust between the researcher and participants (Lincoln & Guba, 1985b). I am an insider-researcher (Mercer, 2007), having been a classroom teacher at Riverside for six years before this research began. I remained in this role until submission of this thesis. However, I did not occupy a leadership position nor did I teach any of the student participants. Prior to beginning the geoscience unit, I was invited into Ethan, Charlotte and Rachel's classes twice for students to become comfortable with my presence in the classroom. Throughout the research, prolonged engagement was maintained through focus groups, interviews, classroom observations and ongoing teacher support as needed both in/outside the classroom.

Triangulation

Triangulation means bringing more than one source of data to converge on a single point (Flick, 2004b; Marshall & Rossman, 2006). In grounded theory triangulation sits at the heart of constant comparison and theoretical sampling as concepts are developed and redefined. Denzin (1978, 1989) identified two types of triangulation:

1. Triangulation of data; and
2. Within method triangulation

*Triangulation of data* combines data collected from different individuals at distinct times and places (Flick, 2004b). Teacher professional growth was the focus of this research and data gathered from documents, observations and student participants were utilized to triangulate teachers' personal reflections of their rights and duties and the possible symmetry between those identified by students and the professional expectations placed on teachers. *Within method triangulation* occurs within one method of data collection.

During interviews while participants narrated their experiences, I sought semantic clarification (Flick, 2004b). In addition, follow up interviews enabled me to invite participants to further explain data gathered from PMMMs, CIDs, focus groups and individual interviews.

External Checks and Refinement of Hypotheses

Memos have a variety of purposes (Maxwell, 2013). In addition to being used in data analysis, they contributed to the rigor and trustworthiness of this research (el Hussein, Hirst, Salyers, & Osuji, 2014). At the outset, I recorded possible outcomes shaped by my own experiences working within the Riverside context. I compared these memos with the emergent focused codes and theoretical categories to confront my existing bias and focus on the unexpected. Some memos were made available to participants who were invited to check and challenge my interpretations. Data analysis procedures and the emergent theory were discussed with two supervisors and critical colleagues. These exercises were crucial to maintaining the credibility of the research (Lincoln & Guba, 1985b).

### 3.9.2 Transferability

As a qualitative researcher, I am required to gather extensive, rich data to produce thick description (Geertz, 1973). I also have a responsibility 'to provide the *data base* that makes transferability judgments possible' (Lincoln & Guba, 1985b, p. 316). Mercer (2007) cautions that being an insider-researcher 'does not, of itself, make the data richer' (p.5). My role as a classroom teacher may have alerted me to documentation detailing the history of the geoscience meaning making space and the implementation of policy surrounding digital technology use, however extensive data collection and fine-grained analysis procedures with both student and teacher participants speak to the richness of the research. Chapters four through 10 exemplify, analyze and explain documents, participants' personal reflections and embed memos to enable the reader to make her/his judgments about transferability.

Theoretical models built for an applied field, such as education, should be concerned with how well they fit into the substantive area (Merriam, 1988; Starks & Trinidad, 2007; Taber, 2000). Positioning theory and constructivist grounded theory are heuristic and the

explanatory power of both has been justified throughout this chapter. The Explicit Personal Pragmatic Approach (EPPA) to professional learning was constructed and written for an audience of researchers and practitioners seeking to better understand the possibilities that may be afforded to science teachers while teaching at the intersection of the geoscience and digital technologies curricula. As such this thesis was written in a style to guide readers' conclusions about transferability to other situations.

## 3.10 Limitations

Working within the Riverside local moral order may have eased data collection in ways unavailable to an outsider, however the findings of this research should not be free from scrutiny. This section identifies the limitations of the research in terms of researcher values, bias and presence; sample size and style of writing.

### 3.10.1 Researcher Values, Bias and Presence

Qualitative research is weighted in values and biases that are inescapable and researchers must actively identify and report the 'value-laden nature of information gathered in the field' (Creswell, 2013, p. 20). I acknowledge that the data have ultimately been examined through the lens of my experiences and preconceived beliefs and attitudes as an insider-researcher. Utilizing positioning theory as an overarching philosophy and methodology for the research design alongside constructivist grounded theory coding procedures has enabled me to take a more reflexive stance and minimize elevating my 'tacit assumptions and interpretations to objective status' (Charmaz, 2006, p. 132).

Furthermore, as a classroom teacher, my professional role within the Riverside local moral order was not associated with duties to manage my colleagues nor was I teaching student participants. However, I was acutely aware that my presence may have affected my participants' actions and behavior during data collection. Data collection from students and teachers within and beyond the Riverside context, triangulation and multiple member checks of emergent findings challenged me to reflect on my presence and analytic perspective that may have been informed by personal biases.

### 3.10.2 Sample Size

This research was limited to the perceptions and experiences of 10 teacher participants at Riverside High, triangulated with 28 student participants from three year nine classes and 22 STAV conference attendees. According to Charmaz (2014), a small sample size 'belies a large effort' (p. 108) and can yield an in-depth study. Efforts to maintain credibility through prolonged engagement, triangulation, external checks and refinement of emergent theories speak to the rigor of this research. The sample size was not considered a limitation because it enabled me to analyze teachers' experiences in depth and reflect on the complexity of their perceived rights and duties, professional knowledge and personal capacity. Although this research was completed in the context of geoscience, participants utilized digital technologies that could be applied across curriculum areas and used in similar contexts where in-depth analyses of data from small samples of teachers could be compared for generalizability and refinement of findings.

### 3.10.3 Style of Writing

The constructivist researcher's voice can emulate a passionate participant actively facilitating both the multiple voices of participants and her/himself in the writing process (Lincoln, 1991). Through the positioning triad (Harré & van Langenhove, 1999) participants' discursive practices were interpreted to understand their perceptions of their rights and duties in the emergent storylines and I have tried to reflect the multiple realities of participants rather than dramatizing them (Charmaz, 2002).

Within the text I have included participants' reflections demonstrating their language at the time and place of our work together. Capturing participants' language, rhythm and timing portrays the tone and relationships of the participants with themselves and me (Charmaz, 2000; Charmaz & Mitchell, 1996). As such the style of writing reflects the notion that participants 'have the right to expect that we [researchers] will represent their lives as something more than scientific artifacts' (Charmaz & Mitchell, 1996, p. 300).

## 3.11 Ethical Considerations

Ethical challenges exist in all research designs and researchers must be alert to these implications (Punch & Oancea, 2014). I am an insider-researcher, a classroom teacher

working within the same context as my participants. Mercer (2007) explains that when making judgements about insider-research assumptions about ease of accessibility and efficiency of data collection may be made. However ethical protocols must be adhered to prior to seeking participants. In addition, pre-existing relationships pose additional ethical challenges for insider-researchers. As such, the research design was conducted with acute awareness of my position within the school and the potential vulnerability of the participants.

I had pre-established relationships with some participants through my professional history designing and implementing teaching and learning experiences, participating in extra-curricular activities and teaching siblings of student participants. Some teacher participants were recently hired at Riverside and I had not yet developed professional relationships with them. Due to the nature of this research, asking teachers and students to take risks to utilize digital technologies, I had to negotiate these boundaries with care and respect. Strict protocols were composed and abided by to minimize potential harm. These protocols were based on National Statement on Ethical Conduct in Human Research (National Health and Medical Research Council, 2007). Regular supervision meetings were held with my supervisors to ensure strict adherence to procedures and protocols developed.

The Melbourne Graduate School of Education: Human Ethics Advisory Group and the Human Research Ethics Committee approved a Standard Project Application. The Department of Education and Training also granted approval for this research to be conducted in a government school. These approval letters can be found in Appendix C. Fieldwork conducted in familiar institutions is inevitably subversive (van Maanen, 1991). Consent was provided from the principal who was supportive of this research, but not involved in participant recruitment. As a classroom teacher I was not assigned duties to manage other members of staff nor did I teach any of the student participants.

All participants, including parents for minors, were provided with PLSs and CFs, exemplified in Appendix D. These forms:

- Explained the project;
- Outlined the methods of data collection;

- Clarified processes of data storage and strategies for anonymity; and
- Explained possible risks of participation

Prior to any data collection, participants were reminded that their involvement in the research was voluntary and that they could withdraw at any time without consequence. Apart from peer-reviewed literature, pseudonyms have been used for the school, participants and others who informed this research. Audio-visual recordings for all participants were conducted in areas of the school or classroom set apart from non-participants to minimize potential recording of these members of the school community. When non-participants inadvertently entered the interview space, I stopped the line of questioning and did not transcribe these interruptions. All interview and focus group transcriptions were provided to the participants for their review.

During data collection, I tried to maintain an environment of collegiality. I implemented strategies intended to offer teachers a safe transition to teaching OOF with digital technologies. These included conducting professional learning workshops during faculty meetings, an accepted practice at Riverside. While collecting data in the classroom, I made efforts to disengage from my teacher professional duties by offering technology support and referred students to their teacher for content-related questions unless otherwise invited into the conversation. While student participants completed questionnaires during class, their non-participating peers engaged in other classroom activities.

I continually monitored my interactions with participants and regularly checked in with them to offer support on an as-needed basis. On one occasion, a participant became uncomfortable reflecting on a student's statement. As per the protocols developed, I reminded the participant s/he was not obliged to respond to the question. Drawing on my teacher identity, I sympathized with the participant and explained that some students in other classes expressed similar sentiments possibly feeling unsettled because students did not yet have a personal history collecting data with digital technologies. In the end the participant decided to reflect on the statement.

Finally, I scheduled data collection at times and in places convenient for participants. Taylor (2011) reminds insider-researchers that data collection can be

prolonged when participants and the researcher already have an established, intimate relationship. This was even reflected on by one participant as s/he was telling a story and made reference to how long it would take me to transcribe the interview. For teachers, story-telling seems to be a common reflective practice. During interviews and focus groups, I made a conscious effort to limit my own contributions to the conversation to enable my participants to reflect in this way while also monitoring the time to meet ethical protocols.

### 3.12 Conclusion

This chapter began by explaining the philosophical and methodological underpinnings of the research. Positioning theory (Harré & van Langenhove, 1999) was presented as the overarching philosophy and can be seen to be justified as a methodological approach through comparison to the well-known constructivist grounded theory (Charmaz, 2014) methodology. The research design was presented and the methods of data collection, analysis and triangulation were explained. This chapter closed by providing a framework to evaluate the research and presented the limitations and ethical considerations.

# Part II: Preparing to Teach Out-of-Field with Digital Technologies

# Chapter 4: Interpreting Riverside's Digital Technologies Curriculum and Teachers' Perceptions of their Digital Technology Use in Science

> *Suppose you came as an explorer to an unknown country with a language quite unknown to you. In what circumstances would you say that the people there gave orders, understood them, obeyed them, rebelled against them, and so on?*
>
> *- Wittgenstein (PI §206) (2009)*

## 4.1 Introduction

Chapter three provided a comparative analysis of positioning theory (Harré & van Langenhove, 1999) and grounded theory methodology (Charmaz, 2014) as justification for utilizing positioning theory as the overarching philosophy for the research. The positioning triad, shown in Figure 4.1, was explained because it offered a framework for a fine-grained analysis of the data. Constructivist grounded theory coding procedures, pronoun grammar analysis (Mühlhäusler & Harré, 1990; Redman, 2013a; Redman & Fawns, 2010) and cover, sacred and secret stories (Clandinin & Connelly, 1996) were shown to be analytical tools that could be used to better understand the extent to which teachers feel empowered to act autonomously.

This chapter now explains the Riverside digital technologies context and then exemplifies teachers' self-assessments of their digital technology use and the analytical tools to interpret them. This was the first step taken to plan for and offer support to out-of-field (OOF) geoscience teachers teaching with digital technologies. These teachers demonstrated varying levels of empowerment (Foucault et al., 1988) to use, produce and transform their lessons with digital technologies. Their subsequent reflections indicated and gave rise to categories along a continuum that ranged from utilizing digital technologies to mostly teach science content to teaching science inquiry skills. Unexpectedly, early-career teachers who trained as scientists were found to be placed at novice and apprentice levels of the continuum challenging a widely held assumption that scientific researchers can intuit their laboratory-based technology skills to teach for technology-enabled learning (Brantley-Dias & Ertmer, 2013; Ertmer & Ottenbreit-Leftwich, 2013).

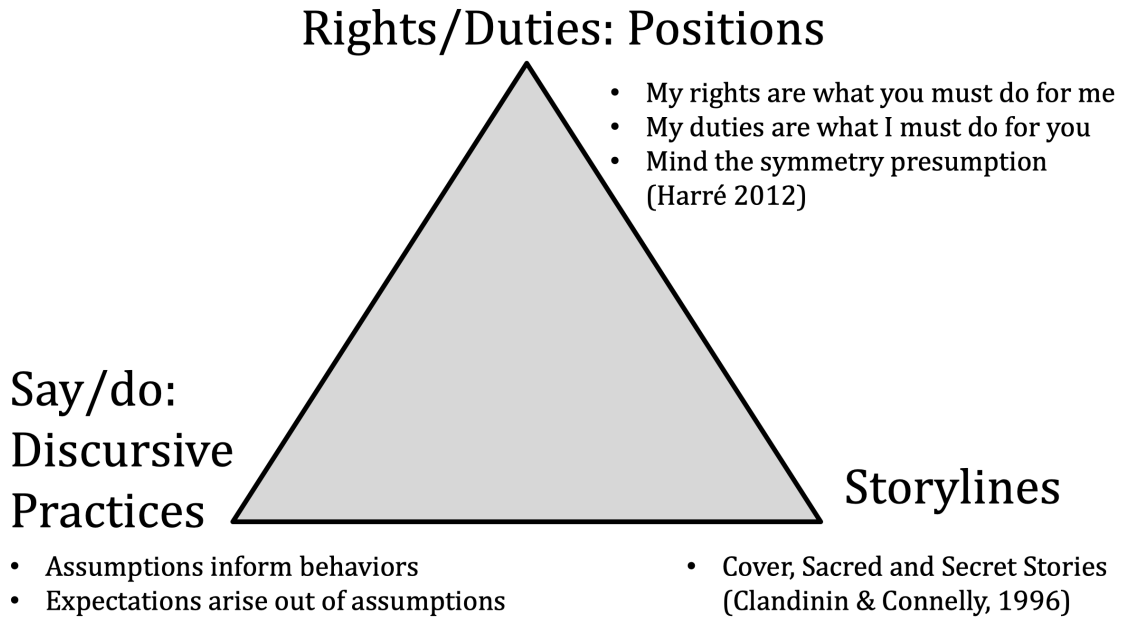



**Figure 4.1: The Positioning Triad, adapted from Harré and van Langenhove (1999)**

## 4.2 The Riverside Digital Technologies Context

Ertmer (1999) draws on the work of Brickner (1995) to describe strategies to circumvent first-order barriers to technology use in the classroom. External to teachers and affecting their choices and use of digital technologies, these barriers include access to computers and software, planning time and inadequate technical and administrative support. Almost 20 years later, access to computers and software is no longer a barrier at Riverside, yet exploring the types of devices students utilize through Riverside's Bring-Your-Own-Device (BYOD) Program offers a contemporary understanding of the external barriers these teachers continue to face when seeking to utilize technologies in their science classes.

### 4.2.1 Riverside's Bring-Your-Own-Device Program

By 2011, three years into the Australian government's Digital Education Revolution (DER) (DEEWR, 2008), introduced in chapter two, Riverside's stipend from the National Secondary Schools Computer Fund had been used to improve the wireless Internet infrastructure, install projectors and televisions in classrooms and equip all students in

years nine to 12 with Acer Aspire netbooks. Despite claims that the DER was 'a substantial program' (DEEWR, 2011, p. 17), as of 2013 the year 12 students' two-year-old netbooks were no longer fulfilling students' needs and there were no policies introducing strategies to end, update or replace the DER.

In response to the needs of students, Riverside's leadership team, the technology support staff and school council decided to launch a BYOD program. Rather than prescribe a specific device and to minimize the financial burden on families, Riverside students could use a laptop or tablet of their choice including personal or second-hand devices. A cover story, promoted to the wider school community, seemed to have emerged: ***We're a technologically-advanced school mindful of parents' financial burden***. At the same time, however, two classrooms equipped with enough desktop computers for 26 students still remained available for teachers to book and/or utilize for state-mandated standardized testing.

By 2016, the year nine students participating in this study had been using their own devices for a year and a half. Individuals outside the Riverside local moral order (Harré & van Langenhove, 1999) might assume that any difficulties with the BYOD program would have been addressed and resolved. Ultimately, classroom teachers were positioned as the gatekeepers to utilizing digital technologies with their students, but how did teachers assess the BYOD program for their teaching needs and contribution to students' learning?

### 4.2.2 Bring-Your-Own-Device: Reflections of Researchers Who Became Science Teachers

Interestingly, five of the 10 Riverside teacher participants worked in scientific research before pursuing a career in teaching. Eight years ago, when Mary was completing an honors degree researching fluorescent chemical compounds, secondary students working in her laboratory inspired Mary to enter a teacher training program instead of beginning doctoral studies. Ethan and Anthony were both in their second year of teaching. Prior to entering the teaching service Anthony worked in a pathology lab for six years and Ethan spent 10 years as a research scientist in immunology. Rachel was in her first year of teaching after contributing to a variety of research projects for 10 years studying traumatic brain injury, depression, cochlear implants and the bionic eye. William had served at

Riverside for 10 years after working in industry writing software and contributing to particle physics research. These teachers' experiences are summarized in Table 4.1.

**Table 4.1: The Experiences of Scientific Researchers Who Became Teachers**

| Participant | Teaching Experience (years) | Background |
|---|---|---|
| Rachel | 1 | 10 years contributing to research projects studying traumatic brain injury, depression, cochlear implants and the bionic eye |
| Anthony | 2 | 6 years working in a pathology laboratory |
| Ethan | 2 | 10 years as a research scientist in immunology |
| Mary | 7 | 1 year preparing for a doctoral program researching fluorescent chemical compounds |
| William | 10 | 10 years writing software and contributing to particle physics research |

Chapter two explained that technological knowledge is difficult to define. Koehler and Mishra (2009) suggest that it is closely related to Fluency of Information Technology (FITness) (National Research Council, 1999) where individuals:

> [...] 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 (p. 64).

Given these teachers' research experience in fields that depend on technological knowledge for the advancement of science, I deferred to them to reflect on the BYOD program and how it may have affected their perceptions of teaching science. With the exception of Mary, who did not directly refer to the BYOD program in our interviews, Anthony, Ethan and Rachel's *reflections* and my analyses of them are presented in Table 4.2. William's reflections seemed to be distinct from these early-career teachers and follow Table 4.2.

## Table 4.2: Analysis of Early-Career Teachers' Reflections on the BYOD Program

| *Teacher Reflection*<br>Analysis |
|---|
| *[W]hen you've got a BYOD school, like we do, um, it works but there are problems. Um, especially because 80% of the class has a Mac and you've got a PC. What you think will work on theirs [students' computers], like, I've given them links before that haven't worked on theirs and it's sort of-it breaks your lesson down because it's like: 'Well, I've planned for you to do that and you can't.' Um, and that brings in the whole issue of you have to go hire, um, book a lab, a computer lab [...]*<br><br>Anthony begins with a cover story that shifts to a secret story: ***The BYOD program works, but there are problems***. Anthony identifies professional duties (Harré & van Langenhove, 1999) to plan for digital technology use, but expresses frustration reflecting on the incompatibility between his government-issued school computer and students' devices. Some operating systems are not pre-set to enable web-based software to run properly. In addition, the affordances of some software were unavailable to students using tablets. To mediate the problem, Anthony assumes an additional professional duty to book a computer lab to ensure that all students have access to the resources. |
| *[M]aybe even in just a simple PowerPoint that I make, um, it may show up differently. If I make it on a Windows machine, it may show up differently on a Mac machine and just because certain words are-are-are slightly off position or graphics are slightly off position it could create a totally different meaning. [... W]ith these compatibility issues it might mean that they [students] come away with a totally incorrect understanding of what I'm trying to teach.*<br><br>Ethan identified similar frustrations to Anthony and an expectation to 'keep on top' of technologies that are compatible across devices, an understanding which might only surface during lessons. Here, Ethan reflects on conceptual difficulties students encounter due to formatting changes as files are accessed with different operating systems. Like his colleagues working within this local moral order, Ethan ascribes students duties to view PowerPoint presentations during class and to revise material. Although the technology appears to enable Ethan to attend to his professional duties in similar ways to his colleagues, a secret story emerges: ***The operating systems of the BYOD technology may prevent students from understanding content***. |
| *Yeah, well I just-I think we, like, the students need computers that are compatible with the things we wanna do and that work and that are charged and that they know how to use. [... I]f we were going to do a unit that is really computer intensive and technology intensive, everything has to work for that to really benefit everyone and not take up, you know, three quarters of the class, of every class, cannot be just troubleshooting.*<br><br>Rachel draws on the personal pronouns 'I' and 'we' to explain that teachers are the drivers for digital technology use. She ascribes students duties to ensure their computers are functional and expects them to be competent digital technology users. In the second half of the turn, Rachel asserts her rights (Harré & van Langenhove, 1999) as a classroom teacher explaining that developing a 'technology intensive' unit means using technology that 'works' and 'benefits everyone,' both teachers and students. Rachel's use of 'just' suggests uncertainty and may indicate a lack of professional history successfully utilizing digital technologies in the classroom. A secret story seems to emerge: ***Compatibility problems arising from the BYOD program waste classroom time and compromise implementing technologically-focused teaching and learning***. |

In Table 4.2 Anthony, Ethan and Rachel identified limitations of the BYOD program. Although these teachers assumed a professional duty to draw on their technological knowledge and utilize digital technologies in science, the distinct ways they attended to compatibility problems seemed to indicate a continuum of commitment to teach students digital skills. Instead of booking a computer lab, Anthony and Ethan could have taught students how to change settings on their computers to access the affordances of websites. Although Ethan used the classroom projector to present content with software that was incompatible with students' devices, converting these to .pdf documents and teaching students how to do this would have solved present and future compatibility problems. In her classroom, Rachel was observed to model troubleshooting, yet without a personal and professional history utilizing some digital technologies, she may have struggled to do so across the different devices present in any particular class.

Anthony, Ethan and Rachel were early-career teachers. Although they may have had the technological knowledge to produce (Foucault et al., 1988) lessons to teach digital skills, assuming a duty to do so may have been compromised as they sought to balance a range of other professional and administrative duties. William, an experienced teacher of 10 years, reflected on the pedagogical possibilities to teach science inquiry skills:

> *[A]ll-all smart phones have accelerometers on them, but they [students] don't know about this, so you have to actually physically tell them.*

For William, the BYOD program extends beyond students' use of personal computers and tablets. Using the qualifying word 'actually' William implies certainty that students are unaware of the scientific affordances of smart phones and he identifies a professional duty to develop this awareness. William also signals a personal commitment to teaching students science inquiry skills and has been observed scaffolding students' use of smart phones in physics experiments. Here a sacred story emerges: ***Students' personal devices can be harnessed to teach science inquiry***.

As both an experienced teacher and confident digital technology user, William was empowered to produce lessons with digital technologies to teach inquiry skills whereas his early-career colleagues seemed to struggle with manipulating digital technologies across devices. As such, a secret story emerges: ***Despite good intensions, the BYOD program may not provide equitable learning experiences for science students.***

## 4.3 The Enacted Curriculum and Teachers' Digital Technology Use

The expectations placed on Riverside teachers to utilize digital technologies not only arose from the implementation of the DER (DEEWR, 2011) and Riverside's strategy to maintain a one-to-one BYOD program. Chapter two explained the policy and state-mandated curricular environment placing professional expectations on science teachers to incorporate digital technologies in ways that not only reflect the realities of working in a networked society but also facilitate conceptual understanding and engage students in the epistemic practices of scientists. To better understand the extent to which Riverside teachers may have transferrable ideas about how to teach science with digital technologies, an analysis of teachers' perceptions of the enacted curriculum is necessary.

The remainder of this chapter draws on interview data from all 10 Riverside teachers. Mary, Ethan, Anthony, Rachel and William have been introduced, thus a brief introduction to the other participants is required. Charlotte, a junior science, senior biology and chemistry teacher, was in her 25$^{th}$ year of service having taught in Australia, Asia and the Middle East. In 2013, her first year at Riverside, Charlotte applied for and was assigned the role of Science Coordinator. Olivia held a variety of positions over 10 years at Riverside, including Science Coordinator and Year Level Leader, in addition to teaching junior science, senior chemistry and psychology. James had been Riverside's Sustainability Coordinator for 11 years while teaching junior science and senior biology. Isabelle had served at Riverside for 13 years teaching junior science, mathematics and senior chemistry. In 2016, she was appointed the role of Science Coordinator. Helena had experience teaching across rural and urban areas in Victoria until she came to Riverside 15 years ago as a junior science and senior psychology teacher. All 10 Riverside teachers' experiences are summarized in Table 4.3.

**Table 4.3: Summary of Riverside Teachers' Experience**

| Pseudonym | Teaching Experience* (years) | Background |
|---|---|---|
| Rachel | 1 | 10 years contributing to research projects studying traumatic brain injury, depression, cochlear implants and the bionic eye |
| Anthony | 2 | 6 years working in a pathology laboratory |
| Ethan | 2 | 10 years as a research scientist in immunology |
| Mary | 7 | 1 year preparing for a doctoral program researching fluorescent chemical compounds |
| William | 10 | 10 years writing software and contributing to particle physics research |
| James | 11 | 11 years as Riverside's Sustainability Coordinator |
| Olivia | 10+ | 10 years at Riverside, assumed the role of Science Coordinator in 2010; time teaching in Catholic schools |
| Isabelle | 13+ | 13 years at Riverside, assumed the role of Science Coordinator in 2016 |
| Helena | 15+ | 15 years at Riverside and experience teaching in rural and regional Victoria |
| Charlotte | 25 | Taught internationally, assumed the role of Science Coordinator in 2013 |

* The '+' sign indicates teachers had more experience than stated, but did not specify further

### 4.3.1 The Enacted Digital Technologies Curriculum: Cover and Secret Stories

Riverside science teachers were preparing for the implementation of the Victorian Curriculum (VCAA, 2016d) in 2017. Throughout her 15 years of service at Riverside, Helena had experienced a number of state-mandated curriculum changes including the Curriculum and Standards Framework II, the Victorian Essential Learning Standards and the Australian Curriculum. As such, I deferred to Helena's experience as a starting point to better understand Riverside's enacted digital technologies curriculum. Reflecting on the shift to the Victorian Curriculum, she explained:

> *I think it's just digital technologies-it's just-it's ICT [information and communication technology] under a different name, you know, we've had-we've meant to be doing this stuff for years and years. I don't, um, you know, I don't think we should be too scared by it*

*because a-a, you know, we-we do use digital technology but the question is: How well are we using it?*

In the beginning of the turn, Helena's use of 'just' seems to imply an ease to utilizing digital technologies in the classroom and is indicative of a cover story: ***We have a professional history using digital technologies in ways that are intended by the state-mandated curriculum***. Helena's tone, however, changes as she seeks to invite me, into the secret story using the phrase 'you know.' The shift between cover and secret story becomes evident with Helena's use of 'meant' and she finishes the turn by positioning (Harré & van Langenhove, 1999) herself with the right to speak on behalf of science teachers questioning how well digital technologies are used. As such a secret story emerges: ***Although digital technologies are used prevalently we may not be using them as well as expected***.

Helena's reflection draws attention to a distinction between *technology integration*, increasing teachers' and students' use of technology, and *technology-enabled learning*, placing emphasis on content-based pedagogy and digital tools to enhance students' learning (Brantley-Dias & Ertmer, 2013; Ertmer & Ottenbreit-Leftwich, 2013). Anthony, a second-year graduate teacher, had worked within the Riverside local moral order for less than a year. I deferred to him to better understand how the ICT general capability (ACARA, n.d.-b) was being formally implemented in science, if at all. Speaking on behalf of Riverside teachers Anthony reflected:

*Well I feel like it's up to each teacher at the moment, there's no real unified protocol [to utilize digital technologies]. We don't, as a science department, we don't have: 'Ok we're all gonna do this.' It's more so personal [to] each teacher.*

Anthony's explanation seems to indicate that he had no awareness of any type of formal induction to the accepted digital practices within the Riverside local moral order. Developing students' digital skills seemed to depend on teachers interpreting the learning outcomes from common assessment tasks and sense of oughtness (Linehan & McCarthy, 2000) to draw on their capacity to utilize digital technologies and assume a professional duty to teach them. Riverside's cover story: ***We're a technologically advanced school where teachers equip students with 21st century skills***, seems to be in tension with the secret story: ***Digital technologies are used inconsistently across classes***.

For Wittgenstein, understanding meaning is related to rule-following (Bailyn, 2002):

> A rule stands there like a signpost. […] And if there were not a single signpost, but a sequence of signposts or chalk marks on the ground – is there only *one* way for interpreting them? – So, I can say that the signpost does after all leave room for doubt. Or rather it sometimes leaves room for doubt and sometimes not (Wittgenstein, 2009, PI §85).

Bailyn (2002) explains that rules are 'ways of using a word that are sanctioned by other language users and render the word meaningful to those users' (p. 313). Defining what constitutes following the rules must be established before the community can assume, ascribe to or ignore them. To prepare for the Victorian Curriculum implementation, and possibly draw on feedback from teachers new to the Riverside local moral order, members of the leadership team assumed a professional duty to begin to define the expectations of digital technology use across learning areas.

### 4.3.2 Toward a Documented Digital Technologies Curriculum

Chapter two explained that the influence of state-mandated policy documents varies depending on workplace context and teachers' personal and pedagogical beliefs. Schools with an ICT policy, where teachers have participated in the planning process, use technology more regularly and in innovative ways (Kozma, 2003; Tondeur, van Keer, et al., 2008). In 2016, two months after the science faculty began planning to implement the Victorian Curriculum, the leadership team invited teachers to join a school-based eLearning Group to discuss a vision for digital technology use across all learning areas. The skills Riverside science teachers were tasked with teaching were prepared by members of the leadership team and are presented in Table 4.4.

**Table 4.4: Digital Technologies Curriculum for Science**

| |
|---|
| **ICT Basics**<br>• Saving and securing documents and files<br>• Printing/page layout/previewing<br>• File formats/use of .pdfs/converting formats |
| **Multimedia Presentation/Software**<br>• Creating presentations for different audiences<br>• Creating slide templates<br>• Understanding characteristics of good presentations<br>• Using hyperlinks and navigation buttons<br>• Incorporating multimedia into presentations |
| **Internet Use/eResources**<br>• Bookmarking regularly used/important websites<br>• Performing simple internet searches<br>• Referencing information from a website<br>• Using library electronic resources for research purposes |

Adapted from the Riverside Digital Technology Plan drafted in 2016

Preparing a draft of these skills prior to the meeting seemed to make the digital technologies curriculum (VCAA, 2016b) more accessible for teachers who may lack a personal and professional history utilizing digital technologies to the extent assumed within state-mandated curriculum documents. For example, the content description for levels nine and 10 of digital systems strand states:

> Investigate the role of hardware and software in managing, controlling and securing the movement of and access to data in networked digital systems (VCDTDS045)

This content description appears to be met in Table 4.4 as teachers address the 'ICT basics' across operating systems used within the BYOD program. Some of these skills, however, are reminiscent of the Curriculum and Standards Framework (VCAA, 2002) from over 20 years ago and are thus dated. In addition, teachers assuming professional duties to teach from this list may require further instruction about how to scaffold students' digital skill sets along a developmental continuum. For instance, differentiating between 'simple' and complex Internet searches and whether students should know how to manage and back up folders of bookmarks is unclear.

Content descriptions from both the Australian (ACARA, n.d.-a) and Victorian (VCAA, 2016d) curricula ascribe teachers the professional duties to incorporate digital

technologies in ways that develop students' subject-specific digital skills. Yet opportunities to develop cross-curricular skills seemed to be missing from the eLearning Group's discussions at this early stage of documentation. Despite the good intentions of the leadership team to ensure a productive meeting by interpreting curriculum documents and providing a list of skills to be taught, doing so seemed to compromise teachers' professionalism to interpret these documents and evaluate their current practices. Furthermore, for teachers with the capacity to act as border-crossers between subject specific learning areas and the digital technologies curriculum, this process may exclude connections they could make to build the personal and professional capacity of their colleagues teaching at this curricular intersection. Table 4.5 presents examples of these connections prepared for a geoscience unit of work at levels nine and 10 of the Victorian Curriculum.

**Table 4.5: Curricular Connections Between Digital Technologies and Geoscience**

| Digital Technologies Curriculum (VCAA, 2016g) Content Description | Example* |
|---|---|
| **Data and Information:** Develop techniques for acquiring, storing and validating quantitative and qualitative data from a range of sources, considering privacy and security requirements (VCDTDI047) | Students utilize Google Earth to collect qualitative and quantitative data about volcanos. Elevation profiles and observations enable them to hypothesize volcano type. Using overlays and place marks students store their data as .kmz files. Data are recorded and analyzed collaboratively using Google Docs and Google Sheets. Students use simulations and animations to validate or contradict their hypotheses. |
| **Data and Information:** Analyze and visualize data to create information and address complex problems, and model processes, entities and their relationships using structured data (VCDTDI048)<br><br>**Creating Digital Solutions:** Evaluate critically how well student-developed solutions and existing information systems and policies take account of future risks and sustainability and provide opportunities for innovation (VCDTCD054) | Students access and collect data about seismic activity from geological surveys online. Arrival times of seismic waves are plotted using Microsoft Excel to calculate lag time. Students reason whether computer models used by scientists should consider this information and evaluate how people living in earthquake-prone areas are affected by these models. |
| **Creating Digital Solutions:** Define and decompose real-world problems precisely, taking into account functional and non-functional requirements and including interviewing stakeholders to identify needs (VCDTCD050) | Students utilize Google Earth and .kmz files with overlays of geological maps in conjunction with online publications about past geological events to discuss appropriate places for human settlement. Students question and/or confirm their understandings by communicating with geoscientists over the Internet. |

* The proposed activities using .kmz files with Google Earth have been adapted from the Cyber-Enabled Earth Exploration curriculum (Almquist et al., 2012; Blank et al., 2016; Blank et al., 2012)

Helena and Anthony's experiences seemed to indicate tension between Riverside's cover story and the secret story of teachers' classroom experiences, yet developing a documented digital technologies curriculum for 2017 appeared to be a step to ameliorate inconsistent classroom practices. To contribute to this whole-school initiative and better understand individual experiences Riverside teachers' self-assessments of their digital technology use are now presented and analyzed.

### 4.3.3 Riverside Teachers' Self-Assessments of their Digital Technology Use in Science

Nineteen teachers attending the annual science education conference run by the Science Teachers' Association of Victoria (STAV) indicated that they use digital technologies in science either every day or a few times a week. Riverside science teachers are also frequent digital technology users and year nine student participants reported that digital technologies are used more in science than other subject areas. In this section, Riverside teachers' self-assessments of their digital technology use are exemplified and analyzed. Of note is that Charlotte, Rachel, Ethan and Isabelle participated in this research to a greater extent than others by teaching a year nine geoscience unit with digital technologies. Their experiences are analyzed extensively in chapters seven, eight, nine and 10 respectively.

Apart from school-mandated professional duties to use Compass, Riverside's attendance and learning management system, both teachers and students reported using a variety of digital technologies to facilitate science content understanding and inquiry. These are listed in Table 4.6. Personal meaning making maps and follow up interviews indicated that some digital technologies were utilized across all science classes. These included Microsoft PowerPoint and Excel, podcast and movie making software, videos, websites, simulations and smart phones. Although there is no shortage of digital technology use, teachers' pedagogical choices to employ some digital technologies in preference to others may be indicative of the extent to which their personal agency is strengthened toward engaging students in technology-enabled learning.

**Table 4.6: Student and Teachers' Reported Use of Digital Technologies in Science**

| | Digital Technology | Teachers' Use | Students' Use |
|---|---|---|---|
| Science Content Understanding | Online 'educational' games | | • Reinforce understanding |
| | Microsoft PowerPoint | • Present and explain content | • Take notes and revise<br>• Present assessment tasks demonstrating content knowledge |
| | Podcast and movie making software | | • Present assessment tasks demonstrating content knowledge |
| | Online Quiz software | • Design quizzes for introduction/revision<br>• Teach concepts through dialogic instruction (Alexander, 2006) | • Engage with and revise content<br>• Develop conceptual understanding |
| | Videos | • Present and explain content<br>• Question students' alternative conceptions | • Engage with and revise content<br>• Understand different representations of content<br>• Identify and question alternative conceptions |
| | Websites | • Present and explain content<br>• Respond to students' questions | • Read and take notes<br>• Research for assessment tasks and personal questions |
| Science Inquiry | Applications and simulations | • Connect students to citizen science projects<br>• Model scientific phenomena | • Connect to citizen science projects<br>• Perform virtual experiments and collect data |
| | Data loggers | • Model scientific practices<br>• Collect experimental data | • Collect experimental data |
| | Flexible cameras | • Perform demonstrations | |
| | Microsoft Excel | • Demonstrate data analysis | • Analyze primary and secondary data |
| | Smart Phones | • Model scientific practices<br>• Collect experimental data | • Time experiments<br>• Collect experimental data |

Isabelle, Olivia, Ethan and Anthony seemed to produce lessons that mostly enabled students to be presented with, practice and demonstrate content knowledge. Some digital technologies they utilized included online 'educational games' from a variety of companies and organizations, Socrative and Kahoot! quiz software and videos explaining scientific phenomena. Although these teachers seemed to draw on similar digital technologies for comparable pedagogical practices, their personal and professional histories with digital technologies seemed to be distinct. As such Table 4.7 exemplifies and analyzes Isabelle and Olivia's self-assessments of their digital technology use, while Ethan and Anthony's self-assessments and analyses are presented in Table 4.8.

**Table 4.7: Isabelle and Olivia's Assessments of their Digital Technology Use**

| *Teacher Reflection*<br>Analysis |
|---|
| *Even for, um, chemistry, um, modelling the periodic table, there's different activities. I can't remember 'em off the top of my head but I've got a whole heap of them that I use and, um, putting compounds together and there's different websites that, yeah.*<br><br>Isabelle has interpreted sign systems (Foucault et al., 1988), the social interactions between teachers, to draw on a trusted resource, the textbook, to utilize interactive software produced by publishers. She positions herself as a chemistry specialist, emphasizing that there are 'even' activities modelling the periodic table and formation of compounds. Although she assumes a professional duty to use digital technologies, Isabelle struggles to articulate how they develop students' science understanding beyond 'emphasizing points.' As such, her self-assessment seems to reflect a cover story: ***Teachers at this school regularly utilize digital technologies***. |
| *I don't use them [data loggers] very much, um, and I'm not all that excited about them. [A]nd sometimes they mess up, they don't work. [A]nd the whole thing's, m-um, the whole lesson's wrecked.*<br><br>Responding to social signs within the local moral order, Olivia has explored using Riverside's data loggers in some of her classes. Here, she defers to her professional duty to assess the value of digital technologies and right to choose whether or not to use them in her classes. Olivia positions the data loggers themselves as barriers to technology-enabled learning because she perceives them to compromise her lessons. Olivia's lack of personal history with the data loggers, however, seems to indicate tension between the sacred and secret stories: ***I see others using data loggers to promote technology-enabled learning, but I'm not sure how they work.*** |

**Table 4.8: Ethan and Anthony's Assessments of their Digital Technology Use**

| *Teacher Reflection*<br>Analysis |
|---|
| *Well, I think, uh, Microsoft Office would be one and to quite a high detail, so things like format-knowing how to format documents, creating charts, adding labels, how to use, um, PowerPoint properly. Um, uh, they [students]-I think they need to know how to use Google properly [...T]here's a digital literacy if you like. And maybe that needs to be formally taught as well.*<br><br>By explaining the digital skills he expects students to be familiar with, Ethan shares his own technological knowledge and indicates that he is able to proficiently manipulate (Foucault et al., 1988) digital technologies. Digital literacy is an important component to completing school work and although Ethan attends to a professional duty to integrate these technologies in his classes, the final sentence of the turn suggests that he may not assume a professional duty to teach digital literacy. A secret story emerges: ***I'm a teacher of science, not digital skills***. |
| *I want kids to come to science and at least be excited to come to science. I don't want science just to be a lesson of notes, notes and talking and notes and walk out of there and memorize this and that's it. I want them to be-actually come to science and, you know, use their creative side in movie making or have a bit of a play on a game which they hopefully will learn something out of or, you know, do a Kahoots and have a bit of a, um, competition among the class, you know, who's gonna come first and all that.*<br><br>Anthony is driven to utilize digital technologies to engage his students. He draws on his personal capacity to manipulate them and uses 'actually' to indicate a personal commitment to attend to students' rights to be creative and have fun. However, this seems to be a cover story in tension with the sacred story, the theory-driven view of practice. Despite Anthony's intensions for students to be engaged, he seems unsure of the value these technologies bring when he says 'hopefully [students] will learn something.' A secret story emerges: ***I'm integrating digital technologies in my classes, but I'm unsure whether students are learning.*** |

Overall, Isabelle, Olivia, Ethan and Anthony integrated digital technologies into their lessons promoting Riverside's cover story: ***At this school, we regularly utilize digital technologies***. The secret stories emerging, however, seem to indicate that these teachers require support to develop a personal and professional history with successful digital technology use in the classroom to scaffold students' skill sets.

Apart from gathering and analyzing data with smart phones and Microsoft Excel, accepted practices within the local moral order, Charlotte, James and William seemed to feel a sense of oughtness to explore the interplay between technology use and teaching science inquiry. These teachers were empowered to utilize technologies such as data loggers and simulations to collect and analyze data in addition to video developing students' science communication and conceptual understanding. Table 4.9 exemplifies

Charlotte, James and William's self-assessments of their digital technology use alongside the analyses.

**Table 4.9: Charlotte, James and William's Assessments of their Digital Technology Use**

| *Teacher Reflection*<br>Analysis |
|---|
| *When you're in a science classroom, it's more about designing experiments and knowing how to. So, I'm always concerned about teaching the kids how you design an experiment well so that the data you gather is meaningful. And these are the things that we have to take care with [...] I think that we-we like to, um, you know, keep abreast of what the new frontiers are. Digital technology is the latest new frontier.*<br><br>Charlotte draws on the pronoun 'I,' to explain a personal professional duty she accepts as part of her regular practice: Teaching students how to design experiments and the skills to collect meaningful data. Speaking on behalf of teachers, Charlotte positions them with this duty in addition to keeping up-to-date with the latest technological developments. Charlotte is empowered to utilize data loggers and simulations to not only produce but transform lessons where students regularly practice the digital skills needed to collect and analyze data. The sacred story emerging seems to be: ***I'm a competent digital technology user scaffolding students to develop digital skills when planning for and carrying out experiments***. |
| *Um, and so there are just fantastic virt-virtual, sorry, animations that show, you know, sea level rise and moving of continents and that sort of thing that just brings to life, you know, and connects things that students are familiar with like a current day coastline to previous things. And, um, so, I think digital visualizations are-are really helpful in that regard.*<br><br>Like his colleagues, James was driven to use digital technologies to 'engage' students, but unlike some of them, he seemed empowered to selectively produce lessons with them. James attended to students' rights to be engaged while assuming a professional duty to use digital technologies to achieve clearly defined pedagogical goals. Here, he explains how Sahul Time, an animation produced by Monash University, enables him to facilitate connecting students' current understanding of local coastlines to rising sea levels. As such a sacred story emerges: ***I use digital technologies to achieve pedagogical goals that might be impossible without them.*** |
| *I-I probably don't use stuff [digital technologies] that I don't think should be there. [...] Um, the ability to go into concepts, um, and I'm always on the lookout for things that can-kids can do at home as well, not just in the classroom.*<br><br>William asserts a right to choose the digital technologies he uses through a sense of oughtness to evaluate their added value. William is driven to use digital technologies that enable him to teach conceptual understanding both within and beyond the classroom. His technological pedagogical content knowledge (Koehler & Mishra, 2009) seems to empower him to seek out and employ digital technologies in pedagogically distinct ways. As such, William uses technologies like Socrative online quiz software and video, but does so through dialogic instruction (Alexander, 2006). A sacred story emerges: ***I'm selective about which technologies to use, they must add value to lessons in ways that promote conceptual change.*** |

Charlotte, James and William's self-assessments of their digital technology use differed from Isabelle, Olivia, Ethan and Anthony's. Although these teachers may have explored similar digital technologies in their classrooms, Charlotte, James and William's self-assessments seemed to reflect more of the goals of the intended curriculum and promote the sacred story: ***Students use digital technologies to engage in the epistemic practices of scientists***.

Both groups of teachers discussed thus far seem to sit at opposite ends of a continuum ranging from technology integration to technology-enabled learning. Helena, Mary and Rachel's use of digital technologies, however seemed to rest at the intersection between developing students' content knowledge and science inquiry skills. Their self-assessments and analyses are presented in Table 4.10.

## Table 4.10: Rachel, Helena and Mary's Assessments of their Digital Technology Use

| *Teacher Reflection*<br>Analysis |
|---|
| *[You] can't do it just for the sake of incorporating [technology], [...] how is it going to enhance what they're [students] already doing anyway? [... S]o we did some-I had to do some online research and I said: 'Ok, so websites that have-usually websites with, like, .edu, .gov, .org are usually more reliable than ones with just .com or .co.uk' or something like that. So, and that was just a starting point to go: 'Well, that's a more reliable website. Does it come from an organization? Does it come from the RSPCA? Or is it just coming from some Pete's Animal Farm,' you know [...]*<br><br>Rachel is a proficient digital technology user, drawing on the affordances of her personal device in addition to her government-issued computer. She explains her professional duty to selectively utilize digital technologies to enhance lessons. Rachel continues by explaining how she deviates from the lesson plan to attend to students' queries. She is empowered to seize this opportunity to discuss and model the critical thinking skills required to conduct effective Internet searches. Other reflections, however, seem to indicate that Rachel may struggle to do this with technologies she has not personally explored. As such, her sacred and secret stories seem to be in tension: ***I'm able to teach students digital skills with some technologies, but I struggle to integrate others even though they may add value***. |
| *I do-I-I feel that it's part of my job to-to, you know, to assist with that process [teaching digital skills], but I don't always feel that, um, I'm very proficient in it myself. You know, I feel quite, um, inadequate sometimes [... Y]ou kn-I'll use-I'll use it if it's-if I think it's going to support, um, support what I've-what I've said prior, um, or if it's going to compliment what I'm saying at the time.*<br><br>Helena began this turn by explaining the wider community's expectations of teachers to prepare students for the workforce. Although she feels a sense of outghness to attend to this professional duty, her capacity to utilize digital technologies seems to prevent her from doing so with confidence. Sharing deflating beliefs (Rokeach, 1968) about self, her moments of hesitation and use of paraverbals indicate a lack of personal history utilizing digital technologies. Helena's secret story seems to be: ***I need support to develop my own digital skills***.<br><br>In the second part of the turn, Helena explains that she is driven to utilize digital technologies when they support or compliment instruction. At the same time, however, she draws on social signs (Foucault et al., 1988) through assistance from some of her colleagues to learn how to manipulate previously unexplored technologies. Without this assistance, however, the sacred story, ***I use digital technologies that support my content delivery***, seems disconnected from teaching students digital skills. |
| *[M]aybe I'm not u-I-I'm not facilitating its use to the potential that it could have the best outcome for the child. I think that sometimes it's easy for you to use something and then it's not really tapping into their higher-order thinking [...]*<br><br>Mary identifies a professional duty to facilitate digital technology use such that students engage in higher-order thinking. Mary attends to the social signs of the local moral order to utilize previously unexplored technologies and she seems confident to be able to manipulate them. Mary's perceptions about her ability to facilitate digital technology use and higher-order thinking, however, may constrict her capacity to integrate digital technologies in ways that foster technology-enabled learning. As such there seems to be tension between the sacred and secret stories: ***I have a duty to facilitate digital technology use for higher-order thinking. I'm interested in doing this but I need help***. |

Rachel, Helena and Mary all expressed professional duties to utilize digital technologies with pedagogical purpose, yet their capacity to translate these duties into practice may have prevented them from producing lessons to support technology-enabled learning. These teachers seemed to require support to develop their design thinking skills, what Tsai and Chai (2012) describe as a third-order barrier to technology use, and explore pedagogical opportunities with technologies they did not yet have a personal history using. Thus, their experiences seemed to occupy a liminal space between the sacred and secret stories. This is the space between the intended use of digital technologies, promoted by theoreticians, policy makers and some Riverside colleagues, and teachers' personal capacity to attend to these duties: ***We want to explore pedagogical uses of digital technologies and teach students digital skills, but we need support to do so***.

### 4.4 A Continuum of Riverside Science Teachers' Digital Technology Use

To varying extents, Riverside science teachers assumed professional duties to utilize digital technologies and teach students' digital skills. Despite working within a technology-rich school, however, these teachers continued to face barriers that compromised effective digital technology use, including a lack of technical support to navigate BYOD compatibility problems, insufficient personal and professional history and concerns about the interplay between technology use and best practice. As Riverside teachers' self-assessments were analyzed and compared, the initial codes (Charmaz, 2014) of their self-identified rights and duties (Harré & van Langenhove, 1999) and the emergent cover, sacred and secret stories were raised to focused codes that seemed to reflect categories along a continuum of digital technology use. Figure 4.2 illustrates this continuum from technology integration to technology-enabled learning.

Charlotte, James and William were considered expert users. Rachel, Helena and Mary were placed at the apprentice level. Ethan and Anthony were novice II users and Isabelle and Olivia were novice I users. Of note is that teachers were not presumed to sit discretely within these boundaries. For instance, those placed in the novice I category struggled to identify some digital skills to teach students but did assume a professional duty to do so when expectations from the local moral order provided the social signs and support mechanisms. These categories, grounded in teachers' self-assessments at this time

and place, guided me to plan for teaching experiences with both un-/familiar technologies and anticipate areas where support may be required as these teachers took risks teaching an out-of-field area of science drawing on a range of digital technologies.

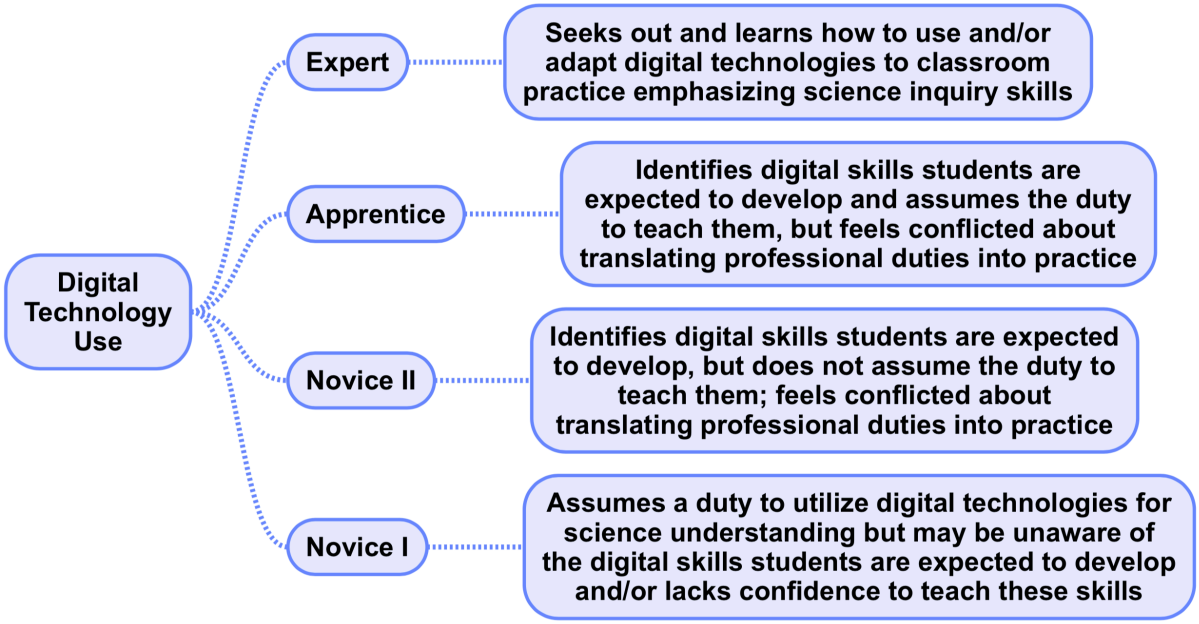



**Figure 4.2: Continuum of Digital Technology Use**

## 4.5 Conclusion

Drawing on Bandura (1989), Tschannen-Moran et al. (2014) remind us that members of the school community evaluate themselves and others based on the normative conditions they encounter on a daily basis. This chapter introduced the Riverside digital technologies curricular context and exemplified the analytical tools used to interpret teachers' self-assessments of their digital technology use.

The work of Ertmer (1999) and Brickner (1995) describing first- and second-order barriers is still relevant. For these teachers, external barriers to effective technology integration came from BYOD compatibility problems, a lack of technical support and shared vision for digital technology use within the school. Internal barriers included a lack of personal and professional history with some digital technologies which may compromise enhancing beliefs (Rokeach, 1968) about self and one's capacity to use and teach with

them. In addition, teachers' expressed concerns about the interplay between technology use and best practice.

A continuum of digital technology use grounded in Riverside teachers' self-assessments was produced to respond to the first subsidiary question: How do secondary science teachers self-assess their uses of digital technologies in the classroom? Teachers were grouped into categories from *technology integration*, mostly teaching science content, toward *technology-enabled learning*, using technology to teach science inquiry skills. These categories include novice, apprentice and expert teachers *with* and *of* digital technologies. Unexpectedly, early-career teachers who trained as scientists were found to be placed at all levels along the continuum challenging an assumption that scientific researchers may not intuitively draw on their transferrable skills to teach for technology-enabled learning.

# Chapter 5: Interpreting Riverside's Geoscience Curriculum and Teachers' Perceptions of their Capacity to Teach Out-of-Field with Digital Technologies

> *It is not [...] simply by seeing the concretion of mineral bodies that a philosopher is to be gratified in his intellectual pursuit, but by the contemplation of that system in which the necessary resolution of this earth, while at present it serves the purpose of vegetation, or the fertility of our soil, is the very means employed in furnishing the materials of future land.*
>
> *- Hutton (1795, p. 309)*

## 5.1 Introduction

Chapter four introduced the Riverside context and exemplified and discussed a complex analysis of teachers' self-assessments of their digital technology use. Teachers could then be placed along a continuum of categories ranging from utilizing digital technologies to mostly teach science content to teaching science inquiry skills. Unexpectedly, early-career teachers who trained as scientists were found to be placed at novice and apprentice levels of the continuum. This was the first step taken to plan for and offer support to out-of-field (OOF) geoscience teachers teaching with digital technologies.

This chapter analyzes Riverside's curriculum development process, documentation and teachers' perceptions of their personal history teaching geoscience. Geoscience is defined as the study of the solid Earth including the structures and processes acting on them (King, 2008). Despite attending to some of the expectations in the Australian Curriculum (ACARA, n.d.-c), these teachers seemed to require support to develop students' higher-order thinking and science inquiry skills with a connection to digital technologies. Surprisingly most teachers did not seem to readily identify that their existing digital practices were transferrable to the teaching of geoscience. The secret and sacred stories (Clandinin & Connelly, 1996) emerging from teachers' perceptions of the possibilities for empowerment (Foucault et al., 1988) enacting transferrable digital practices in an OOF area were raised to focused codes (Charmaz, 2014) that indicated categories along a continuum of awareness for digital technology use.

## 5.2 The Riverside Geoscience Context

In August 2016, on a pupil-free day for professional learning, Riverside teachers were meeting to prepare for the implementation of the Victorian Curriculum in the following year. The Victorian Curriculum (VCAA, 2015d) for science is organized into two strands further divided into sub-strands, shown in Table 5.1. Unlike the Australian Curriculum (ACARA, n.d.-c) which is structured across years of schooling, the Victorian Curriculum is organized across levels of learning where:

> [T]he curriculum is used to plan in relation to the actual learning level of each student rather than their assumed level of learning based on age (VCAA, 2015c).

**Table 5.1: Structure of the Victorian Curriculum for Science (VCAA, 2015a)**

| Strands | Science Understanding | Science Inquiry Skills |
|---|---|---|
| **Sub-strands** | Science as a human endeavor | Questioning and predicting |
| | Biological sciences | Planning and conducting |
| | Chemical sciences | Recording and processing |
| | Earth and space sciences | Analyzing and evaluating |
| | Physical sciences | Communicating |

These structural changes did not seem to be significant points of discussion for Riverside science teachers as they accounted for the placement of the science understanding content descriptions for each sub-discipline of science. The science as a human endeavor sub-strand and the science inquiry skills strand were not discussed at this stage of planning, indicating the emergence of a secret story: ***These teachers may perceive the science curriculum to comprise of the science understanding strand, specifically the content descriptions of the four sub-disciplines of science.***

Content descriptions for the Earth and space sciences are shown in Table 5.2. When the discussion turned to the placement of those related to geoscience, teachers decided that the rocks and minerals unit, first introduced in 2014, would continue to be taught in year eight. Plate tectonics and continental drift would be taught in year nine. At Riverside, year 10 science consisted of four electives without a focus on space science thus, at the expense

of time, teachers decided to teach the Universe at year nine as well. Teaching geoscience topics inconsistently and to varying extents across years seven to nine was not unique to Riverside, Science Teachers' Association of Victoria (STAV) conference attendees reported similar experiences. The sacred story, ***we must ensure to address all sub-disciplines of science***, seemed to be in tension with the secret story, ***we favor some sub-disciplines over others***.

**Table 5.2: Content Descriptions for the Earth and Space Sciences Sub-Strand of the Victorian Curriculum (VCAA, 2015d)**

| Levels | Content Descriptions |
|---|---|
| **7-8** | Predictable phenomena on Earth, including seasons and eclipses, are caused by the relative positions of the Sun, Earth and the Moon (VCSSU099)<br><br>Some of Earth's resources are renewable, but others are non-renewable (VCSSU100)<br><br>Water is an important resource that cycles through the environment (VCSSU101)<br><br>Sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales (VCSSU102) |
| **9-10** | The theory of plate tectonics explains global patterns of geological activity and continental movement (VCSSU127)<br><br>Global systems, including the carbon cycle, rely on interactions involving the atmosphere, biosphere, hydrosphere and lithosphere (VCSSU128)<br><br>The Universe contains features including galaxies, stars and solar systems; the Big Bang theory can be used to explain the origin of the Universe (VCSSU129) |

### 5.2.1 Curriculum Change: Helena and Olivia's Perspectives of Geoscience at Riverside

I am an insider-researcher (Mercer, 2007) and although I completed my teacher training in the Australian state of Victoria, I attended secondary school in Ontario, Canada. Noting curriculum variances, I wondered why biology, chemistry and physics seem to be prioritized. This section reviews how past curriculum practices may have influenced and served to justify present curricular decisions.

Helena had adapted to multiple state-mandated curriculum changes throughout 15 years of service at Riverside. In chapter four her reflections initiated the analysis of the

enacted digital technologies curriculum. Here I defer to her experience again to better understand past geoscience curriculum practices. Helena reflected:

> *I think, um, it's [geoscience] always been bumped. You know? Like, it's just-it's-it's always been tacked on at the end of the year because I think teachers were-saw it as being boring and being dry because: 'Oh, we're talking about rocks and things, so they're dry objects.' So, you know, I think-I think there's that sort of, (sighs) um, a-you know, because they're not-because rocks and soils are maybe not living things?*

With 'you know,' Helena invited me into the professional conversation about accepted practices within this local moral order (Harré & van Langenhove, 1999). Although teachers seemed to have a sense of outghtness (Linehan & McCarthy, 2000) to address all state-mandated sub-disciplines of science, they asserted professional and personal rights to choose when and to what extent topics were addressed.

Helena continued her reflection, yet lowered her voice when she explained:

> *[...] Um, and also possibly they felt that there wasn't enough resources out there. That it wasn't su-adequately supported. And-and I also think that it's has to do with teachers' level of expertise on top of it [...] So, it just goes to, you know, to part of-quite-can-it has been in the past a really-really powerful determinant of the curriculum in the school is what the teachers feel comfortable and safe teaching.*

Helena's shift in tone and use of paraverbals seemed to indicate that the beginning of the turn was a cover story (Clandinin & Connelly, 1996): ***Geoscience is boring so teachers spend less time teaching it***. In this part of the turn, she appeals to teachers' rights to be adequately resourced to teach topics for which they seem to lack expertise. Without this support, teachers' sense of empowerment to produce rigorous geoscience lessons is compromised. A sacred story appears to be in tension with a secret story: ***We have a duty to teach state-mandated sub-disciplines of science, yet the depth of the enacted curriculum is driven by teachers' perceptions of their capacity to do so and their students' potential interest.***

Helena's reflections were similar to her colleague Olivia who, over 10 years, was not only a classroom teacher but also a member of multiple leadership teams. In 2010, Olivia served as Science Coordinator. From 2011 to 2016, Olivia attended to other leadership duties, yet she seemed to feel a sense of oughtness to support five different colleagues assuming the professional duties of Science Coordinator over this time. As such, I deferred to Olivia to triangulate Helena's reflection. Olivia explained:

*[Geoscience] didn't have much.. of a, um, presence. [W]hether that's because it wasn't part of the curriculum, um, dep-um, well, I can't remember seeing much of it.*

Olivia's reflection indicated that Riverside teachers assume a professional duty to attend to state-mandated curriculum documents that seem to offer sign systems (Foucault et al., 1988) informing their teaching. She reflected on the Victorian Essential Learning Standards (VELS) the curriculum framework preceding the Australian Curriculum. According to the VELS, students should be able to 'use timescales to explain the changing Earth' and 'physical and theoretical models to investigate geological processes' (VCAA, n.d.-b). Lacking specificity, these achievement standards seemed to compromise teachers' ability to produce units with specific learning outcomes. For instance, OOF geoscience teachers may have required additional support to identify the timescales and geological processes they were expected to teach. Again, the sacred and secret stories seem to be in tension: ***We use state-mandated curriculum documents to inform our teaching, but without clarity we struggle to enact abstract expectations***.

In 2013, the VELS was superseded by the Australian Curriculum in Victoria (AusVELS) (ACARA, n.d.-c) with more specific achievement standards (VCAA, n.d.-a; VCAA, n.d.-b). At this time Riverside staff began discussing how to better document the enacted curriculum.

### 5.2.2 Toward a Documented Geoscience Curriculum

The initiative to formally document the enacted curriculum began in 2014 with the implementation of the Australian Curriculum. In science, units of work from years seven to 10 were equally divided between teachers who were responsible for entering information into a curriculum mapping software. For the first time a geoscience curriculum would become visible to all staff. Figure 5.1 presents this documentation for the year nine geoscience unit of work and Table 5.3 unpacks the AusVELS (ACARA, n.d.-d) content descriptions.

<table>
<tr><td colspan="2"><u>Unit Description</u><br><br>Over four weeks, students will understand the stages in the formation of igneous, metamorphic and sedimentary rocks and identify rocks based on their physical and chemical characteristics. They will understand that rocks are a collection of different minerals and that minerals and ores provide different resources. Students will understand that Earth is made up of different plates and recognize major plates on a world map to relate the occurrence of earthquakes and volcanic activity to constructive and destructive plate boundaries. They will understand the role of heat energy and convection currents in the movement of tectonic plates and relate the extreme age and stability of a large part of the Australian continent to its tectonic plate history.<br><br><u>Essential Questions</u><br><br>1. Is science useful to predict the future?<br>2. What do we know? How do we know it?<br>3. What is good evidence? What is bad evidence?<br>4. Why is science always changing?</td><td><u>AusVELS Standards</u><br><br>• ACSSU153<br>• ACSSU180<br>• ACSIS174<br>• ACSHE157<br>• ACSHE158<br>• ACSHE160</td></tr>
<tr><td colspan="2"><u>Knowledge, Understanding, Content and Skills</u> Students will be able to:<br><br>Identify rocks based on their physical and chemical characteristics<br><br>Recognize<br>• that rocks are a collection of different minerals and that rocks, minerals and ores provide valuable resources<br>• Earth’s major plates on a map<br><br>Relate<br>• the occurrence of earthquakes and volcanic activity to constructive and destructive plate boundaries<br>• the extreme age and stability of a large part of the Australian continent to its plate tectonic history<br><br>Represent the stages in the formation of igneous, metamorphic and sedimentary rocks based on their physical and chemical characteristics<br><br>Model seafloor spreading<br><br>Consider the role of heat energy and convection currents in the movement of tectonic plates</td></tr>
<tr><td colspan="2"><u>Assessment Evidence</u><br><br>1. Written test<br>2. Practical test: Identification of rocks and minerals</td></tr>
<tr><td colspan="2"><u>Learning Activities</u> Various worksheets and activities</td></tr>
<tr><td colspan="2"><u>General Capabilities</u> No connection to the AusVels General Capabilities</td></tr>
</table>

**Figure 5.1: Year Nine Geoscience Curriculum Documentation in 2014**

**Table 5.3: AusVELS Content Descriptions for Year Nine Geoscience (ACARA, n.d.-d)**

| **Science Understanding** |
|---|
| **Earth and Space Sciences**<br>Sedimentary, igneous, and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales (ACSSU153)<br><br>The theory of plate tectonics explains global patterns of geological activity and continental movement (ACSSU180) |
| **Science Inquiry Skills** |
| **Communicating**<br>Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS174) |
| **Science as a Human Endeavor** |
| **Nature and Development of Science**<br>Scientific understanding, including models and theories, is contestable and is refined over time through a process of review by the scientific community (ACSHE157)<br><br>Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries (ACSHE158)<br><br>**Use and Influence of Science**<br>People use scientific knowledge to evaluate whether they accept claims, explanations or predictions, and advances in science can affect people's lives, including generating new career opportunities (ACSHE160) |

Riverside has a prestigious reputation in the local community, the media repeatedly defer to the leadership team to reflect on current issues in education because this government school is acknowledged to hold high standards for students' academic performance and teacher professionalism. Documenting the enacted curriculum in this way positioned (Harré & van Langenhove, 1999) teachers with the professional duty to enact consistent curricular goals across classes, but I wondered whether this initiative strengthened teachers' capacity to teach geoscience.

## 5.3 Assessing the Enacted Geoscience Curriculum through Three Perspectives

State-mandated curriculum suggests conventions and expectations for what constitutes acceptable teaching practice, yet policy is understood to be transformed through the enacted curriculum (Eisner, 2002). To better understand how these teachers might be supported to deliver a geoscience unit of work this section assesses the year nine

Riverside geoscience curriculum document shown in Figure 5.1 through three perspectives:

1. A Riverside science teacher's perspective;
2. A Bloom's Revised Taxonomy (Krathwohl, 2002) perspective; and
3. An in-field geoscience curriculum planning perspective

To ensure that the following analysis aligned with an in-field geoscientific educational perspective, this section, first authored by me as an OOF geoscience teacher, was member checked by a geoscience university lecturer with 20 years' experience teaching secondary schools.

### 5.3.1 A Riverside Science Teacher's Perspective

In 2015, a year after formal curriculum documentation began, Riverside teachers were tasked with reviewing their colleagues' work to evaluate the ease with which educators new to the school or year level would be able to deliver the curriculum. Measures were put in place to ensure that teachers responsible for the original documentation would not assess their own work. Figure 5.2 presents the outcome of this evaluation process for year nine geoscience.

| | |
|---|---|
| Q 1: **For this unit, please complete the following rating scale.** | |
| The unit description explains what this unit is about clearly and in detail | Strongly agree |
| This unit... | |
| • contains links to AusVELS standards that cover all areas of the unit | Strongly agree |
| • lists ALL the knowledge and content that students will learn | Strongly agree |
| • lists the skills that a student should develop | Strongly agree |
| • includes a clear sequence of learning activities | Strongly agree |
| • contains at least one assessment task which assesses the skills and knowledge listed | Strongly agree |
| • includes a quality assessment rubric for the assessment task | Disagree |
| • lists some general capabilities that students will develop | Disagree |
| • lists how less/more able students will be assisted/extended in their learning | Disagree |
| Q 2: **Do you have any comments about this unit?** Needs test marking scheme and rock identification rubric. | |

**Figure 5.2: Evaluation of the 2014 Year Nine Geoscience Curriculum Documentation**

Although the document shown in Figure 5.1 appeared to have successfully met most of the requirements set by the leadership team, this assessment indicated that state-mandated general capabilities (ACARA, n.d.-e) had not been incorporated into the enacted curriculum. In addition, a recent leadership initiative promoting differentiated instruction had not been met and, like Helena, this assessor identified a professional right (Harré & van Langenhove, 1999) for teachers to be better supported with resources to strengthen their assessment practices. Riverside's cover story promoted to the wider community, ***we maintain high standards for students' performance and teacher professionalism through curriculum documentation***, seemed to erode.

### 5.3.2 A Bloom's Revised Taxonomy Perspective

The previous section seemed to indicate that Riverside teachers required support attending to the sacred story. To better understand the context within which this support could be provided, Bloom's Revised Taxonomy serves as a useful framework to compare the thinking skills teachers were positioned to teach and the extent to which these duties may have been assumed. Table 5.4 summarizes the language from both the AusVELS and teachers' interpretations of this state-mandated curriculum as articulated in the knowledge, understanding, content and skills section in Figure 5.1.

**Table 5.4: Thinking Skills and Teachers' Interpretations of the AusVELS**

| **Bloom's Revised Taxonomy** | | **Language from AusVELS** | **Teachers' Language** |
|---|---|---|---|
| **Higher-order thinking** ↑ | **Create** | Communicate | |
| | **Evaluate** | Evaluate, review | |
| | **Analyze** | Construct evidence-based argument, link | |
| | **Apply** | Pattern | Model |
| | **Understand** | Explain | Relate, represent, understand |
| **Lower-order Thinking** | **Remember** | | Identify, recognize |

This comparison seems to indicate a disconnect between the expectations of state-mandated curriculum documents, placing emphasis on developing students' higher-order thinking skills, and teachers' interpretations of these professional duties. The essential questions in Figure 5.1 were written by teachers and may indicate a commitment to developing students' higher-order thinking, however these goals were not explicitly connected to geoscience. In addition, the term 'consider' is absent from in Table 5.4 because considering the role of heat energy and convection currents in tectonic plate movement could have a variety of meanings situated at different levels of higher-order thinking. Do students consider the role of heat in convection currents to *explain* tectonic plate movement and/or to *evaluate* whether heat and convection currents alone are a plausible explanation for plate movement?

To challenge this analysis, I invited Riverside teachers to reflect on the importance of students remembering facts compared to applying knowledge of geological processes. All 10 participants seemed to promote the sacred story, ***scaffolding students for application of knowledge is more important than teaching facts***. In addition, some teachers positioned digital technologies as material objects (Harré, 2002b) that discouraged teaching facts because students could 'just look them up.' These perceptions seem to imply a simplicity to seeking out and finding facts while possibly enabling teachers to relinquish a professional duty to teach students how to perform and evaluate Internet searches. Teachers relinquishing these duties were placed at the novice level along the continuum for digital technology use explained in chapter four.

The sacred story, ***teaching students to apply knowledge is more important than teaching facts***, however, seemed to be compromised by teachers' perceptions of the accepted practices within the local moral order. Even though summative assessment in junior science is not driven by state-mandated examinations, some teachers reflected on a culture of 'spoon-feeding' that may compromise their sense of empowerment to take risks teaching higher-order thinking skills. Ethan invited me into the secret story:

> *We-we don't teach application skills. Um, … you know, … a lot of it's just remembering stuff or-y-you still need to understand it to be able to answer a question. But we don't, um, we don't ask a lot of application-type questions. Um… s-so, for students that are good at, uh, understanding the basic concepts, you know, it's easy for them to sort of go*

*through a test or exam. Um, ask them to apply however and they may not have the skills to turn that knowledge to something else.*

Utilizing the personal pronoun 'we,' Ethan spoke on behalf of Riverside science teachers carefully explaining and justifying that professional duties to teach application skills may be relinquished, if recognized at all. Riverside is a school acknowledged publicly for having high standards and staff feel accountable to this. Here, some teachers suggested that students' drive for marks may augment practices to assess demonstration of lower-order thinking skills. Although Ethan's reflection may not mirror the perceptions and practices of all Riverside science teachers, William, known for his commitment to teaching higher-order thinking, stressed teachers' professional duty to improve their practice such that students 'do more synthesis and extrapolation rather than just regurgitating facts.'

Riverside's geoscience curriculum was derived within the context of this established secret story and so the curriculum document in Figure 5.1 did not appear to reflect a collective duty to develop students' higher-order thinking skills. This analysis seems to indicate that supporting Riverside teachers to attend to the sacred story would not only require provision of resources, but also support to interpret, document and enact state-mandated expectations. The next section assesses the year nine unit from a geoscience curriculum planning perspective to better understand how teachers could be offered this support.

### 5.3.3 A Geoscience Curriculum Planning Perspective

All Riverside participants reflexively positioned themselves (Harré & van Langenhove, 1999) as OOF geoscience teachers. Despite having contributed to curriculum documentation and evaluation, strengthening their practice would need to begin with a provision of sign systems, social interactions designed to support their capacity to produce geoscience units of work, to enable these teachers to attend to both state-mandated curriculum and the sacred story of improving differentiated instruction. This section unpacks the document in Figure 5.1 through a geoscience curriculum planning perspective to understand how these teachers' geoscience pedagogical content knowledge development may be better supported.

The curriculum documentation in Figure 5.1 shows that when the Australian Curriculum was first implemented, year nine Riverside students had not yet received tuition in rock and mineral formation. Thus, the science understanding content descriptions for year eight (ACARA, n.d.-d, ACSSU153) were taught in year nine. In addition, plate tectonics and the theory of continental drift, year nine topics (ACARA, n.d.-d, ACSSU180), were also taught. Assuming the duty to teach content descriptions from two year levels seemed to indicate a sacred story, ***we need to ensure students are offered experiences with all aspects of science understanding***.

In addition, state-mandated curriculum documents also professionally positioned teachers to address standards from both science inquiry skills and science as a human endeavor. Although these standards did not appear to be the focus of the initial planning meetings, the content descriptions shown in Table 5.3 seemed to promote a sacred story that aligns with teachers' beliefs about best practice including their uses of digital technologies. Chapter four analyzed and explained teachers' self-assessments of their digital technology use where students were tasked with demonstrating content knowledge through digital presentations and some teachers felt a sense of oughtness to scaffold students' digital skills for their future in the workforce. As such, teachers may have taken opportunities to have students create and deliver digital presentations demonstrating their geoscience understanding.

The science inquiry skills strand enables students to 'achieve deeper understanding of the science concepts and how scientific thinking applies to these understandings' (ACARA, n.d.-d). Lacking a personal history with geoscience themselves, however, Riverside teachers may have unintentionally overlooked inquiry skills that could be taught through geoscience and that were specifically connected to the information and communication technology (ICT) general capability (ACARA, n.d.-b). Chapter four explained how Google Earth software could be used to collect and analyze data engaging students in modern geoscientific epistemic practices. Thus, a secret story seemed to emerge: ***We don't know what we don't know, so it doesn't get taught.***

Although these teachers were committed to developing students' inquiry skills in their specialist areas, they seemed to require specific support to do so in geoscience. Furthermore, the continuum of digital technology use presented in chapter four indicated

that teachers at the Expert level were empowered to produce and transform lessons through digital inquiry activities. Charlotte, for instance, used the data loggers to model sea floor mapping. The opportunity to scaffold teachers' geoscience pedagogical content knowledge seemed an appropriate place to explore strengthening teachers' personal capacity to manipulate and possibly transform their practice through the use of digital technologies.

Apart from curriculum standards, the documentation and evaluation presented Figures 5.1 and 5.2 drew my attention to two other areas for which these teachers seemed to require support. I wondered whether certain rocks and minerals would be more appropriate to the timescales represented in the state of Victoria possibly enabling teachers to make connections between the classroom and their local area. Although 'various worksheets and activities' could be accessed through a shared folder located on Riverside's server, an acceptable practice within this local moral order, a sequence of topics and learning activities was not outlined. Should igneous rock formation and samples be discretely introduced and studied, followed by the processes of weathering and erosion, then sedimentary and metamorphic rock formation?

The absence of readily available answers to these questions created pedagogical tension between the intended and enacted curricula. The extent to which Riverside teachers could attend to the sacred story appeared to be compromised indicating additional areas where more support was needed to possibly strengthen teachers' capacity to manipulate, produce or transform (Foucault et al., 1988) lessons along a developmental continuum. Overall, a shifting plotline seemed to exist within the sacred story: ***We're making headway documenting the curriculum, but we need support developing our geoscience pedagogical content knowledge.***

## 5.4 Riverside Teachers' Current Beliefs About and Practices Teaching Geoscience

Despite documenting and evaluating the enacted curriculum, Riverside's year nine geoscience unit became obsolete in less than a year. With the implementation of the Australian Curriculum in 2014, year eight students would have learned about rocks and minerals and year nine teachers in 2015 were no longer expected to teach the science

understanding strand for two Earth and space science content descriptions. Although teachers were still expected to document the evolving curriculum, as of 2016 the documentation had not been updated to reflect this change. There seemed to be a shift from the sacred to the secret story: ***Even though we've been tasked with continuous curriculum documentation, we've returned to previously accepted practices***.

Helena began this chapter by explaining the history of geoscience at Riverside. In addition to state-mandated curricular changes, she explained that additional factors may be shifting the sacred story:

> *I think there's been a change, you know, as new staff have come along I think that has-that has changed which is-which is really good.*

For Helena, new staff members seemed to provide social signs (Foucault et al., 1988) challenging accepted practices within the local moral order. Whether or not this storyline shifted as a result of new staff, more specific state-mandated achievement standards (VCAA, n.d.-a; VCAA, n.d.-b) and/or teachers documenting and reflecting on the curriculum, Riverside participants all responded positively to the statement: I believe geoscience is important for all students to learn.

Teachers cited professional duties to prepare students for future career pathways – *I think we need to capitalize on that [being in Australia] with our kids going into geosciences,* understanding sustainability issues – *I think it's essential that-that kids have an understanding of where their energy comes from,* and duties to offer an equitable curriculum – *What gives one area of science more merit than another?* These reflections exemplify beliefs about teaching geoscience, some more central within the belief system than others. For instance, if economic circumstances change, and they have, would teachers still endeavor to inspire students to pursue a geoscience career pathway? Beliefs about teaching for sustainability and offering a 'well-rounded education' seem to indicate a sense of conviction that may be more central in the belief system.

Despite signaling a sense of oughtness to attend to professional duties to teach geoscience, teachers' reflections were peppered with moments of hesitation, paraverbals and pauses, indicating that they were traversing a new language environment to articulate the importance of an OOF area. Assessments of the enacted curriculum in section 5.3 further indicated that without a lived script, in particular a connection to the ICT general

capability (ACARA, n.d.-b), teachers' capacity to assume their self-identified professional duties may be compromised. Of note is that Riverside teachers were assuming their professional duties to the extent that their personal and professional capacities enabled them to feel empowered to do so.

This section seeks to analyze and explain teachers' approaches to plan for and teach at the intersection of the geoscience and digital technologies curricula. Similar to chapter four, teachers' reflections seemed to indicate categories along a continuum for digital technology use in the geosciences.

### 5.4.1 Teachers' Self-Identified Duties to Prepare for Out-of-Field Teaching

Offering teachers support to teach an OOF area of the curriculum would depend on understanding how they have negotiated or were prepared to challenge the accepted practices of the local moral order. Figure 5.3 illustrates the points of entry and preparation pathways Riverside teachers took to plan for teaching geoscience. Single-headed arrows indicate where teachers began and ended their searches for information. Double and triple-headed arrows indicate an iterative process where different sources of information were utilized simultaneously.

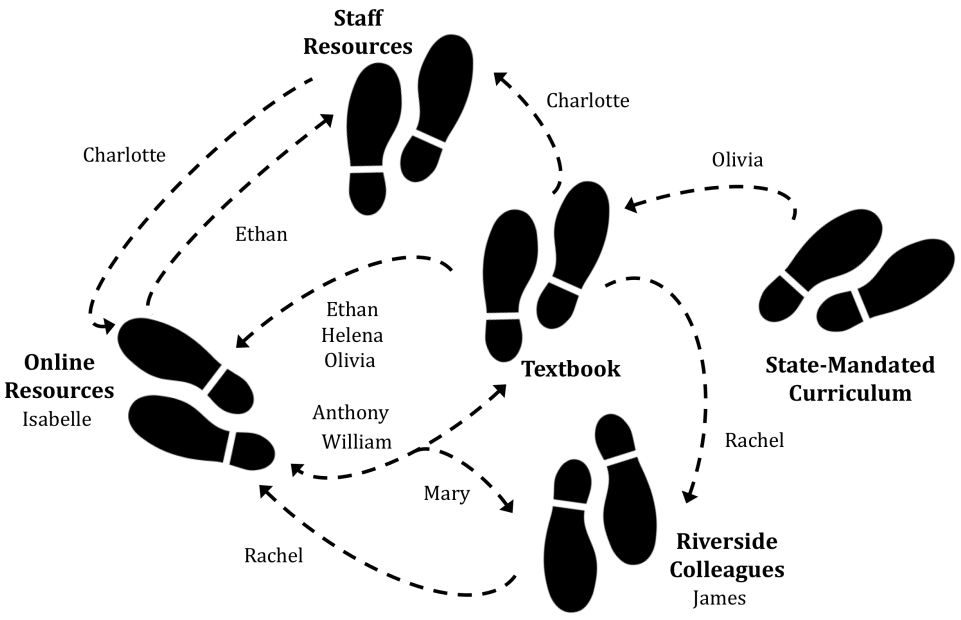



**Figure 5.3: Pathways to Preparation for Teaching Geoscience OOF**

As seen above, textbooks seemed to be the most common resource consulted by teachers followed by online resources including Wikipedia, YouTube and applications; and then other text-based material from the staffroom library including suggested activities and worksheets. Isabelle primarily relied on online resources whereas James turned to colleagues for support. Overall, teachers seemed to perceive these sources of information as strengthening their empowerment to teach geoscience by offering sign systems to understand content, produce lessons and manipulate resources. Table 5.5 exemplifies teachers' reflections about these resources alongside the analysis.

**Table 5.5: Teachers' Assessments of Resources Supporting OOF Teaching**

| **Teacher:** *Reflection*<br>Analysis |
|---|
| **Rachel:** *[F]irst I read the textbook, 'cause that just gives, like, a basic overview of the topic.*<br><br>**Olivia:** *I'd start with the curriculum and then I'd go, um, from whatever I don't know to somewhere so I can find it out [textbooks...] And I'd look at, um, some.. even kids' educational sites. Some of the games and things, the interactive sites to see… almost what's expected?*<br><br>Rachel and Olivia reflect on different starting points to plan for teaching geoscience. Despite having different amounts of teaching experience, both teachers position textbooks and state mandated curriculum documents as enabling them to identify and understand the extent to which topics should be taught. Olivia cites multiple resources, but the pause and inflection at the end of the turn seem to indicate she is unsure why she draws on games and interactive websites. A secret story seems to emerge: ***We're attending to our professional duties, but at times we're unsure what they are.*** |
| **Helena:** *What questions would a kid ask, you know, and how would I respond to that kind of thing? [...] So, um, or, you know, or-or a kid should, you know, a-this question should be asked by them if this is what they've been presented with and how might they respond to it. So, it's time-really, really time consuming [...]*<br><br>Helena is reflecting on her use of Google and YouTube. Using 'you know' she invites me into the professional conversation positioning these technologies as enabling her to assume the professional duty to anticipate and respond to students' questions. At the same time, she expresses frustration at the cost to her personal and professional time. Helena's reflection may indicate tension between the sacred and secret stories: ***I want to prepare for students' queries, but I may relinquish my duty to do so if it takes too long.*** |
| **William:** *And just cross reference to make sure that what I'm looking at is factual and just doing a lot of preparation like that.*<br><br>William explains that he iteratively consults textbooks and online resources signaling a professional duty to ensure that he is able to present accurate information to students. His use of 'just' seems to imply an ease with which these resources can be found. However, William qualifies his response with 'a lot of preparation' suggesting that attending to this duty is not only time consuming but also cognitively demanding. William's reflection is similar to Helena's indicating tension between the sacred and the secret stories. |

Riverside teachers' reflections seemed to indicate that within this local moral order embarking on solitary journeys to plan and prepare for teaching OOF was an accepted practice and largely supported by teachers' use of the Internet. Even though the curriculum document presented in Figure 5.1 did not indicate a connection to the ICT capability, I wondered if some of these digital practices were transferrable to the classroom.

### 5.4.2 Riverside Teachers' Perceptions of Digital Technology Use in Geoscience

In chapter four, Riverside teachers' self-assessments of their digital technology use were analyzed to create the continuum shown in Figure 5.4. Novice, apprentice and expert categories emerged from teachers' reflections, ranging from utilizing digital technologies to mostly teach science content to teaching science inquiry skills. Of note is that this continuum was created based on teachers' self-assessments of their digital technology use across junior science, including specialist areas. As such it serves as a useful framework to help understand the extent to which teachers engage in similar practices for an OOF area of the curriculum.

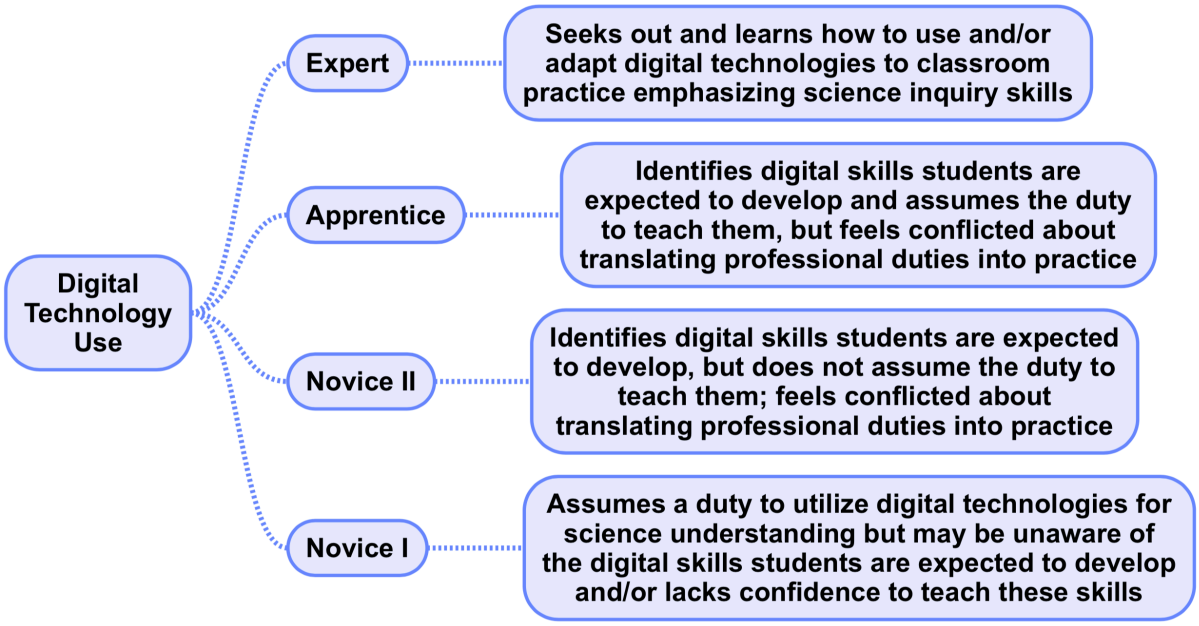



**Figure 5.4: Continuum of Digital Technology Use**

By 2016, only four of the 10 Riverside participants had a personal history teaching geoscience content descriptions from the Australian Curriculum. Through teaching an environmental science elective James also had a personal history teaching geoscience concepts. Charlotte, Helena, Isabelle, James and William, like their STAV colleagues, utilized Microsoft PowerPoint, videos, animations and simulations. In addition, they also reflected on using calculators, Google Earth and data logging equipment. Tables 5.6, 5.7 and 5.8 exemplify teachers' reflections of their digital technology use in geoscience which seemed

to be consistent with their placement along the continuum presented in Figure 5.4.

### Table 5.6: Expert Uses of Digital Technologies in Geoscience

| **Teacher:** *Reflection*<br>Analysis |
|---|
| **William:** *[I]t was all about 'How much money have I got?' and then I had random, (laughs) it was so funny, at one stage I said: 'Ok, there's been a-there's been a major weather incident.' And I went around with a random calculator and then I said: 'Push this button,' and a random number [came up] and I said: 'Oh, no! It's cost you $1,000 in the mine!' 'No!' And then they'd go: 'Oh, it's only cost us 100 bucks!'*<br><br>**Charlotte:** *[W]hen you do the cooking [to model rock formation] you can incorporate it [digital technology], um, making toffee and the, um, modeling the formation of, uh, honey comb and, ah, what's that, .. scoria and the volcanic rock, you could add in the making of that to, um, using your temperature sensors and say: 'What kind of temperatures do you need to get this happening?'*<br><br>William and Charlotte reflect on using digital technologies to model concepts from the year eight rocks and minerals unit. William uses a random number generator on a calculator to model reclamation costs and rehabilitation fines as students 'mine' Christmas cake for 'precious metals.' Charlotte models rock formation through cooking and reflects on the possibilities to incorporate data logging into the activity. In both reflections, these expert digital technology users seek out and learn how to utilize/adapt digital technologies for inquiry. James' use of simulation software modelling coastline changes throughout geological time was similar to Charlotte and William's experiences. The sacred story emerging seems to be: ***My digital practices are transferrable even when I'm developing a personal history teaching OOF***. Of significance is that both teachers seemed to draw personal interest from their uses of digital technologies, William described the experience as 'fun' and Charlotte 'always' sought opportunities to use data loggers. |

### Table 5.7: Apprentice Uses of Digital Technologies in Geoscience

| **Teacher:** *Reflection*<br>Analysis |
|---|
| Helena: [*The Cyber-Enabled Earth Exploration (CE3) curriculum] was just wonderful at getting kids to, you know, we-that-my kids loved using that and, um, I really-I really got into it as well. [...] I thought that was probably the most significant way that I'd actually used learning-tech-, um, digital technologies, you know, in a way that I could really see that it was enhancing kids' learning in some way.*<br><br>Helena is reflecting on using the CE3 curriculum (Almquist et al., 2012; Blank et al., 2016; Blank et al., 2012) that I introduced to her in 2015. This curriculum guides both students and teachers through inquiry-based activities to analyze data gathered from Google Earth. Helena's risk to draw on the social signs and explore using Google Earth in this way seems to have shifted her perceptions of how digital technologies could transform her lessons and strengthen her capacity to enhance students' learning experiences. The sacred story emerging for Helena seems to be: ***With scaffolding from others, my digital technology use is transferrable to an OOF area*****.** |

**Table 5.8: Novice Uses of Digital Technologies in Geoscience**

| **Teacher:** *Reflection*<br>Analysis |
|---|
| **Isabelle:** *[T]hat's [Dante's Peak] more of entertainment rather than anything else [... A]lthough it has got volcanos and so forth, I don't think it actually goes into the plate tectonics that much. It was a reward at the end [of the year].*<br><br>Isabelle reflects on showing the film Dante's Peak at the end of a year nine geoscience unit. Of note is that some STAV teachers also drew on this film when teaching geoscience. Unlike Isabelle one of these teachers, with 26 years' experience, reported challenging students to evaluate the poor science in the film. In contrast Isabelle's reflection seems to indicate that she attends to a self-ascribed duty to reward students knowing that doing so does not reflect what she perceives to be best practice, utilizing digital technologies for revision. A secret story emerges: ***Despite social signs indicating best practice, I sometimes use digital technologies as a reward without learning intentions***. |

Expert and apprentice teachers who were beginning to develop a personal history teaching geoscience seemed to indicate that they were empowered to utilize digital technologies in transferrable ways. Isabelle, the only novice user who had begun to develop a personal history, however, seemed to struggle negotiating her professional duties to students while *integrating* digital technologies into geoscience. To understand the extent to which teachers were aware of the transferability of their digital technology use, the next section compares and contrasts Charlotte, Helena, Isabelle, James and William's experiences to the perceptions of teachers who had not yet begun to develop a personal history teaching geoscience.

## 5.5 A Continuum of Digital Technology Use in Geoscience

Anthony, Ethan, Mary, Olivia and Rachel were teachers who did not have a personal history teaching geoscience. At the outset they could have been grouped as novice teachers of digital technologies in the geosciences. However, section 5.4.2 seemed to indicate that some teachers' digital skills were transferrable to geoscience. Thus, these teachers were invited to reflect on possible digital technologies that could be utilized to teach geoscience concepts. Overall Riverside teachers' past experiences and identification of future possibilities seemed to indicate a continuum of awareness along which support could be offered to them. Figure 5.5 illustrates this continuum.

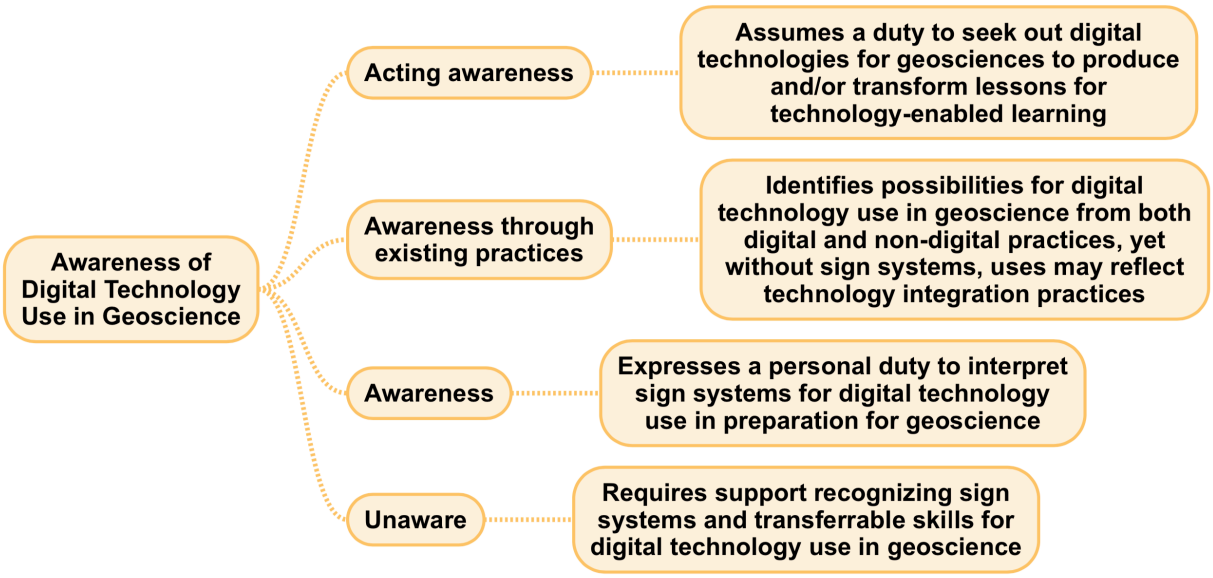



**Figure 5.5: Awareness Continuum of Digital Technology Use in Geoscience**

Anthony, Ethan and Olivia seemed to require the provision of sign systems to be able to recognize various possibilities digital technologies could offer. When asked to complete the sentence: Digital technologies that could be used in geoscience are..., they reflected:

> **Anthony:** *I'm sure there would be really amazing technologies that I'm not aware of [...] I'm-I'm a bit dumbfounded so I'm not too sure.*
>
> **Ethan:** *I'm not sure about what's out there.*
>
> **Olivia:** *I don't know. [...] I can't help with that.*

Anthony and Ethan were both in their second year of teaching after spending time in scientific research whereas Olivia was an experienced classroom teacher who had held a variety of leadership positions. All three reflections indicated that these teachers did not seem to recognize sign systems from their teacher training programs or their colleagues to propose digital technologies that could be utilized in geoscience. In addition, they did not seem to perceive their current practices as transferrable to geoscience. As such a secret story emerges: ***We're unaware of the digital technologies that could be utilized in geoscience and we need support to recognize our transferrable skills***.

Mary, an experienced teacher with a background in scientific research, explained:

> *I think there is-there are things out there. Um, I-do I know what they are? Maybe not. [...] I would say that honestly, I would need to do a bit of research into that.*

Like Anthony, Ethan and Olivia, Mary did not reflect on the transferability of her current digital practices. Her use of the pronoun 'I,' however seemed to indicate a personal commitment to assume a professional duty to 'research' digital technologies she could integrate into her OOF teaching practice.

Despite having a short personal history teaching geoscience, William and Helena identified possible uses of digital technologies that drew on alternativity (Nespor, 1987). This is a structural feature of beliefs that reflects a teacher's perception of an ideal situation that differs from the current situation yet serves to inform practice. They explained:

> **William:** *I-I haven't looked at it in any depth. Um, I don't know, is there-is there anything out there where you can create your own sort of like Earth? [... A]nd you just do very fast time simulations of, um, geo-geological events?*

> **Helena:** *[I]s there any digital technology that exists that you could-where you could, you know, like test the hardness of a rock or, you know, the scratch, you know, you-whether you can scratch it and, um, whether you can analyze [...?]*

From their perceptions of their current digital technology use in science, William and Helena were placed at the expert and apprentice levels on the continuum introduced in chapter four, levels at which teachers tended to draw on digital technologies for technology-enabled learning (Brantley-Dias & Ertmer, 2013; Ertmer & Ottenbreit-Leftwich, 2013). These teachers seemed to propose inquiry-based activities as ideal uses of digital technologies in geoscience. Like Mary, William had not investigated these uses, but the first part of his turn seems to indicate that he would assume this professional duty when approaching a geoscience unit.

Rachel was in her first year of teaching after a 10-year career in medical research. She reflected:

> *I think, like, you know, just iPads and things like that to look up… 'Cause, you know, what is an igneous rock? They [students] can look it up. You know, or what-what would it look like? Uh, when-when were they formed?*

Drawing on social signs within the local moral order and perhaps a sense of oughtness to utilize students' devices, Rachel explains how the Internet could be useful to teach geoscience. The extent to which Rachel identifies the possibilities for Internet use,

however, seems to be for lower-order thinking activities; defining the different types of rock, identifying timescales for rock formation and finding images.

Although Rachel is able to draw on her existing digital practices, she, like Helena, could possibly improve and transform her practice through social signs collaborating with not only Mary and William, but also other expert digital technology users. Charlotte and James seemed to have an acting awareness of digital technologies that could be utilized for technology-enabled learning through attending to personal and professional duties to seek them out and transform their practice. For Helena, Mary, Rachel and William, a story at the intersection between the secret and sacred stories emerges: ***I'm unaware of geoscience related digital technologies, but I'd investigate them if I had to teach it***.

## 5.6 Conclusion

In this chapter, the complexity of the Riverside geoscience curriculum development process was unpacked and analyzed. Teachers attended to their professional duties to teach geoscience through the science understanding strand of the Australian Curriculum, but they seemed to require assistance to reflect on how they might develop students' higher-order thinking and science inquiry skills. Thus, teachers' geoscience pedagogical content knowledge needed to be scaffolded in ways that the intended curriculum could then be enacted and connected to the ICT general capability.

The secret and sacred stories emerging from these analyses and teachers' perceptions of their empowerment to enact transferrable digital practices in an OOF area were raised to focused codes indicating categories along a continuum of awareness for digital technology use in geoscience. Unexpectedly most teachers did not seem to identify their existing digital practices as transferrable to geoscience. As such, this continuum serves as a useful framework to inform the planning of a unit of work by responding to the second subsidiary question: How do secondary science teachers perceive their capacity to teach geoscience with digital technologies?

# Chapter 6: A Year Nine Geoscience Unit Designed to Support Out-of-Field Teachers Teaching with Digital Technologies

> ***Charlotte:*** *You've gotta feel like you know what you're doing. 'Cause if you don't have confidence in what you're doing, how can you get across the excitement and the love of it to the kids themselves? If-if you don't care about it why should they care about it? And that's part of the very human part of our teaching is-is to bring that excitement and passion of-to everything that you do.*

## 6.1 Introduction

With the implementation of the Victorian Curriculum (VCAA, 2016d), teachers are expected to develop students' science understanding and inquiry skills while assuming a professional duty to teach 'complementary' content descriptions from the digital technologies curriculum (VCAA, 2016e). In chapter four, teachers' self-assessments of their digital technology use placed them at novice, apprentice and expert levels, see Figure 6.1. Chapter five explained that, apart from expert users, teachers did not seem to feel empowered (Foucault et al., 1988) to draw on their existing digital practices to teach geoscience, yet apprentice level users identified their sense of duty to explore technologies in ways that mirrored their existing practice, see Figure 6.2.

If teachers are to become effective technology users, they require practical strategies for overcoming barriers (Ertmer, 1999) and models exemplifying the range of possibilities for computer use (Tondeur, Hermans, et al., 2008) to reflect on their professional duties in the learning process. At Riverside, teachers' sense of personal agency to utilize digital technologies seemed to be compromised by compatibility problems associated with the bring-your-own-device (BYOD) program and a lack of technical support. The absence of a formal sequence of digital experiences for students in addition to some teachers' personal and professional history with digital technologies also seemed to hinder teachers' perceptions of their agency to scaffold students' digital skills. Addressing these problems seemed to be possible by attending to opportunities to scaffold teachers' geoscience pedagogical content knowledge and simultaneously offering them support to enact the intended curriculum through the use of digital technologies in this out-of-field (OOF) area. To varying extents, teachers at all levels could possibly benefit from support through sign systems (Foucault et al., 1988) to integrate digital technologies into their

practice and to be scaffolded toward technology-enabled learning (Brantley-Dias & Ertmer, 2013; Ertmer & Ottenbreit-Leftwich, 2013).

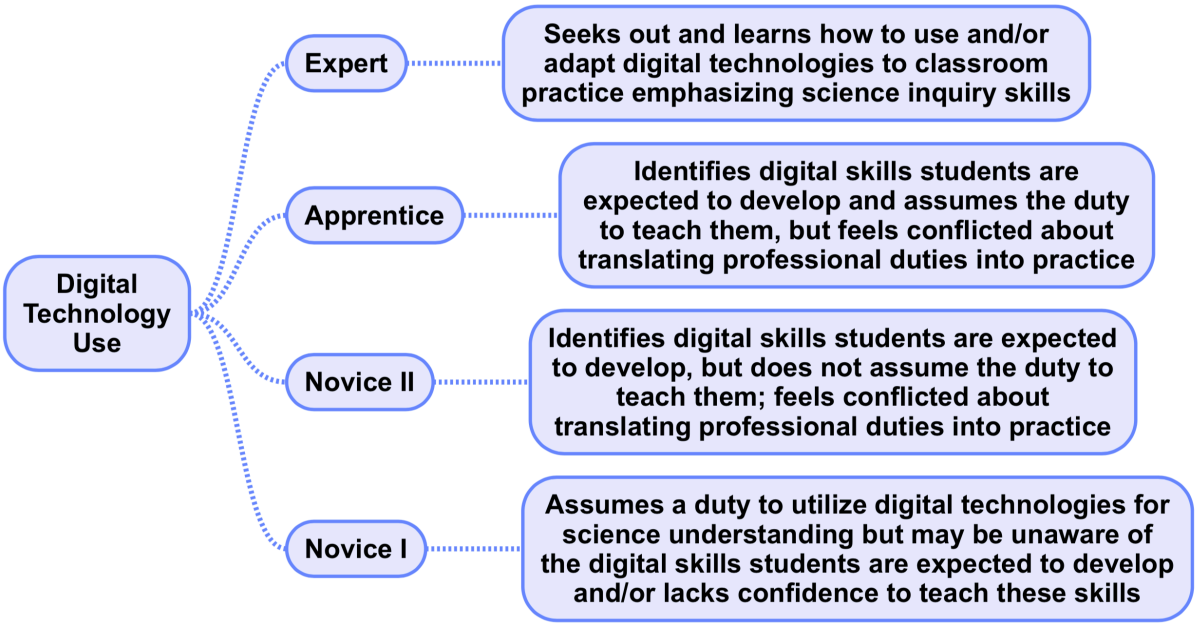



**Figure 6.1: Continuum of Digital Technology Use Across Science**

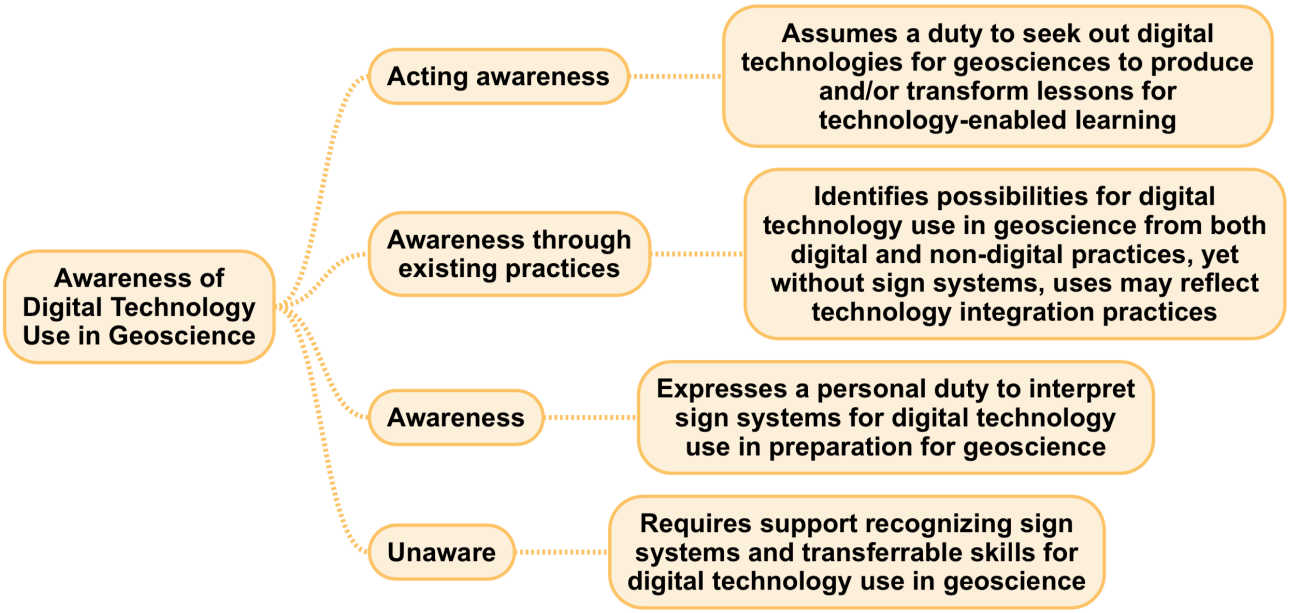



**Figure 6.2: Awareness Continuum of Digital Technology Use in Geoscience**

## 6.2 Curriculum Mapping Software: A Science Coordinator's Perspective

Chapter five analyzed the year nine geoscience curriculum document created as part of a whole-school initiative to formally record the enacted curriculum. By positioning (Harré & van Langenhove, 1999) teachers with professional duties to enact consistent curricular goals across classes, utilizing curriculum mapping software perhaps inadvertently supported the rhetoric of Riverside's cover story (Clandinin & Connelly, 1996): ***Students at this school have similar classroom experiences***. The document itself provided useful insight to better understand teachers' geoscience pedagogical content knowledge, however without subject-specific professional development, this process itself was premised on the assumption that teachers' capacities to execute these duties would be strengthened.

In 2016, Isabelle, an experienced teacher and novice digital technology user, was allocated the role of Science Coordinator. In addition to her on-going duties as a classroom teacher, she was expected to assume additional professional duties of supporting staff through the state-mandated curriculum change. As such, I deferred to her to reflect on the extent to which the process of using the curriculum mapping software may have enabled science teachers to improve their practice. She explained:

> *I think that it's [curriculum mapping software] useful to have there for the parents to see. But a-in terms of helping staff, I don't think that's actually quite useful. You can't put anything on there. It was meant to replace the information we had on M drive [the school's server] 'cause that was all over the place there. But then we could put a lot more [resources] there, 'cause you can't take what's there and put it on [the curriculum mapping software]. So, yeah. That's my opinion. But what do I know?*

Drawing on the personal pronoun 'I,' Isabelle explains that using the curriculum mapping software has not aligned with teachers' needs. Placing resources on the school's server was not ideal, 'that was all over the place,' but the teachers were instructed to refrain from attaching resources to curriculum documentation. In chapters four and five teachers identified their rights (Harré & van Langenhove, 1999) to have access to resources and to be trusted to make professional judgements about when best to utilize them. Thus, Riverside teachers continued to draw on these accepted practices to provide for their students and relinquish what they perceived to be more of an administrative duty. Isabelle finished the turn with frustration, 'That's my opinion. But what do I know?' As Science

Coordinator, she seems to rhetorically question her sense of a lack of professional capacity to support her science staff as they prepared for curriculum change through a process that does not appear to strengthen or respond to their needs. The secret story emerging is in tension with the cover story: ***The purpose of the work we're tasked with is unclear because it doesn't meet our classroom needs***.

Chapter five concluded that an updated year nine geoscience curriculum document was needed to reflect teachers' current practices and offer a means of support to develop their geoscience pedagogical content knowledge and to formalize a program offering students digital experiences in science. Isabelle's reflection, triangulated with those of her colleagues, indicates that the curriculum documentation process should also attend to and support teachers' rights to have an efficient method of accessing resources.

### 6.3 An Insider-Researcher's Professional Duty to Plan for Teaching Geoscience

Chapter five examined Riverside teachers' perceptions of their professional duties to prepare for OOF teaching. James, Mary and Rachel, expert and apprentice digital technology users, identified teaching OOF as an opportunity for collaboration to develop content knowledge and explore pedagogical possibilities. James explained:

> *Textbooks are good, but colleagues are the best source really. You know, I think that our school does it quite well where, um, we allow experts to run with their passions. And so, they'll take on a sort of leading a-a topic or a whole subject. And, um, we rely on our-on our peers and we work together and look at resources and work from there.*

James speaks on behalf of Riverside teachers using the pronoun 'we' to explain that within this local moral order (Harré & van Langenhove, 1999) teachers are afforded the professional right to assert subject-specific expertise and assume personal duties to organize and lead units of work. Although the extent to which each teacher drew on their colleagues for support differed, some seemed to embark on solitary journeys just prior to instruction, as an insider-researcher (Mercer, 2007) the accepted practices within this local moral order enabled me to assume the duty to plan for and offer teachers support to teach geoscience.

Like other Australian teachers (McDonald, 2015), Riverside teachers deferred to textbooks for preparation. In England and Wales, however, King (2010) reported that

junior science textbooks contain an average of one error or alternative conception per page when explaining Earth science concepts. Attending to teachers' rights to be provided with resources, I offered them access to accurate information by providing them an undergraduate textbook *Earth: Portrait of a Planet* (Marshak, 2015). I also collated a list of resources written by geoscientists and geoscience educators. Table 6.1 exemplifies some of these resources.

**Table 6.1: Resources Offered to Riverside Teachers**

| Resource | Description | Source |
|---|---|---|
| Cyber-Enabled Earth Exploration (CE3) curriculum (Almquist et al., 2012; Blank et al., 2016; Blank et al., 2012) | Using field notebooks, students are positioned (Harré & van Langenhove, 1999) as geoscientists collecting and analyzing data from Google Earth and .kmz files to develop scientific reasoning about the processes acting on the physical structures of the Earth. A glossary of terms is included in this curriculum. | A collaboration of teacher education professionals, teachers and geoscientists through the University of Montana, U.S.A. |
| Geoscience Concept Inventory (Libarkin & Anderson, 2006) | These questions, verified by geoscience educators, were originally designed to assess entry-level college students' understandings of geoscience concepts. Teachers could utilize them to assess their own and students' understanding of geoscience concepts. | Co-authored by members of geoscience, education and related communities through The Department of Geological Sciences at Michigan State University, U.S.A. |
| Dynamic Earth Science for GCSE: The Earth and Plate Tectonics, The Whole Story (Baggaley et al., 2009) | This booklet provides hands-on activities for teachers planning units about Earth's structure and plate tectonics. | The Earth Science Education Unit at Keele University, U.K. |
| Various classroom resources available through Geoscience Australia (n.d.-b) | This website provides teacher resource booklets and audio-visual materials that can be utilized in the classroom. | Geoscience Australia, the Australian government's advisor on the geology and geography of Australia |

## 6.4 Planning for Year Nine Geoscience with Riverside Teachers

Chapters four and five explained how teachers' perceptions of their personal and professional histories utilizing digital technologies and teaching geoscience informed the planning of a unit of work. To provide sign systems scaffolding teachers' geoscience pedagogical content knowledge and possibly strengthen their personal commitment to teach this OOF topic, I invited teachers to provide feedback on a list of geoscience topics including their importance and learning intentions during a faculty meeting. This list is presented in Table 6.2, Vignette 6.1 exemplifies a memo written shortly after this meeting.

In addition, I proposed that all resources could be stored on Google Drive, a cloud computing software, and linked to the curriculum mapping software. In this way, teachers could attend to institutional expectations requiring them to use the curriculum mapping software while also meeting their self-identified rights to access resources. Thus, greater symmetry may exist between the duties ascribed to teachers and teachers' perceptions of their professional rights to shift the secret story (Clandinin & Connelly, 1996), ***we're not sure why we're doing this***, toward a sacred story, ***we're attending to both state-mandated professional duties and school-mandated administrative duties in an OOF area***.

## Table 6.2: Geoscience Topics, Importance and Learning Intentions

| Topics | This topic is important because... | Students should... |
|---|---|---|
| Geological Time | Tectonic plate movement happens on the geological timescale | • Distinguish between short and long timeframes<br>• Understand that life on Earth began a short time ago geologically speaking |
| Earth's Structure | The transfer of energy between Earth's layers is determined by their physical properties | • Compare the composition, states, density and viscosity of Earth's layers<br>• Explain convection currents and their role in tectonic plate movement<br>• Differentiate between S and P seismic waves and explain their importance to understanding Earth's structure |
| Theory of Continental Drift and Plate Movement | Technological advances prompted a paradigm shift explaining continental drift and informing current understanding of Earth's structure including tectonic plate movement | • Understand sea floor spreading and subduction by analyzing data and explaining magnetic striping, fossil evidence and the age and distribution of rocks<br>• Explain geological events at convergent, divergent and transverse plate boundaries |
| Rifts and Mountains | Geographical features of the landscape are formed by tectonic plate movement | • Analyze data and explain the formation of rifts and fold mountains |
| Volcanos | The structure of the Earth and tectonic plate movement are responsible for natural disasters | • Analyze data and explain how cinder cone, shield and composite (strato) volcanos work while inferring safety in active volcanic areas |
| Earthquakes | | • Analyze data from seismometers and geological maps to explain earthquakes while inferring safety in earthquake-prone areas |

## Vignette 6.1: Researcher Reflection from the First Planning Meeting

Isabelle, Charlotte, Ethan, Rachel and two teachers not participating in this research attended the meeting. When I introduced the summary of possible topics, teachers tentatively offered their feedback: 'I've never taught this before,' 'I've got a video,' 'Could they use their phones?' Of note, is that Rachel, an early career teacher, assumed a professional duty (Harré & van Langenhove, 1999) to check the requirements from the Earth and space science understanding strand of the Victorian Curriculum (VCAA, 2015d). Charlotte drew on her personal history teaching geoscience to suggest that 1-2 lessons at most would be sufficient to teach geological time. She also proposed beginning the unit with earthquakes and volcanos. At this stage, I wondered whether Rachel and Charlotte would be empowered to transform their practice from the outset.

One week later, I met with teachers to guide them through the structure of the lesson plans and two activities introducing students to geoscience and the concept of geological time. Figure 6.3 exemplifies one of the lesson plans. Together teachers accessed a shared Socrative quiz with pre-prepared Geoscience Concept Inventory (Libarkin & Anderson, 2006) questions designed to assess student understanding of geoscience topics. Teachers also participated in a construction activity to build a model of the geological time scale. A section of this lesson plan is shown in Figure 6.4. My reflection of this meeting is presented in Vignette 6.2.

**Lesson 1: Introduction to Geoscience**

Learning Intentions:
- To introduce geoscience and the overarching question of the unit
- To understand that geoscience draws on other areas of science

Success Criteria:
- Students should be able to assess their scientific understanding of geoscience concepts related to this unit of work

1) To get started, try one of these hooks or go to the next activity if you feel the lesson is too jam packed:

   https://www.ted.com/talks/jill_heinerth_the_mysterious_world_of_underwater_caves

   https://www.ted.com/talks/francesco_sauro_deep_under_the_earth_s_surface_discovering_beauty_and_science

2) Explain to the students that the overarching question of this unit is:

   **How do scientists make observations about the Earth both on and underneath its surface?**

   Students will have already studied some aspects of natural disasters in year 8 geography as part of the Humanities. They may tell you that they've already done this. Let's give them some credit for the knowledge they bring to the lesson, but see how scientific their knowledge is by completing some questions from the Geoscience Concept Inventory related to our topic:

   Website: www.socrative.com
   Sharing code: SOC-23011634

   First you will need to set up an account with a username and password. The students do not need to do this. You will be given a classroom number which the students can put into their devices when you want to run a quiz.

   In your account go to *Quizzes*, then *import quiz*. Put in the sharing code as above. This will allow you to have access to the quiz that has already been made. Next, go to *Launch* and launch a *space race*. Choose the quiz *Geoscience Concept Inventory Diagnostic*, select between 6-8 teams which will give you groups of 3-4 students. You can select *automatic assignment* so the students are randomly assigned. They won't know who is in their team unless they share the color of the team they are in. No one will know who responds in/correctly, but they are playing as a team. It's up to you whether you choose to *enable/disable student feedback*. You will have the option to view their results after the quiz.

**Figure 6.3: Sample Lesson Plan Scaffolding Teachers' Use of Socrative**

**Lessons 2-3: Geological Time**

Learning Intentions:

- To understand that the Earth is very old and that the geological time scale divides Earth's history into eons, eras and periods

Success Criteria:

- In small groups, you should be able to create a geological time scale illustrating some research about events occurring in Earth's past

**Note:** If you would like to explore geological time for 2 lessons, use **Option 1** as a guide. If you would like to explore geological time for 1 lesson, use **Option 2** as a guide.

1) Begin by presenting the Geological Time PowerPoint presentation, this should take 10-15 minutes with some discussion from the students. You may want to hand out some of the laminated geological time scales to the students now and refer to eons, eras and periods. This PowerPoint should be made available for students to put into their Geoscience Google Drive folder.

   The main purpose of today's lesson is to understand that the geological time scale is long and that life on Earth is relatively recent. Students will work in small groups to complete this task.

   **Option 1: Proceed to the Challenge slide in the PowerPoint presentation.** First, students will convert dates on a standard geologic time scale into distance. They will begin their conversions on the Geologic Time Scale Worksheet, where 1mm = 1Ma. You should highlight the terms eon, era and period to the students. As they work through their calculations you can check their work.

   Next, students will show their representations by constructing a time scale using receipt paper. The total length of the time scale is approximately 4.6m long. They should separate and label the eons, eras and periods.

   At the same time, students can also use the Internet to look up and label when these 10 events occurred:

   - The first microbes, cyanobacteria, began producing oxygen through photosynthesis 2.7 Ga
   - T-rex lived 70 Ma
   - Earth formed 4.54 Ga

**Figure 6.4: Sample Lesson Plan Scaffolding Understanding of Geological Time**

**Vignette 6.2: Researcher's Reflection on the Second Planning Meeting**

I began by inviting teachers to reflect on the topics presented in our last meeting. Rachel seemed to feel empowered to explore resources placed on the Google Drive, explaining that she 'enjoyed' reading the text and watching The Deepest Place on Earth (Martin & Kern, 2009) . She also seemed to feel a sense of oughtness (Linehan & McCarthy, 2000) and assumed a professional duty to contribute to unit planning by posting suggestions for introducing magnetism and polarity to teach sea floor spreading.

Using Socrative and accessing shared quizzes weren't new skills for these teachers. However, using Socrative to pre-test students' understanding, seemed to be a new practice for Rachel and Isabelle. As teachers created geological timescales they seemed to have 'A ha!' moments as they realized how little time had passed when life first began on Earth. Running both of these activities has signaled the importance of not only identifying what to teach but how to teach it, including the provision of time for teachers to experiment, an uncommon practice within the local moral order of the science faculty.

These meetings were scheduled during working hours, however teachers' availability to plan together is telling of the complexity of their lived experience. Through participation in this study, these teachers expressed a sense of oughtness to learn how to manipulate digital technologies and possibly transform their practice, yet administrative duties seemed to compromise these efforts. Of seven year nine teachers only four were able to participate in the second planning meeting. As Science Coordinator Isabelle was required to meet with other learning area coordinators and, like most classroom teachers, Charlotte was supervising students as part of her after-school yard duty. The sacred story (Clandinin & Connelly, 1996) seemed to be in tension with the secret story, ***we're developing our practice, but other duties compromise these efforts***. For these reasons, I decided to meet with teachers on an as-needed basis by regularly checking in with them and attending to their queries as they arose.

Being in her first year of teaching, Rachel was not yet assigned the additional administrative duties of her more experienced colleagues. Rachel's sense of oughtness and personal interest to explore resources, assumption of her professional duty to contribute to the Google Drive and enthusiasm to engage her students in technology-enabled learning informed my decision to defer to her to pilot the unit. In addition, Rachel seemed ideally placed as an apprentice digital technology user and former research scientist to possibly critically evaluate lesson plans, the digital technologies and skills students were expected to develop.

## 6.5 An Updated Year Nine Geoscience Curriculum

The analysis of Riverside's year nine geoscience curriculum in chapter five indicated that teachers required an updated curriculum document written to the Victorian Curriculum (VCAA, 2015d). This meant providing a clear sequence of topics with greater connection to the science inquiry skills strand and to the digital technologies curriculum (VCAA, 2016b) with planned digital experiences to strengthen students' skills. Figure 6.5 presents this updated curriculum documentation. Tables 6.3 and 6.4 unpack the Victorian Curriculum content descriptions listed in this document.

Of note is that progression of and justification for the sequence of topics was informed by Blank et al. (2016). Describing their CE3 curriculum, a Google Earth-based middle school science curriculum, they explain that beginning a geoscience unit of work with natural disasters followed by plate tectonics was:

> [A] deliberate attempt to help students experience the historical processes of discovery scientific communities have engaged in as they struggled to delineate the mechanisms responsible for observable Earth processes; and foster students' appreciation and understanding of a scientific worldview (p. 78).

This pedagogical choice was intended to offer teachers sign systems (Foucault et al., 1988) to possibly transform the secret story, ***we address all sub-disciplines of science yet somewhat inconsistently***, toward a sacred story, ***we justify pedagogical choices based on best practice***.

**Unit Description**

Geoscience is the study of the solid components of the Earth. Over six weeks, students will study six topics:

1. What is Geoscience?
2. Geological Time
3. Natural Disasters: Volcanos
4. Natural Disasters: Earthquakes
5. Earth's Structure
6. The Theory of Plate Tectonics

The sequence of these topics is distinct from the textbook. After introducing geoscience, the surface of the Earth will be explored including the effects of and explanations for natural disasters. This is how geoscientists first began to understand Earth's structure. Next, technological developments are explored to explain how they enable geoscientists to understand the structure of the Earth on/below its surface. This mirrors the sequence of knowledge development that supported Alfred Wegener's Theory of Continental Drift.

Throughout this unit students will develop their digital skills as they utilize Google Drive and other subject-specific software including Google Earth, simulations, animations, video, data loggers and data analysis software. With these technologies, students will work toward understanding geoscientific concepts through science inquiry and apply their knowledge to new situations.

**Essential Question:** How do scientists make observations about the Earth both on/below its surface?

**Victorian Curriculum Standards**

**Science:**

- VCSSU114
- VCSSU115
- VCSSU116
- VCSSU127
- VCSIS134
- VCSIS136
- VCSIS137
- VCSIS138
- VCSIS140

**Digital Technologies:**

- VCDTDS045
- VCDTDI047
- VCDTDI048
- VCDTDI049
- VCDTCD050
- VCDTCD054

**Students should know:**

- Geoscience is a sub-discipline of science
- Life on Earth occurred recently according to the geological time scale
- The causes of natural disasters and their effects
- How technological development has influenced our understanding of natural disasters and the structure and history of the Earth
- How a body of evidence influenced scientists' acceptance of Alfred Wegner's Theory of Continental Drift
- How convection currents may be used to explain the Theory of Plate Tectonics

**Students should develop:**

- An understanding of geoscientific reasoning skills and intentionally apply these to unfamiliar contexts
- Dispositions that support logical, strategic and flexible thinking to analyze qualitative and quantitative geological and geographical data

**Assessment Evidence**

1. Formative assessment activities as structured into individual lesson plans, see link below
2. Summative written test with practical component, see link below

**Learning Activities**: https://drive.google.com/open?id=0B5SpmLIa9a5YSDI2dW5SZ0FTUG8

**Figure 6.5: Year Nine Geoscience Curriculum Documentation 2016**

## Table 6.3: Science (VCAA, 2015d) Content Descriptions from the 2016 Curriculum Documentation

| Science Understanding |
| --- |
| **Earth and Space Sciences**<br>The theory of plate tectonics explains global patterns of geological activity and continental movement (VCSSU127)<br><br>**Science as a Human Endeavor**<br>Scientific understanding, including models and theories, are contestable and are refined over time through a process of review by the scientific community (VCSSU114)<br><br>Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries (VCSSU115)<br><br>The values and needs of contemporary society can influence the focus of scientific research (VCSSE116) |
| **Science Inquiry Skills** |
| **Questioning and Predicting**<br>Formulate questions or hypotheses that can be investigated scientifically, including identification of independent, dependent and controlled variables (VCSIS134)<br><br>**Planning and Conducting**<br>Select and use appropriate equipment and technologies to systematically collect and record accurate and reliable data, and use repeat trials to improve accuracy, precision and reliability (VCSIS136)<br><br>**Recording and Processing**<br>Construct and use a range of representations, including graphs, keys, models and formulas, to record and summarize data from students' own investigations and secondary sources, to represent qualitative and quantitative patterns or relationships, and distinguish between discrete and continuous data (VCSIS137)<br><br>**Analyzing and Evaluating**<br>Analyze patterns and trends in data, including describing relationships between variables, identifying inconsistencies in data and sources of uncertainty, and drawing conclusions that are consistent with evidence (VCSIS138)<br><br>**Communicating**<br>Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (VCSIS140) |

**Table 6.4: Digital Technologies (VCAA, 2016b) Content Descriptions from the 2016 Curriculum Documentation**

| **Digital Systems** |
|---|
| Investigate the role of hardware and software in managing, controlling and securing the movement of and access to data in networked digital systems (VCDTDS045) |
| **Data and Information** |
| Develop techniques for acquiring, storing and validating quantitative and qualitative data from a range of sources, considering privacy and security requirements (VCDTDI047)<br><br>Analyze and visualize data to create information and address complex problems, and model processes, entities and their relationships using structured data (VCDTDI048)<br><br>Manage and collaboratively create interactive solutions for sharing ideas and information online, taking into account social contexts and legal responsibilities (VCDTDI049) |
| **Creating Digital Solutions** |
| Define and decompose real-world problems precisely, taking into account functional and non-functional requirements and including interviewing stakeholders to identify needs (VCDTCD050)<br><br>Evaluate critically how well student-developed solutions and existing information systems and policies take account of future risks and sustainability and provide opportunities for innovation (VCDTCD054) |

## 6.6 Scaffolding Riverside Teachers to Teach Year Nine Geoscience

Apart from the intended learning outcomes for students described in Figure 6.5, this unit of work was planned with a deliberate intention to possibly empower teachers to:

1. Explicitly teach digital technology skills;
2. Develop their geoscience content knowledge; and
3. Enact pedagogies strengthening students' higher-order thinking and engagement in the epistemic practices of scientists.

Although the established local moral order permitted me to craft the year nine geoscience unit of work, ultimately teachers' perceptions and acceptance of their professional duties and sense of self-efficacy (Bandura, 1989) would inform their pedagogical choices for when and to what extent they would utilize digital technologies. As such, pedagogical suggestions for exploring topics were explicitly introduced into the lesson plans. Two full lesson plans are exemplified in Appendix E. In addition, teachers were provided with a selection of activities, extension work and resources. The following

sections further explain how this unit was structured to help strengthen these teachers' sense of empowerment to manipulate digital technologies and possibly transform their practice in an OOF area.

### 6.6.1 Scaffolding Teachers to Teach Digital Technology Skills

Assisting Riverside teachers to explicitly teach digital skills meant offering them solutions to face barriers compromising effective digital technology use including a lack of technical support to navigate BYOD compatibility problems, insufficient personal and professional history and concerns about the interplay between technology use and best practice. Table 6.5 summarizes the digital technologies teachers could utilize while teaching year nine geoscience. To provide an entry point for novice, apprentice and expert teachers, this list included technologies with which they had already developed a personal history as well as those that could possibly add to their pedagogical repertoire. All of these technologies were tested across both MacIntosh and Windows operating systems.

**Table 6.5: Summary of Digital Technologies Used in Year Nine Geoscience**

<table>
<tr><th>Organizational Technologies</th><th>Subject-Specific Technologies</th></tr>
<tr><td>• Google Drive including Google Docs, and Drawings<br>• Instructional videos<br>• Scanning function on library photocopiers to convert written notes to .pdf files to be saved in Google Drive</td><td rowspan="3">• Animations<br>• eChalk web-based resources<br>• Google Earth<br>• Google Sheets (equivalent to Microsoft Excel)<br>• Media websites<br>• .mp3 files<br>• Podcasts<br>• Microsoft PowerPoint<br>• Simulations<br>• Videos (TED, Documentary, Data plot)</td></tr>
<tr><th>Other</th></tr>
<tr><td>• Padlet<br>• Socrative<br>• Web browsers</td></tr>
</table>

To help strengthen teachers' capacity to utilize technologies new to their practice lesson plans always included written instructions and screenshots modeling the step-by-step processes required to teach students specific skills. Figure 6.6 provides an example of how I explained and supported teachers and students at the point of need to manage the sharing settings on Google Docs. As the unit progressed and fewer skills were introduced, students were required to practice and refine them.

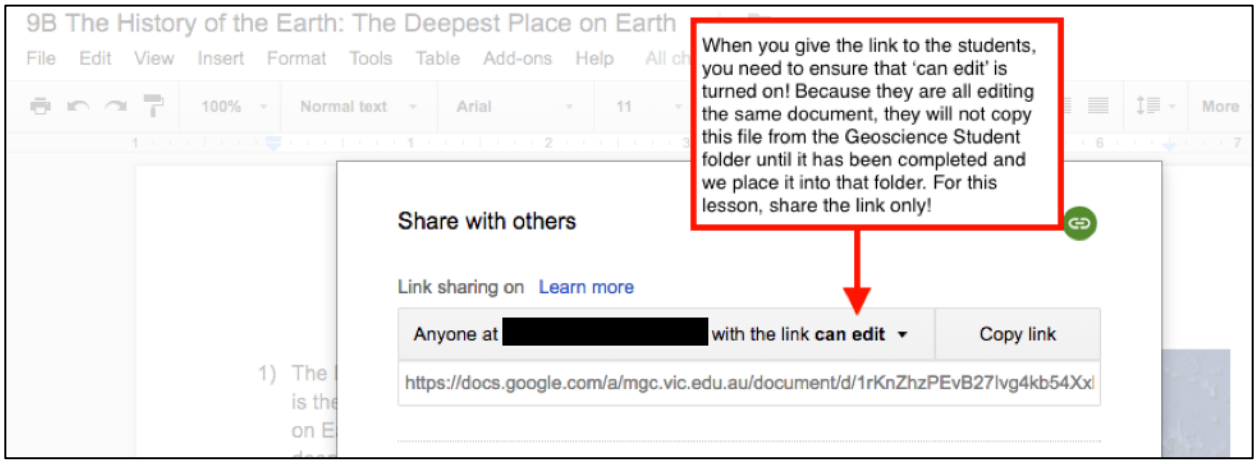



**Figure 6.6: Scaffolding for Digital Technology Use within Lesson Plans**

Section 6.4 explained reasons for deferring to Rachel to pilot the unit. As an apprentice digital technology user, Rachel identified digital skills students were expected to develop and she indicated a sense of oughtness to teach these skills. At the same time, apprentice digital technology users seemed to feel conflicted about translating their professional duties into practice. In three interviews, Rachel advised that apart from instructions written within lesson plans, both teachers and students would require further support utilizing Google Drive and Google Earth across devices. In response and to better assist them to troubleshoot problems, I then created these instructional videos:

1. Getting Started with Google Drive;
2. Asking a Question to a Resident Geoscientist;
3. Socrative Introduction; and
4. Google Earth with Mac and Windows

In addition, in section 6.4 I explained that linking resources through Google Drive was intended to enable teachers to meet professional expectations to use curriculum mapping software while attending to their self-identified rights to access resources. This cloud computing software, including Google Docs, Drawings and Sheets, could also possibly scaffold both teachers and students toward manipulating the affordances of these tools by exploring collaborative real-time editing and file sharing. As such, the unit of work was

organized into two folders. The student folder is exemplified in Figure 6.7, Figure 6.8 exemplifies the teacher folder.

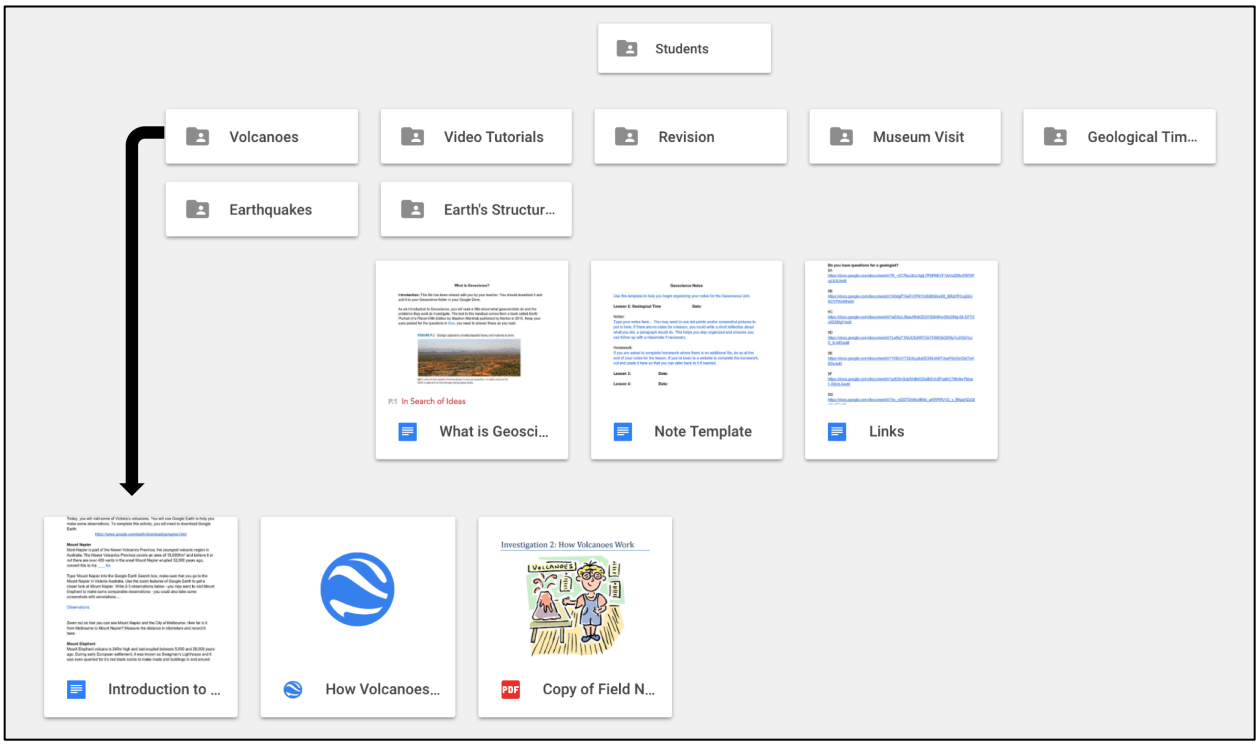



**Figure 6.7: Organization of Google Drive Student Folder**

Students were assigned the duty to download the student folder and add this to their personal drive. The student folder was divided into sub-folders with specific information and supporting materials for each topic. For example, the Volcanos folder can be seen to contain three files including the Introduction to Volcano Observation worksheet, a Google Earth .kmz file and field notebook. Students were also provided a folder of instructional videos and then positioned with the duty to refer to these videos should they require support individually utilizing the technologies outside of class. Finally, the organization of the folders offered students a model demonstrating how to efficiently organize stored information.

The teacher folder was organized in a similar way and included planning documents, resources and lesson plans. Individual folders contained each lesson plan and the associated resources. In the folder named Lesson One: Introduction to Geoscience,

teachers could find the lesson plan, student worksheets, teacher solutions and three instructional videos to scaffold both teachers and students through the necessary digital skills introduced in the lesson.

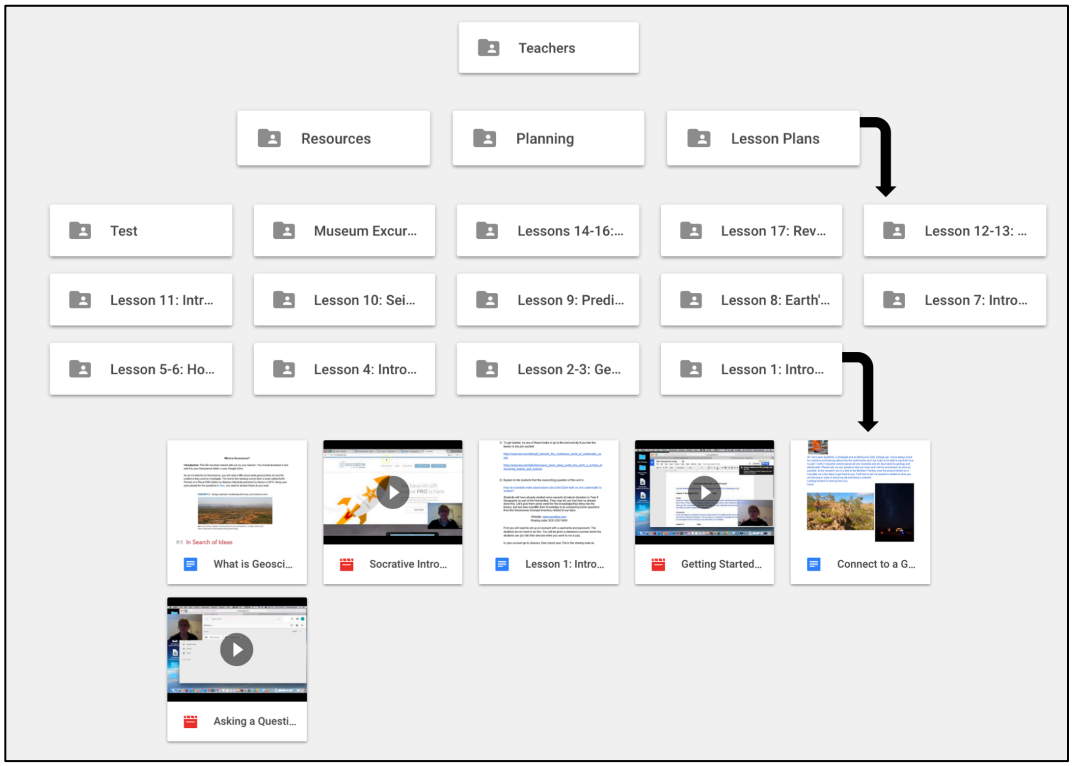



**Figure 6.8: Organization of Google Drive Teacher Folder**

At the outset, positioning teachers to feel comfortable as learners with Google Drive was intended to begin developing their personal practical skills prior to teaching with it and possibly empowering them to confidently address the expectations of the digital technologies curriculum (VCAA, 2016b) to:

1. Investigate the role of hardware and software in managing, controlling and securing the movement of and access to data in networked digital systems (VCDTDS045); and

2. Manage and collaboratively create interactive solutions for sharing ideas and information online, taking into account social contexts and legal responsibilities (VCDTDI049)

### 6.6.2 Scaffolding Teachers' Geoscience Content Knowledge

Chapter five indicated that Riverside teachers assumed personal and professional duties to prepare for teaching OOF. Working toward strengthening teachers' geoscience content knowledge meant offering them resources on an as-needed basis, just prior to instruction. In addition to providing teachers an undergraduate textbook and collaborating with them through planning meetings, all lesson plans and resources were developed and made available to teachers prior to instruction offering them the opportunity to explore student activities.

Teachers enacting their professional duties to prepare for lessons, could do so by downloading .kmz files and working through Google Earth activities before introducing them to students. In this way teachers could further strengthen their personal history learning the material by engaging in geoscientific methods of inquiry. As a classroom teacher, I understand that a teachers' sense of oughtness to fully prepare for lessons in advance can, at times, be compromised as they negotiate their professional and administrative duties. As such I also provided sample responses to worksheets and activities and I had ensured that all lesson plans contained explicit instructions for teachers to efficiently make sense of learning outcomes and extension opportunities. Figure 6.9 exemplifies these instructions through an explanation of how to use an interactive resource to explore Earth's structure.

4) Students will use the Structure of the Earth .pdf in the Geoscience Student folder and the eChalk website to explore the layers of the Earth. The instructions for accessing the eChalk resource are included in the PowerPoint presentation and on the .pdf. Students should annotate the .pdf as they explore the eChalk resource.

Give students 30 - 40 minutes to explore and write their notes. The following slide on the PowerPoint has some additional notes that should be added and discussed with the students.

You might want to have some samples of basalt (oceanic crust) and granite (continental crust) on hand to demonstrate the density of these two rocks. Oceanic crust is more dense than continental crust. This is the reason why it sinks and gets melted into the mantle when oceanic and continental crust meet at convergent boundaries. We will study this later in the unit. Please see Em if you'd like some of these samples.

**Figure 6.9: Example of Explicit Instruction for Teachers**

Although having a strong interest in geoscience, I do not come from a geoscience background and there are many geoscience topics that I endeavor to learn about. As such, these teachers and their students were anticipated to pose questions which I may not have been adequately able to answer. To ameliorate these possible situations while expanding the boundaries of the classroom teachers and students were connected to, Susan, a Riverside alumnus and geoscientist who volunteered her time through the Commonwealth Scientific and Industrial Research Organisation's (CSIRO's) Science, Technology, Engineering and Mathematics (STEM) Professionals in Schools program. Unfortunately, Susan was unable to visit Riverside when year nine students were learning about geoscience. Google Docs for each class were created with written and video instructions encouraging teachers and students to ask Susan questions throughout the unit. Figure 6.10 exemplifies this document for year nine class A.

**9A Questions for our Resident Geoscientist**

Do you have questions about what you're learning? Ask resident geologist, and Riverside alumnus, Susan!

Hi! I am Susan, a Geologist and ex-Riverside High girl. I have always loved the outdoors and learning about how the world works and I am lucky to be able to say that I love my job! I work in beautiful remote places all over Australia and am fascinated by geology and planet earth. Please ask me any questions that you have and I will try and answer as soon as possible. At the moment I am in a tent in the Northern Territory (see the picture below!) so it may take me a few days to get back to you. Feel free to ask me questions related to what you are learning in class or about my job and being a scientist.

Looking forward to hearing from you,

Susan

**Figure 6.10: Connecting Teachers and Students to Riverside's Resident Geoscientist**

6.6.3 Scaffolding the Enactment of Geoscience Pedagogical Content Knowledge

Chapter five indicated that Riverside teachers required support to scaffold students' science understanding and inquiry skills. Alexander (2006) identifies five types of classroom talk that teachers may harness as part of their pedagogical repertoire:

1. **Rote:** Drilling facts and ideas through repetition;
2. **Recitation:** Stimulating recall through cues;
3. **Instruction/exposition:** Imparting information and/or explaining facts, principles or procedures;
4. **Discussion:** Exchanging ideas to share information and solve problems; and

5. **Dialogue:** Achieving common understanding through structured questioning and discussion (p. 30)

Alexander (2006) explains that discussion and dialogue have the greatest potential for students' cognitive development and clarifies that they are demanding in terms of teachers' skill and subject knowledge:

> Rote, recitation and expository teaching give us security. They enable us to remain firmly in control not just of classroom events but also of the ideas with which a lesson deals. They keep power firmly in our hands as teachers. They reduce the risk that the limits of our subject knowledge will be tested, still less exposed. They make it unlikely that awkward questions about evidence, truth and opinion will interrupt the flow of information from the teacher to taught. However humanely or humorously packaged, they are monologic (p. 31).

Science can be taught dialogically when teachers prepare students to ask questions and engage them in real science such that one day they may take the long-term cultural dialogue of science further (Wegerif, 2013, 2018). Alexander (2006) identifies five principles of dialogic teaching:

1. **Collective:** learning tasks are approached by teachers and students together;

2. **Reciprocal:** teachers and students listen to each other, share ideas and consider alternative points of view;

3. **Supportive:** Students are free to articulate their ideas and help each other reach common conclusions;

4. **Cumulative:** Teachers and students build on their ideas and link them into coherent lines of thinking; and

5. **Purposeful:** Teachers plan and facilitate dialogic teaching to achieve educational goals (p. 28)

Alexander's (2006) work is especially pertinent to the OOF teaching experience designed for Riverside teachers as they negotiate unfamiliar content while taking risks to employ pedagogies that possibly empower them to transform their practice while assuming their professional duties to enact state-mandated curricular goals.

Lesson plans and resources offered to teachers were intended to support them to employ the principles of dialogic teaching. For instance, teachers were encouraged to have their students work in pairs while completing inquiry-based Google Earth activities from

the CE3 curriculum. Together students could gather evidence and explain their claims through dialogue facilitated by teachers in both small group and whole-class discussion. Teachers may have been better supported to explore the principles of dialogic teaching in this OOF area through the use of resources designed to elicit joint reasoning.

Despite trialing aspects of the CE3 curriculum with Charlotte and Isabelle in 2015, utilizing Google Earth to teach geoscience in this way was a new practice for Ethan and Rachel. However, I wondered whether Riverside teachers' geoscience pedagogical content knowledge could be scaffolded by drawing on technologies with which they already had a personal history. Utilizing Microsoft PowerPoint to teach science was an accepted practice within this local moral order, James explained:

> *PowerPoint's nowhere near cutting edge (laughs) digital technology these days but it-it is a way of getting-getting through the content and a neat way of organizing [notes].*

PowerPoint seemed to enable these teachers to attend to their professional duties to teach science content and organize notes for student revision, yet a secret story seemed to emerge: ***Perhaps we depend on PowerPoint too much***. Given teachers' personal history with this presentation software, I crafted lessons using PowerPoint to possibly support them to employ the principles of dialogic teaching, focusing on the pedagogy, without having to learn an additional technology.

Figure 6.11 shows four PowerPoint slides from a lesson sequence through which students explore Alfred Wegener's evidence for continental drift, a theory fraught with debate in the 1920s but responsible for a paradigm shift in scientific understanding of the structure of the Earth in the late 1960s. These slides exemplify how PowerPoint was utilized to structure students' discussion, exploration and evidence-based response to the overarching question: How do scientists make observations about the Earth both on/below its surface?

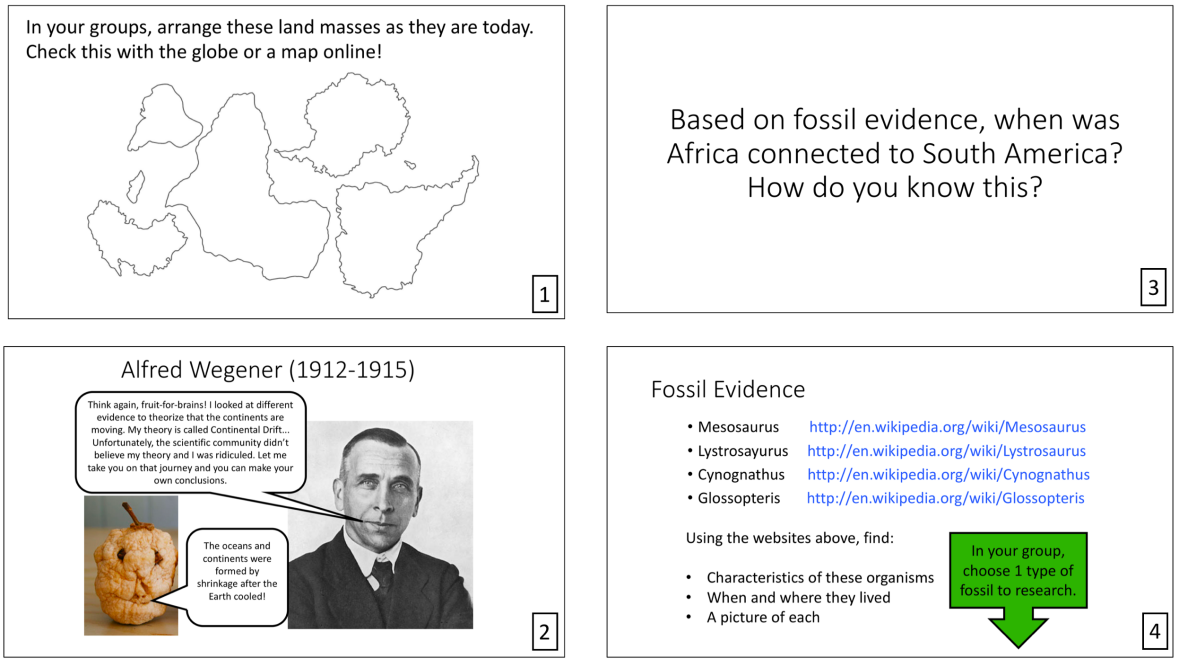



**Figure 6.11: PowerPoint Slides Scaffolding a Dialogic Approach**

## 6.7 Conclusion

This chapter concludes Part II: Preparing to Teach Out-of-Field with Digital Technologies. Teachers' self-assessments of their digital technology use and perceptions of teaching geoscience with technologies enabled me to develop a unit of work intended to strengthen their personal sense of agency. Part III: Teaching Out-of-Field with Digital Technologies, Teachers' Perceptions of Change exemplifies and explains how constructivist grounded theory coding procedures (Charmaz, 2014), pronoun grammar analysis (Mühlhäusler & Harré, 1990; Redman, 2013a; Redman & Fawns, 2010) and the technologies of the self (Foucault et al., 1988) were utilized to track changes in expert, apprentice and novice teachers' discursive practices (Harré & van Langenhove, 1999) before, during and after teaching OOF to understand the extent to which these teachers felt empowered to act autonomously while teaching with digital technologies.

# Part III: Teaching Out-of-Field with Digital Technologies, Teachers' Perceptions of Change

# Chapter 7: Interpreting an Expert Teacher's Perceptions of Agency Utilizing Digital Technologies in Science

***Interviewer:*** *What do you think the purpose is of schooling?*

***Charlotte:*** *Having fun. For me, as a teacher. That's why I do it. I do it 'cause I love it. I have fun. I know that sounds insane, doesn't it? But, you know, um, yes, hopefully the kids will learn something along the way. But, h-actually what-what really drives me as a teacher is getting those few sparks of kids who go: 'Oh, fantastic! Had a fantastic year, Miss.'*

## 7.1 Introduction

After completing an honors degree in pharmacology and brief periods of employment as a hospital laboratory technician and drug company representative, Charlotte trained as a teacher. By 2016, she had spent 25 years in the teaching service in Victoria and at international schools in Asia and the Middle East. Shortly after returning to Melbourne, she accepted a junior science and senior biology teaching position at Riverside. In addition, Charlotte was assigned the role of Science Coordinator. With a modest time allowance and no financial incentive, she was required to attend to many more administrative duties across the faculty and support teachers in their professional development. After a year, Charlotte did not pursue this role and returned to a full teaching allotment.

Charlotte's participation in this research includes constructing a personal meaning making map (PMMM) and follow-up interviews before and after teaching year nine geoscience. Of note, is that she taught this unit alongside Ethan, an early-career teacher introduced in chapter four. Charlotte had already developed an effective professional relationship with Ethan when he was employed as a laboratory technician and during his first teaching year as he substituted science classes for teachers taking leave. At the time of data collection, Charlotte and Ethan were co-teaching a year-long combined year seven science class of 52 students. They both contributed to five collaborative interactive discussions (CIDs) and focus group interviews. Following each focus group, Charlotte and Ethan participated in follow-up individual interviews. I was able to observe Charlotte's class eight times and was asked to substitute it once as part of my professional duties as a

Riverside teacher. I also recorded memos of my observations and interactions with her. In 2018, two years after teaching geoscience, Charlotte participated in a final interview.

This chapter introduces Charlotte and, through the positioning triad (Harré & van Langenhove, 1999) shown in Figure 7.1 and complementary analytical tools, examines her sense of agency to utilize digital technologies in her science teaching. Constructivist grounded theory coding procedures (Charmaz, 2014), pronoun grammar analysis (Mühlhäusler & Harré, 1990; Redman, 2013a; Redman & Fawns, 2010) and Rokeach's (1968) five types of beliefs are utilized to track changes in Charlotte's discursive practices (Harré & van Langenhove, 1999). These changes highlight tensions and shifts between cover, sacred and secret stories (Clandinin & Connelly, 1996) as Charlotte positioned the digital technologies as material objects (Harré, 2002b), herself and her students. As such, they are indicative of the extent to which she felt empowered (Foucault et al., 1988) to act autonomously while teaching with digital technologies.

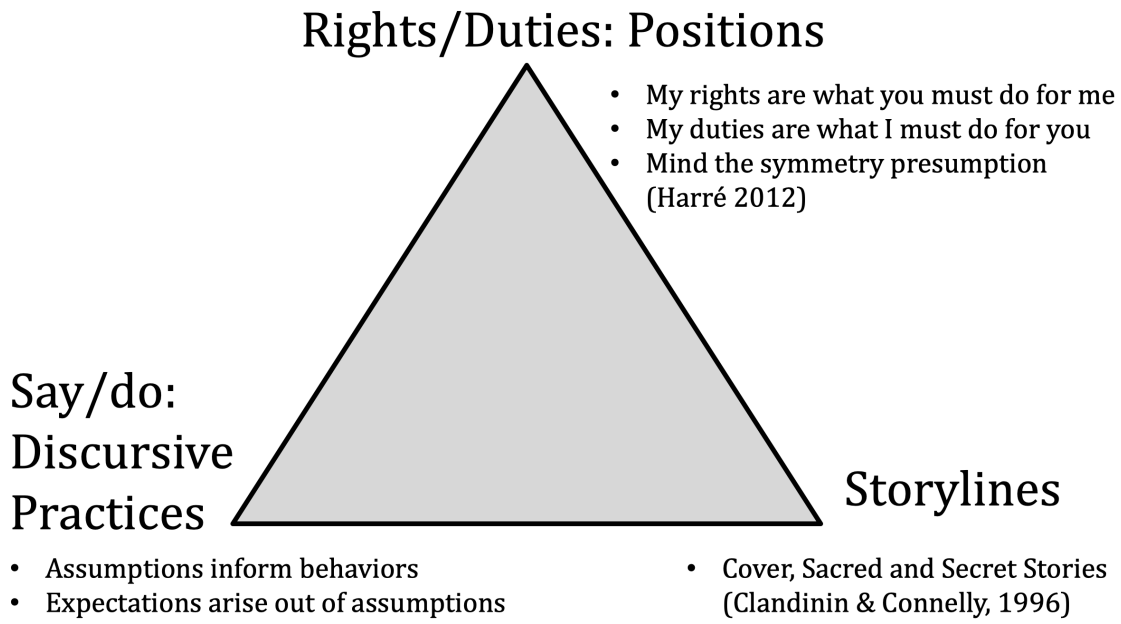



**Figure 7.1: The Positioning Triad Adapted from Harré and van Langenhove (1999)**

Table 7.1 shows the focused codes and theoretical categories (Charmaz, 2014) derived from Charlotte's discursive practices. Prior to teaching geoscience, Charlotte's self-assessments of her digital technology use positioned (Harré & van Langenhove, 1999) her

as an expert. Experts seem to create technology-enabled learning (Brantley-Dias & Ertmer, 2013; Ertmer & Ottenbreit-Leftwich, 2013) environments and in doing so they seek out and learn how to use and/or adapt digital technologies to their classroom practice. In addition, experts assume a duty (Harré & van Langenhove, 1999) to utilize digital technologies in ways that develop their students' science inquiry skills. Charlotte's sense of agency to utilize digital technologies in this way appeared to be strengthened by the local moral order (Harré & van Langenhove, 1999) as she was permitted to experiment and 'have fun' in her classroom. However, in the absence of a program of experiences to develop students' digital skills, Charlotte's sense of agency appeared to be compromised when she did not perceive them to be transferrable.

Charlotte will be seen to employ an experimental approach to her classroom teaching satisfying a personal right and professional duty to enhance the learning experience for both herself and her students. As such the resources offered to her while teaching out-of-field (OOF) seemed to upset an established equilibrium, which Charlotte herself was known to tinker with, and provide an already agentic teacher the opportunity to strengthen her pedagogical capacity at the intersection of the science and digital technologies curricula. For Charlotte professional learning was perceived to be a personal, ongoing and dynamic process and her reflections unexpectedly indicated that even the most experienced and agentic teachers still require support to cross borders at curricular intersections.

**Table 7.1: Overview of the Focused Codes and Theoretical Categories**

| | Prior to Being Offered Support | Being Offered Support |
|---|---|---|
| **Development of Focused Codes** | **Positioning of Digital Technologies** | |
| | Digital technologies enabling the teaching of science inquiry skills | Digital technologies paving the way forward to experiment with distinct pedagogical practices |
| | **Positioning of Self** | |
| | Approaching teaching as a craft | Developing pedagogies at the intersection of science and digital technologies |
| | **Positioning of Students** | |
| | Requiring support as a border crosser | Requiring support to make the abstract visible by modeling metacognitive strategies of self-directed learners |
| **Theoretical Category** | **Teaching as Experiment** | **Pedagogy Maintaining Equilibrium** |

## 7.2 Before Teaching Year Nine Geoscience: Teaching as Experiment

Charlotte's professional duties prevented her from constructing her PMMM, shown in Figure 7.2, with other participants. Apart from clarifying the meaning of 'digital technologies,' her reflections seem to highlight the possibilities of how digital technologies could be utilized in different ways. For instance, Charlotte reflected on the potential for collaboration using Edmodo, the educational social networking software, bulletin board websites such as Padlet and Google Docs, an online software similar to Microsoft Word. Charlotte also indicated that Riverside's growing Science Technology Engineering Arts and Mathematics (STEAM) program could provide inspiration for subject-based activities by incorporating 3D printing into a year seven ecology unit.

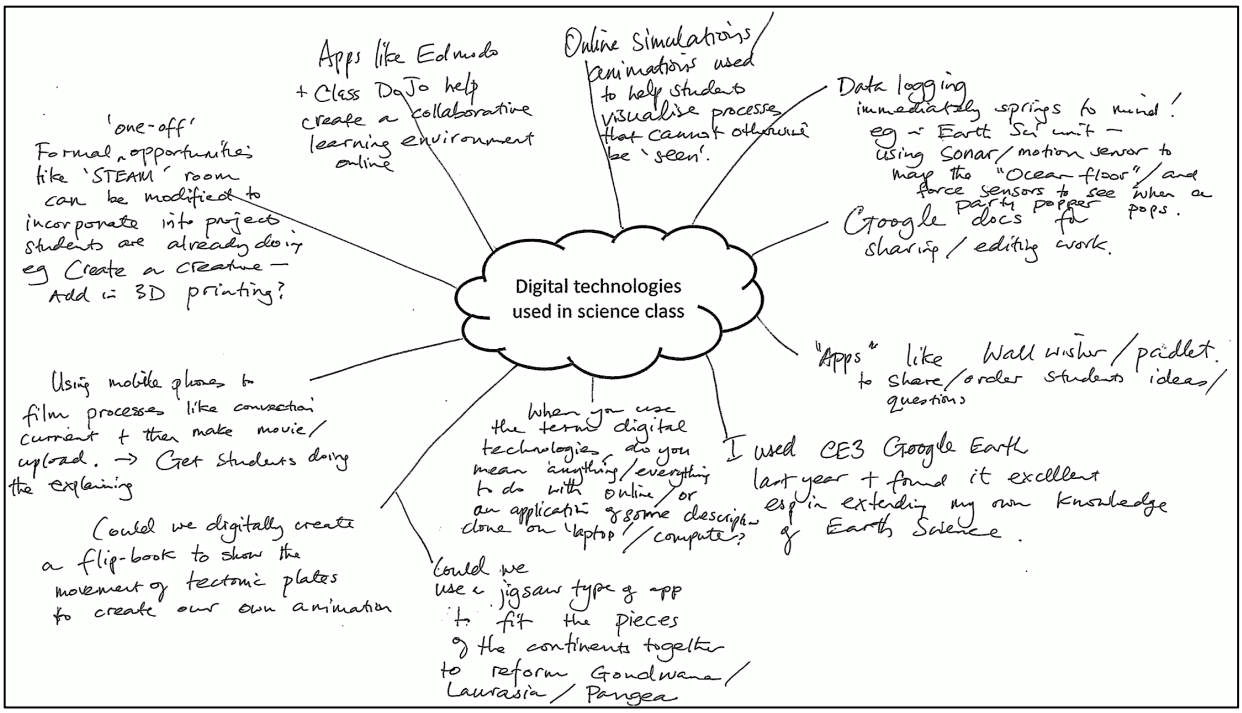



**Figure 7.2: Charlotte's Personal Meaning Making Map from August, 2016**

Of note is Charlotte's focus on the potential for digital technologies to be utilized in geoscience, perhaps anticipating her participation in this research and also inspired by her daughter's interest in rocks and minerals. In 2015, I trialed digital technologies suitable for this research with my year nine class and shared some Cyber-Enabled Earth Exploration (CE3) curriculum activities (Almquist et al., 2012; Blank et al., 2016; Blank et al., 2012) with Riverside teachers. The data and analysis presented in chapter five explained that Charlotte seemed to have an acting awareness for digital technology use in geoscience. As such, she was empowered to assume a personal and professional duty to explore them in this OOF area. Charlotte indicated satisfaction (Krathwohl et al., 1980) using these resources in terms of developing her 'own knowledge.' Independently, she also investigated the use of data loggers for students to perform practical experiments and model sea floor mapping. In addition, Charlotte reflexively positioned (Harré & van Langenhove, 1999) herself as part of a group of teachers who were willing to take risks to adapt well-known classroom activities for a digital learning environment. Using the pronoun 'we' to indicate group membership she inquired:

*Could we use a jigsaw type of app to fit the pieces of continents together to reform Gondwana/Laurasia/Pangea?*

*Could we digitally create a flip-book to show the movement of tectonic plates to create our own animation?*

Charlotte's personal and professional duties to explore the CE3 activities, try new teaching approaches with data loggers and reflect on the possibilities for digital technology use in science suggest that she was conducting an ongoing pedagogical experiment enabling her to 'have fun' but also to try new approaches to learning science that may inspire 'those few sparks of kids.' Within the Riverside local moral order, teachers are expected to utilize common assessment tasks across year levels, however they are respected as professionals and permitted to explore different pedagogical practices. For Charlotte, the local moral order seemed to strengthen her sense of agency by permitting her to perform pedagogical experiments that she, as a professional, perceived to enhance the learning experience and offer enjoyment for both herself and her students. How then did Charlotte position the digital technologies, herself and her students prior to teaching geoscience?

### 7.2.1 Digital Technologies Enabling the Teaching of Science Inquiry Skills

For Rokeach (1968) beliefs are predispositions to action with cognitive, affective and behavioral components. Attitudes arise out of clusters of beliefs that can advocate action or inaction. In Table 7.2 some examples of Charlotte's *reflections*, their initial codes and her **beliefs** about digital technologies are presented and analyzed along the positioning triad to form the focused code: Enabling the teaching of science inquiry skills.

## Table 7.2: Digital Technologies Enhance the Learning Experience

Enabling the teaching of science inquiry
**Enhancing Belief**

*Um, uh, it [digital technology] makes a lot of things so much easier that you can get to the point. [...] You can analyze the data so much more readily and get the kids thinking more scientific[ally], you know, thinking at a deeper level, I reckon.*

Charlotte reflects on what drives her to utilize digital technologies. She explains that digital technologies make teaching 'easier' because they enable her to attend to what she perceives to be the most important professional duty (Harré & van Langenhove, 1999) of a science teacher: teaching science inquiry skills. Throughout our first interview, Charlotte reflected on different ways that digital technologies enable her to attend to this duty. These included introducing year seven students to pivot tables in Microsoft Excel to analyze height; using mobile phones to take and share pictures of microscopic cheek cells in year eight; producing video to film and explain convection currents in year nine; and studying inheritance patterns in year 10 using simulations to 'breed' fruit flies. A sacred story, the theory-driven view of practice, seems to emerge: ***Digital technologies enable teachers to challenge students to think scientifically by collecting, analyzing and evaluating data to communicate understanding about the natural world***.

Being able to do many activities without digital technologies
**Deflating Belief**

*[W]ith a lot of these things we could do it all the old-fashioned way there's very little you that can't do the old-fashioned way.*

Charlotte and I were discussing digital technologies that may enable students to create new ideas. She seemed to overclaim for the creative potential of digital technologies when she said: 'They all can, I reckon.' I invited Charlotte to consider an alternative perspective suggesting that many classroom activities could be done without digital aides. Here Charlotte shares a deflating belief: digital technologies offer 'very little' when compared to 'old-fashioned' methods. This appears to be a cover story that, despite championing tried and tested non-digital pedagogies, detracts from Charlotte's sacred story shared above. This cover story, however, exemplifies the complexity of the evolving teaching experience as Charlotte negotiates tried and tested non-digital practices with the expectations to utilize digital technologies from policy, administrators, parents and students.

Enhancing the learning experience
**Enhancing Belief**

*..... It's not a need, .... it's a can. It's not like 'have to' 'cause you don't have to do anything, you can meet your educational objectives in other ways, but as teachers we like to enhance the learning experience and, uh, that's what they [digital technologies] do. They enhance the learning experience, you know. Um, and I think that's the most important thing.*

Charlotte took time to think for almost 10 seconds before reflecting on whether digital technologies are needed to teach science. She acknowledges that teachers have the right (Harré & van Langenhove, 1999) to pedagogically engineer lessons for students to meet educational objectives in distinct ways. Charlotte speaks on behalf of teachers when she says: 'we like to enhance the learning experience.' In this way, she draws on the sacred story by positioning teachers with the personal and professional duty to seek out and pursue alternative practices with pedagogical value. As such Charlotte positions digital technologies as material objects that enable her to assume this duty and enhance students' learning experiences.

Overall Charlotte expressed more enhancing than deflating beliefs about digital technologies, but she refrained from overclaiming for their learning potential. Charlotte identified deflating beliefs that were shared across all 10 Riverside participants. These included positioning digital technologies as distractions for students while at the same time enabling students to submit work that may not have been their own. Like some of her colleagues, Charlotte also questioned the benefits of utilizing digital technologies instead of pen and paper. These deflating beliefs should not be viewed as compromising Charlotte's use of digital technologies but may enable her draw on the accepted practices of the local moral order to more selectively choose technologies that align with her pedagogical beliefs.

For Charlotte, a science teacher's most important duty is to teach science inquiry. Her reflections in Table 7.2 seem to position digital technologies as tools that enable her to assume this duty. A sacred story emerges: ***Using digital technologies to teach science inquiry helps me achieve my personal right to have fun in the classroom and professional duty to invite students into the inquiry process***.

In 2015, I shared some of the Cyber-Enabled Earth Exploration (CE3) inquiry activities with my colleagues. Charlotte seems to have perceived being introduced to these Google Earth resources as another opportunity to explore alternative classroom practices both in her own time and with her year nine class. She reiterated the importance of utilizing digital technologies to teach science inquiry:

> *No, I think the depth, so for example with Google Earth, the fact that you can take, uh, the, um, you can have a bird's eye view or you can have the elevation and you can see how, like, volcanos you know, what steep sided, um, co-, you know what kind of volcano it is and all of that kind of stuff. I think that-that would be very hard to do non-digitally [...]*

Charlotte clarifies that utilizing digital technologies is not simply about making her job easier. Her moments of hesitation and use of paraverbals seem to indicate that she is traversing a new language environment to describe how she is able to assume a professional duty that may be impossible without digital technologies. She explains how Google Earth and the CE3 curriculum guide students to collect qualitative and quantitative data, including observing and classifying rocks and taking elevation profiles of volcanos. Students analyze these data to categorize volcanos by type and explain the eruption process past, present and future.

Overall, the Riverside local moral order appeared to contribute to strengthening Charlotte's personal agency to enact her sense of empowerment as she assumed self-identified personal and professional duties to experiment with digital technologies in ways that invited her students into the inquiry processes of scientists. As such Charlotte's attitude toward digital technologies and the emerging sacred stories were raised to the focused code: Digital technologies enabling the teaching of science inquiry skills. How, then, did Charlotte position herself to enact her sense of agency as she utilized digital technologies in her classes?

### 7.2.2 Approaching Teaching as a Craft

In section 7.2.1, Charlotte's reflections indicated that although digital technologies enabled her to invite students into science inquiry, she seemed to be navigating an evolving pedagogical environment as she explored digital and non-digital classroom activities. In our first interview, Charlotte reflected:

> *I don't think we've come to terms with what having a digital device means in the classroom every single lesson*.

Using 'we' Charlotte reflexively positioned herself again as part of a group of educators with a personal and professional duty to reflect on the learning environment. I asked Charlotte who is responsible for the use of digital technologies and she explained:

> *Oh, I think the teacher's responsible for it always. The teacher's responsible for everything that happens in the classroom [...] I've gotta say that, for me, I will use stuff that other people have done without going through every single thing, but I've learnt enough to check the websites and see 'cause often the links have expired or they're no longer maintained or whatever, and I've had a few times where you get to a page and it's just-and you go: 'Oh, was that all it is?' You know, it's a bit of a let-down-type moment but yeah it's up to the teacher always to be.. making sure that what you want to achieve in the classroom is gonna work.*

Using the personal pronoun 'I' indicates that this reflection signals ownership and is deeply personal as Charlotte highlights the complexities of the lived teaching experience. To members of the wider community who have shared, generic expectations of teachers, but do not serve within the profession, it might seem obvious that the teacher is responsible for what happens in the classroom, including how and for what purpose digital technologies are used. However, not all teachers assume this duty and when they do the extent to which

it is attended to may be reflected by a teacher's technological and pedagogical knowledge (Koehler & Mishra, 2009). Chapters 8, 9 and 10 draw on the experiences of Rachel, Ethan and Isabelle to exemplify variations in teacher responsibility for digital technology use.

Above, Charlotte was reflecting on an accepted secret story within the teaching profession: ***I'm trying to balance my time between attending to students, lesson planning and administrative tasks that all vie for my attention***. When Charlotte says: 'I will use stuff that other people have done without going through every single thing,' she is reflecting on a personal sense of oughtness (Linehan & McCarthy, 2000) to trial resources and make professional judgements about whether or not they enable students to successfully meet learning outcomes. At times the intention to thoroughly investigate others' resources may be compromised by time commitments to more pressing professional duties. Charlotte, however, adapts to these time constraints by ensuring websites are accessible and suited for purpose.

Not all digital technologies are created equally and, for Charlotte, there seemed to be one particular digital technology that she would always make time to explore: data loggers. When Charlotte was assigned the role of Science Coordinator in 2013 Riverside's Parents' Association awarded her $10,000 to purchase data logging equipment. This included the hardware and software to measure temperature, potency of hydrogen (pH), light transmittance, force as well as various gas sensors. According to Charlotte, this was her 'biggest contribution to the school.' She reflected on a personal and professional duty to teach with data logging equipment when she said:

> *I'm always, <u>always</u> looking for an opportunity to use them 'cause they're my little babies, you know. And I love them, you know, um, and other people are just like: 'Yeah, whatever.'*

As Science Coordinator, Charlotte set aside time in faculty meetings for teachers to learn how to use data logging equipment by taking part in demonstrations and experiments. Unfortunately, these endeavors were not as successful as Charlotte had expected. Despite expressing personal commitment (Krathwohl et al., 1980) to using the equipment, Charlotte's colleagues appeared indifferent toward incorporating it into their practice. Riverside's local moral order, including past discursive practices, can serve to explain why data logging may not have drawn the attention Charlotte expected. Although

some Riverside teachers may have had professional experience with data logging, utilizing this type of equipment in the classroom was not a standard practice. In our interviews Charlotte reflected on the importance of practice and success as a determining factor when bringing digital technologies into the classroom:

> *[I] like to have a little go at the things myself before I try and get the students do it 'cause then I've got an idea of actually how hard it is. [...] I think that's really important for teachers to have an understanding of the I-don't-get-this feeling so that you can get past that yourself and lead your students to where you want them to go.*

Unfortunately, Riverside teachers may not have experienced practice and success to the extent that they believed they had the capacity to incorporate data logging into their lessons. Furthermore, in 2013 Riverside teachers had not yet been tasked with formally documenting the curriculum. If teachers were using data loggers with their students, these practices may have remained hidden within the private classroom space, a further hindrance to developing standard practices.

Apart from Charlotte's self-identified duties to trial digital technologies prior to introducing them in the classroom and exploring how to integrate teaching science inquiry with data loggers, how did she position herself as a teacher using digital technologies? Table 7.3 exemplifies how Charlotte's *reflections* were initially coded and how her **beliefs** about self were identified and analyzed. Charlotte's attitude, teaching is a reflective profession, as well as the secret and sacred stories emerging were raised to the focused code: Approaching teaching as a craft.

## Table 7.3: Teaching is a Reflective Profession

| |
|---|
| Wanting to get away from standing at the front<br>**Deflating Belief**<br><br>*I still think, you know, for-for me my own teaching is a little bit too much stand up the front and me talking and kids listening and then asking questions when they need to. I wanna get away from that, you know?*<br><br>This reflection is deeply personal for Charlotte. She draws on the pronouns 'I,' 'me,' and 'my,' throughout to reflect on a personal sacred story: ***There's too much teacher talk in my classroom.*** Charlotte identifies an expectation that students assume the duty to ask questions 'when they need to' and at the same time a right for students to participate more in knowledge construction. In this way, Charlotte identifies the importance of reflection on her professional practice and that, even after two decades, pedagogical development is an ongoing, dynamic process. |
| Being proficient with Excel and Taking digital technologies too far<br>**Deflating/Enhancing Belief**<br><br>*[...] I thought: 'I think that was a bit too much.' A bit too much, but I was excited because I had taught myself how to do it [use frequency histograms and pivot tables] so I wanted to teach them [students] how to do it.*<br><br>Charlotte explained how she taught year seven students to create and use frequency histograms and pivot tables to analyze height measurements in Microsoft Excel. After seeking assistance from mathematics teachers, who were unaware of these affordances, Charlotte reflected: 'I just had to go online.' Charlotte's use of 'just' signifies a high level of self-efficacy (Bandura, 1989) to journey into the unknown and solve a problem others may have deemed no longer worthy of their time. Charlotte seemed to draw on the technology of the self (Foucault et al., 1988) to transform her own understanding of Excel and classroom practice. In doing so she attended to a self-identified duty to extend her students, an endeavor which gave her satisfaction. Using Excel in this way was an uncommon practice within the Riverside local moral order. In junior science classes students are typically taught to gather small data sets and create bar or line graphs. Charlotte shares a deflating belief when she confesses that the activity 'was a bit too much.' Although she seemed to draw on enhancing beliefs about self to incorporate these affordances of Excel, Charlotte's personal agency to utilize the activity again may be compromised because despite 'everyone' being able to use these affordances, students were not going to use it in other learning areas 'even in <u>all</u> of their secondary schooling.' |
| Knowing purpose for digital technology use<br>**Enhancing Belief**<br><br>*Um, I-and I know, for-for example, when I'm using things like data logging in my classroom I know exactly what I want the kids to get out of it. [...] So, as scientists, we want to say what was the difference between this and that, what caused this difference? Was there a difference? Et cetera. Whereas over here [in the STEAM program] I don't see this as being a direct-this is not a directed end, this is creativity, this is like sandpit department. What-build whatever you want to build, make whatever you want to make, let's-just take it wherever you want to go with it.*<br><br>Charlotte compares digital technology use in science with Riverside's STEAM program suggesting that the learning outcomes for digital technology use in each space are unique. In the first part of the turn Charlotte positions both herself and students as scientists, indicating the value she ascribes to teaching science inquiry skills. As such Charlotte has a duty to clearly define the purpose for integrating data logging into her classes. Charlotte describes the sacred story, the story of practice, as she explains how she uses the data loggers to teach students about precision, accuracy and reliability. This is not to say that Charlotte devalues STEAM pedagogies, but for her they do not enable her to meet the professional duties of a science teacher. |

The reflections in Table 7.3 speak to Charlotte's attitude toward self and the teaching profession more so than her self-identified capacity to produce lessons and manipulate digital technologies. The sacred story that seems to emerge is: ***To meet my self-identified duties to extend students and teach science inquiry skills, I understand that crafting pedagogy is an ongoing and reflective practice***. Collectively these reflections exemplify Charlotte's commitment to developing her craft, a task that can sometimes leave her unsettled. She explained:

> *You know, sometimes I do feel like I'm reinventing the wheel because I've forgotten where all my spokes are.*

Here, a distinction should be made between teaching as a job and teaching as a craft. Teaching as a job is the static role that positions a person on paper with a pre-determined list of rights and duties as part of a contractual agreement. Individuals who are not members of the teaching profession and may assume that a person has chosen to become a teacher for the perceived holiday benefits understand teaching as a job. Teaching as a craft, however, includes both the personal and professional duties teachers attend to that, although may be part of the contractual agreements they sign, are also the manifestation of an individual's moral values, a sense of oughtness (Linehan & McCarthy, 2000).

Teaching as a craft encompasses the creative and experimental component of the profession of teaching, where, to attend to these values, a teacher seeks out opportunities and resources to reflectively develop her/his practice. Charlotte's reflections exemplified thus far seem to indicate that she approaches teaching as a craft. In addition, these duties may diverge from the accepted practices of the local moral order when an individual feels a sense of empowerment to enact them. Charlotte's use of the data loggers, her uptake of the CE3 activities and use of Excel in year seven exemplify her sense of personal agency driving her to reflectively integrate digital technologies into her science classes. At the same time, however, the local moral order, may compromise development of a continued practice when expert technology users do not envision uptake from within and beyond the learning area.

### 7.2.3 Requiring Support as a Border Crosser

Similar to her early-career colleagues, Ethan and Rachel, Charlotte could readily identify the digital skills students were expected to develop, but unlike her they seemed to make decisions to utilize digital technologies based on their students' perceptions of them. After reflective evaluation if Charlotte perceived a misalignment between her personal and professional duties and the intended use of digital technologies, she appeared to assert her right to seek out alternative pedagogies and/or resources that would better enable her to meet these duties.

In this section Charlotte's perceptions of her students' use of digital technologies are exemplified and analyzed to explain how she negotiated teaching with digital technologies. Of note is that prior to teaching geoscience Charlotte did not share as many beliefs about her students as she had shared about digital technologies or herself. This may have been due to her belief about the purpose of schooling, 'to have fun,' and because she did not perceive utilizing digital technologies in the classroom as a 'need,' but a 'can.'

Table 7.4 exemplifies some of Charlotte's *reflections* about her students' digital technology use, shows how these reflections were initially coded and identifies the types of **beliefs** she expressed. Charlotte's attitude toward her students' digital technology use and the emergent secret and sacred stories have formed the focused code: Requiring support as a border crosser.

## Table 7.4: Students Can be Distracted but also Enable Teacher Risk Taking

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| <u>Being distracted in the classroom</u><br>**Deflating Belief**<br><br>*Uh, so-so maybe we need more of this, like, freedom over in the regular classroom to bring that joy of creativity and discovery, et cetera back into it. And maybe we are just too formal, but then, you know, I know from experience that if you're not, you know, snapping at their heels all the time, they-they'll [students] just goof off and they'll be looking at Buzzfeed [...]*<br><br>Charlotte explains the difference between teaching science and the STEAM program. Within Riverside's local moral order, teachers' professionalism is respected, as such they have the autonomy to draw on their preferred pedagogical practices in the classroom provided students in each year level complete the same assessment tasks. When Charlotte speaks about 'freedom' in the classroom, she uses 'we' to reflexively position herself as part of a group of teachers enacting an accepted secret story: ***We may strain to negotiate a balance between content delivery and inquiry-based learning***. For Charlotte, the pervasiveness of digital technologies adds to this complexity as she feels positioned with a duty to closely monitor students for whom the temptation of social media and popular websites overtakes their ability to self-monitor and stay on task. |
| <u>Some cohorts enabling teacher risk taking</u><br>**Enhancing Belief**<br><br>*Yeah, I think that you can extend them [students]. I mean you wanna extend them and they want to be extended. And those, like, it's not as if there's anyone saying: 'Why do we have to do this?' You know? Nobody said that. You know, they're going: 'Oh, God, I never even knew you could do this with Excel.' You know, they had never even used Excel before.*<br><br>In contrast to the previous reflection, Charlotte shares an enhancing belief about students and their digital technology use. Overall, Charlotte was careful not to overclaim that students know how to use their devices in the science classroom but she did reflect 'they know how to use Word, they know how to use Excel to a lesser degree.' Here, she continues to reflect on how she taught year seven students to use frequency histograms and pivot tables with 'an exceptional year level.'<br><br>In the first part of the reflection, Charlotte identifies a duty for teachers to want to extend their students which, for her, seems to be in symmetry (Harré, 2012) with students' rights to be extended. For this group of learners, who had never used Excel, Charlotte positions them as 'wanting to be extended.' She perceived her students as accepting this positioning which may have empowered her to take risks producing an inquiry-based activity to enhance the lesson and enable students to experience satisfaction. In this way, Charlotte's students' acceptance of her positioning appears to have strengthened her sense of agency to take greater pedagogical risks knowing that students may never use these affordances of Excel again. |

The reflections in Table 7.4 seem to contradict one another and, to readers outside the profession, may position students with rights and duties reminiscent of the unpredictable Dr. Jekyll and Mr. Hyde. Although Charlotte's reflections appear to be about students, they exemplify the complexity of teaching with digital technologies and the moment-to-moment decisions teachers make in the classroom. As such they may be more telling of a teacher's evolving personal and professional duties. Charlotte explains how

secret stories, of teachers' frustration to compete with popular media outlets, games and social networking, are in tension with the sacred stories of best practice whereby teachers harness the affordances of digital technologies to enable students to meet learning outcomes.

Charlotte appears to have positioned herself as a border crosser traversing an uncharted environment. She reflected that although we, as professionals, have not '[come to] terms with what having a digital device means in the classroom,' at the same time she drew on the accepted practices within the local moral order to assume the duty to experiment with digital technologies. As such Charlotte seems to question whether the benefits of utilizing digital technologies with particular cohorts, including feeling a sense of empowerment to produce and manipulate (Foucault et al., 1988) digital lesson plans, will outweigh the costs such that students meet the learning outcomes.

Charlotte also reflected on another tension she faced as a border crosser. For her, access to the Internet provided an opportunity for students' questions to be 'answered immediately by themselves,' but she also understood that her students' understanding may have been hindered both by their own science literacy skills and the advanced communication practices of users who produce science content. She reflected:

> *[T]hey [students] can just Google anything at any point in time, but often a lot of what they Google is not accessible to them because it is not at a level that they can understand. [...] I think their reading skills are a lot to do with their ability to access that stuff.*

Charlotte's colleagues also reflected on this tension when they tasked students to complete Internet research. Unlike some colleagues, though, Charlotte reported that she assumed a professional duty to seek out websites that would be accessible to students. The time it took Charlotte to attend to this duty, however, left her with a feeling of resistance and perhaps outright rejection of it. She explained:

> *[...] I find myself getting sucked into a black hole. And I emerge after an hour and a half, like, glazed over. And it just kills me. So, yeah, it's my responsibility to choose probably three good ones, but it takes me so long to do it that I resist.*

Compared to her colleagues who expressed similar deflating beliefs about students' ability to perform Internet searches, Charlotte was the only teacher to propose a solution.

She identifies an opportunity for technology companies to help reduce the time pressure on teachers assuming a duty to curate accessible information for students:

> *If you could just, I don't know, have a particular kind of filter that blocked out sites that are too advanced versus too basic to say: 'These are the websites here that are going to give you something useful' [...]*

Charlotte's solution, however, is fraught with ethical issues requiring consideration. These include investigating how computer algorithms would be written to choose information offered to students and whether this information enables students to understand the conventions of effective science communication and implications for variety of stakeholders.

Charlotte concluded the turn above with:

> *I don't think we should have devices being used in every single class at all. I think that they [students] should, I-I personally would prefer them to be doing notes and thinking stuff in the old-fashioned write-it-in-your-log-book way [...]*

In addition to Charlotte's attitude toward her students' digital technology use and the secret and sacred stories shared above, this final reflection seems to further indicate that although Charlotte is a teacher proficient in the use of digital technologies, she still requires support to develop pedagogies enabling her to cross pedagogical borders between the digital and non-digital space.

### 7.2.4 The Emergence of a Theoretical Category: Teaching as Experiment

For Rokeach (1968), a value is a single belief that guides actions and judgements 'beyond immediate goals to more ultimate end-states of existence' (p. 160). In their taxonomy of the affective domain Krathwohl et al. (1980) propose that the act of valuing an object or situation can manifest across a spectrum from acceptance of to preference for and finally commitment to a value. At the level of commitment an individual actively seeks instances to respond such that the value becomes part of her/his identity and guides standards for actions. Charlotte's reflections set her apart from Rachel, Ethan and Isabelle because, for her, teaching science is primarily about 'designing experiments and knowing how to.' As such Charlotte appeared to be guided by a sense of oughtness to attend to a duty to teach science inquiry skills. Her pedagogical use of digital technologies seemed to

reflect a commitment to this value spanning beyond technology integration toward technology-enabled learning.

The theoretical category teaching as experiment is grounded in Charlotte's positionings of the digital technologies, self and her students. Prior to participating in this research Charlotte seemed to draw on the technology of the self and was highly empowered to reflectively manipulate and produce lessons with digital technologies, especially data logging equipment and software. In addition, she interpreted social signs (Foucault et al., 1988) from colleagues within the local moral order to explore Google Earth and Google Docs with her students. As such Charlotte appeared to be agent of change even before beginning the geoscience unit and her reflections imply that she may perceive teaching as an experiment.

Teaching as experiment is pedagogically risky as teachers make hypotheses about the potential success of teaching approaches and resources intended to enhance students' learning experiences. Should a hypothesis be disproven, the teacher, as experimenter, may need to redesign the activity, seek additional support to cross borders with new pedagogies and/or resources or abandon activities altogether. As such, tension may arise at the intersection between what is possible and what actually happens in the classroom as teachers strive to maintain a sense order and continuity to the lessons that is expected by students, parents and administrators. However, teaching as experiment affords teachers the opportunity for both personal and professional growth as they draw on their own creativity to seek out resources and engineer lessons in ways that enable them to challenge not only themselves but also their students.

The following reflection seems to exemplify tensions associated with teaching as experiment:

> *I knew it [teaching students about frequency tables in Excel] was possible and we'd been talking of-like it was an obvious extension of what we were doing in year seven [...] I got a kick out of teaching everyone how to do it and just follow the instructions [...], but the fact that they're not going to use that again even in <u>all</u> of their secondary schooling, I thought that's pretty [inaudible] a bit [inaudible].*

In the first part of the turn, Charlotte displays her technological knowledge (Koehler & Mishra, 2009) and defers to her professional duty to deliver state-mandated curriculum. She hypothesizes the pedagogical value of introducing these affordances of Excel into the

classroom as 'an obvious extension' of the curriculum. Charlotte began the reflection with conviction but her confidence appeared to dissipate to almost a whisper at the end of the turn. Although the accepted practices of the local moral order enabled her to take pedagogical risks that inspired a sense of satisfaction, Charlotte may question whether the endeavor attended to students' rights to be prepared for future learning experiences when they were 'not going to use that again.' In addition, she seems to trivialize the experience as her reflection distilled the activity to 'follow[ing] instructions.'

Teaching as experiment may also offer teachers the opportunity to delve into the unknown. However, Charlotte asserted her right to choose which digital technologies to incorporate in the classroom based on her personal preferences for digital technology use. Unlike Rachel, who regularly listens to podcasts and wonders if podcasting would help students learn more about science, Charlotte reported that she would not incorporate podcasts into lessons because 'I don't have the patience to listen to a podcast.' Here lies an opportunity to provide Charlotte with support to possibly introduce both her and her students to new practices for engaging with scientific communities beyond the classroom.

The previous sections illustrate that Charlotte has a high capacity for digital technology use and is empowered to produce lessons and transform (Foucault et al., 1988) her practice utilizing digital technologies to further students' science inquiry skills. What does it mean, however, for a teacher to grow when she already asserts her personal sense of agency to experiment with pedagogical practices and has experienced success, if there is any growth at all? With support through social signs and scaffolds from colleagues and the wider community of teacher educators, teachers like Charlotte may be invited to experiment with pedagogies and resources not previously employed and which may challenge some beliefs on the periphery of a teacher's belief system. The next sections draw on Charlotte's perceptions of digital technologies and both her and her students' use of them as she was invited to explore teaching an OOF unit of geoscience to better understand whether there were changes in her practice.

## 7.3 Teaching Geoscience: Pedagogy Maintaining Equilibrium

The previous sections indicated that Charlotte approached teaching as an experiment. As such she seemed to ascribe herself the personal and professional duty to seek out and reflectively modify her use of digital technologies to improve her classroom practice, in particular with respect to developing her students' science inquiry skills. In 2015, Charlotte trialed Google Earth and some of the CE3 (Almquist et al., 2012; Blank et al., 2016; Blank et al., 2012) inquiry-based activities. Reflecting on this pedagogical experiment in 2016 she explained:

> *I love the, um, that you could immediately access the, um, the geostationary beacons and that you could access that data. [...] And I also, like for me, I loved the fact that they had all of the questions there for the kids but also the answers for the teachers as well, you know, and the way that they scaffolded the kids through: 'Here's the data. What does the data say? Collect the data and then analyze it.' So, um, so I-I felt like I was being taken through that process myself with, um, lots of support.*

The first part of this reflection is indicative of the values alignment between Charlotte's self-identified seminal duty as a science educator and the learning outcomes of the CE3 curriculum, developing students' inquiry skills. In the second part of the reflection Charlotte expresses satisfaction when she explains that the activities were designed to scaffold both students and teachers with technical and content-based support. In this way, the CE3 curriculum seemed to enable Charlotte to attend to her personal and professional duties to teach science inquiry skills at the intersection of the science and digital technologies curricula.

As a participant in this research, Charlotte, an empowered digital technology user with an acting awareness of digital technologies for use in geoscience, volunteered to teach the year nine geoscience unit alongside her colleague and year seven co-teacher, Ethan, an early-career teacher and novice user of digital technologies in science. Over seven weeks in term four, they both participated in five CIDs and focus group interviews. Each focus group was followed by an individual interview. During this time, I was invited to observe eight of Charlotte's classes and offer her support as needed.

Vignettes 7.1 and 7.2 exemplify memos written in the first two weeks of the unit. They explain how Charlotte seemed to continue to draw on the technology of the self as an

agent of change in this self-identified OOF unit of work and that she maintained a professional duty to develop students' digital skills for technology-enabled learning.

### Vignette 7.1: Feeling Empowered to Modify Lesson Plans

Charlotte's class is studying geological time. She began the lesson with a modification: 'I'd like to share with you some of my most precious things,' ammonite fossils. 'When you look at these things what do you think? Do they look like normal rocks? How old do you think they are? When did these things live?' With these questions Charlotte drew students' attention to the geological time scale. She also showed a video of David Attenborough explaining the emergence of animal life on Earth between 570 and 540 million years ago. Based on the lesson plan provided her students were then offered three differentiated activities to construct scale models of the geological timeline.

Charlotte's choice to modify the lesson was surprising because it illustrated a mismatch between her discursive practices, the say and the do. As the unit was being designed, I met with teachers to discuss a timeline and appropriate sub-topics. Charlotte suggested a conservative timeframe for teaching geological time, no more than one to two lessons. The secret story that appeared to emerge was: ***We're already struggling to deliver a congested curriculum***. However, when Charlotte began teaching the unit her practice indicated a shift from the secret to the sacred story. She seemed to be empowered to spend more time teaching this sub-topic while incorporating additional resources. In this way, Charlotte assumed the duty to offer her students thought-provoking learning experiences while asserting her right to 'enrich' her own teaching experience.

### Vignette 7.2: Being Responsible for Teaching Digital Skills

Charlotte's class is starting their first CE3 activity to study geographic features and eruption patterns of volcanos. First, she demonstrates how to access the .kmz file from the Google Drive. Two weeks in, some students seamlessly do this, while others need to be reminded to 'look at the board' for instruction. Charlotte uses the instructional videos I created to show students how to interpret and manipulate Google Earth's sign systems (Foucault et al., 1988), icons and buttons, to view geographical features and collect data. She does this while connecting these instructions to the purpose of the lesson: To be able to study the features of known volcano types and classify 'unknown' volcanos.

Charlotte's discursive practices are significant because they set her apart from her novice colleagues who seem to separate themselves as facilitators of learning by relinquishing a duty to scaffold students in this way. Although students have been provided the resources and instructions prior to the lesson, Charlotte plans for explicit instruction. She draws students' attention to buttons and markers that enable them to view and engage with datasets while making explicit connections to the purpose of the lesson. In this way, Charlotte indicates a sense of personal agency as she reflexively positions herself as a facilitator and demonstrates her technological pedagogical content knowledge (Koehler & Mishra, 2009) by connecting the use of the digital technologies to the practices of geoscientists.

Charlotte's reflection at the beginning of this section and the vignettes above exemplify her proficiency with familiar digital technologies. These technologies enabled Charlotte to attend to personal rights and professional duties to enhance lessons both for

herself and her students. However, section 7.2 explained that Charlotte seemed to require support to cross borders and explore pedagogical possibilities with unfamiliar digital technologies. Google Drive seemed particularly important because Charlotte identified cloud computing to be the 'biggest' hurdle. The following sections exemplify and explain how Charlotte positioned the digital technologies as well as herself and her students as she taught the year nine geoscience unit.

### 7.3.1 Paving the Way Forward to Experiment with Distinct Pedagogical Practices

Prior to teaching year nine geoscience, Charlotte's reflections in section 7.2.1 indicated that she positioned digital technologies as material objects that enabled her to invite students into the inquiry processes of scientists, in particular to collect and analyze data using data loggers and online simulations. While teaching year nine geoscience, Charlotte almost exclusively shared enhancing beliefs about digital technologies and many seemed to center on Google Earth and the CE3 curriculum, a use of digital technologies that has already been shown to align with Charlotte's pedagogical values.

Chapter six explained that one of the goals of this unit was to introduce teachers to technologies and pedagogical practices that they may not have previously explored. Approximately two and half weeks into the unit, Charlotte reported that she had utilized video in a pedagogically distinct way. The video she reflected on, an earthquake visualization map, did not explain scientific concepts to students, but used volume and pitch to represent data about magnitude and depth of earthquakes. Charlotte reflected:

> *You know, because when I originally saw that that video was nine minutes long and then it was just dots and blips I thought: '[...T]his is not going to sustain them [students] for nine minutes!' And I actually did a quick search to see, 'cause I had found a short video, it was only three or four minutes long, a pretty similar thing but it didn't talk about the depth, you know, but you could hear a blip every time there was a-an earthquake somewhere. But i-it wasn't-it wasn't depth related and-and it wasn't size related, it was just a single solitary bit.*

Charlotte explains her skepticism toward the video by deferring to students' rights to be stimulated in the classroom to which teachers, as professionals, may assume a symmetrical duty to attend to. As such, she sought out a shorter video, but was unable to locate one with similar learning opportunities. The sacred story that emerges seems to be: ***I'm assessing***

***resources for their pedagogical value by comparing and contrasting them with the learning outcomes of the lesson plan***. In the end, the original video was not only 'really stimulating' for students, but also enabled Charlotte to help them connect the magnitude and depth of earthquakes to damage at the epicenter, a seminal distinction between the terms magnitude and intensity.

For Charlotte, the most significant use of digital technologies that was distinct from her preferred teaching practice seemed to be the cloud computing software Google Drive including Google Docs and Sheets, similar to Microsoft Word and Excel. Table 7.5 shows how some of Charlotte's *reflections* about Google Drive were initially coded and classified using Rokeach's (1968) five types of **belief**. These reflections are then analyzed to form her overarching attitude toward this software. Charlotte's attitude as well as the emergent cover, sacred and secret stories about using Google Drive and exploring pedagogical practices were raised to the focused code: Paving the way forward to experiment with distinct pedagogical practices.

## Table 7.5: Google Drive Enables Me to Meet Professional Duties

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| Google Drive enabling easier management of information<br>**Enhancing Belief**<br><br>*Uh..... Oh... It's just-it's just so much easier to have everything in Google Docs and in Google Drive because-because it's a live copy. You know, you don't have to keep uploading new versions of it, um, and things like that so everyone knows that this is the latest up-to-date version [...]*<br><br>This reflection was shared a week and a half into the unit. Charlotte paused for some time to collect her thoughts about the digital skills she was learning and then confidently began with 'just' to express the simplicity with which cloud computing software could ease teachers' professional duties. Previously, Charlotte's reflections indicated that she assumed a professional duty to preview, trial and update resources shared with colleagues. These were accepted practices within the local moral order, but uploading revised documents to Compass, Riverside's attendance and learning management software, was time consuming and teachers often resorted to communicating changes through email. Here, Charlotte highlights an affordance of cloud computing, enabling teachers to attend to their self-identified duties to manipulate and transform (Foucault et al., 1988) resources 'live.' She draws attention to how Google Drive can minimize time spent uploading documents to Compass while ensuring that all teachers and students have access to updated files. |
| Google Docs enabling monitoring of student work<br>**Enhancing Belief**<br><br>*I would much prefer, rather than having a student upload a piece of work on Compass, I would rather just say: 'Share the link.' 'Cause then I can edit it so much more easily and if there's on the page I just write, you know: 'You don't 'seem to have started this. What did you do in your class time today?'*<br><br>In our final interview in 2016 Charlotte explains that the collaborative affordances of Google Docs not only enable her attend to a professional duty to offer students feedback, but also hold them accountable for their duty to utilize class time to complete set tasks. This situation could be interpreted as a teacher negotiating the boundary between teaching content and managing behavior, however this simplifies the pedagogical value of Charlotte's reflection. Within the local moral order students upload work to Riverside's learning management system, Compass, for formal submission. Charlotte's reflection seems to indicate that, through teacher-student collaboration, she may be able to place more value on the process of completing work by providing ongoing feedback to a live document. In this way, the sacred story that appears to emerge is: ***The collaborative affordances of the Google Suite enable me to value the process over product***. |

Charlotte's reflections in Table 7.5 suggest that, in the future, she may actively seek out opportunities to use Google Drive to manage time commitments engaging with colleagues while also providing continuous feedback to students. Of note is that earlier in the year Charlotte had explored the collaborative features of the Google Docs with groups of year nine students designing experiments for a major assessment task. However, she had not utilized cloud computing to the extent it was used in this unit. In our final focus group, she shared the following reflection with Ethan and I:

> *[...] I just really liked the way the kids have their notes online, they've made copies of their-of the files and that they can collaborate. I think the collaboration is a really good one. Um, you know, for me, to get the kids far more familiar with that.*

Charlotte explains that the sharing and editing affordances of Google Drive may strengthen her ability to attend to a self-ascribed duty to engage students in collaborative learning. Ethan, however, was more skeptical about the extent to which students utilized these affordances: 'I'm not sure my students collaborated a lot outside of the set activities [...].' Although both Ethan and Charlotte's sense of agency to utilize digital technologies in science differed, their students confirmed Ethan's perspective.

In addition, Charlotte's use of 'just' implies that collaboration may be easily implemented in the classroom simply by organizing notes and other files. A cover story emerges: ***I think the collaborative affordances of the Google Suite are 'good.'*** Yet the underlying secret story seems to be: ***I'm unsure how the collaborative affordances of cloud computing can add value to students' learning experiences.*** At this stage Charlotte may require more practice and support to produce and manipulate lessons drawing on the collaborative affordances of cloud computing.

Overall, when Charlotte perceived digital technology use to be aligned with what she identified as a science teacher's seminal duty, the technologies were positioned as enabling the teaching of science inquiry skills. Charlotte's reflections about her use of the collaborative affordances of cloud computing software, however, seemed to position these technologies as enabling her to meet professional duties to update resources in a timely manner and provide her students ongoing feedback. At the same time, Charlotte appeared to require additional support to produce and manipulate activities employing the collaborative affordances of Google Drive in pedagogically distinct ways to explore student-to-student collaboration. As such, Charlotte's attitude toward Google Drive and the emergent cover, sacred and secret stories were raised to the focused code: Paving the way forward to experiment with distinct pedagogical practices.

### 7.3.2 Developing Pedagogies at the Intersection of Science and Digital Technologies

In section 7.2.2, Charlotte's perceptions about self and her digital technology use seemed to express less about her capacities to utilize digital technologies and more about

her perceptions of teaching as a craft. Charlotte positioned herself with the personal and professional duty to reflect on her practice in pursuit of improvement. As a participant in this research, Charlotte indicated that teaching at the intersection of the science and digital technologies curricula and being invited to reflect on her practice enabled her to attend to these duties. During CIDs held in the first two weeks of the unit, Charlotte expressed satisfaction toward her use of Google Earth and Google Drive when she wrote:

> *I feel like I am consolidating what I know/how to use Google Earth and Google Drive.*
>
> *I am also learning a huge amount about how to improve my use of Google Earth as a teaching tool.*

To better understand Charlotte's experiences with both Google Earth and Google Drive in addition to other unfamiliar digital technologies Tables 7.6 and 7.7 exemplify some of her *reflections* and explain how they were analyzed. In both tables the initial codes are presented and the types of **beliefs** Charlotte expressed are identified. Table 7.6 presents Charlotte's attitude about self as she utilized Google Earth with the CE3 curriculum, resources she had practice with in 2015. Table 7.7 focuses on digital technologies that Charlotte was less familiar with. These attitudes and the secret and sacred stories emerging have been raised to the focused code: Developing pedagogies at the intersection of science and digital technologies.

**Table 7.6: I am Learning to Use the Affordances of Google Earth and Continue to Develop my Pedagogical Content Knowledge**

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|---|
| Feeling confident with repeated use of Google Earth<br>**Enhancing/Deflating Belief**<br><br>*I didn't do the volcanos one [CE3 activity] last year. Alright? So, I'm not only getting to know my way around Google Earth with much greater confidence, but it's also helping me consolidate, like, I wouldn't-I didn't know anything about volcanos before I started. [...] So, uh, it's having, you know, I-I've increased my own content knowledge but I have also improved my pedagogical content knowledge because I've got a better sense of how to structure it for them [students].*<br><br>This reflection was shared in the second week of the unit. Charlotte begins by explaining that her technical capacity to manipulate Google Earth is improving, an enhancing belief about self. She defined 'not going home moments' as times when she experienced small technical problems that she was able to troubleshoot. For instance, right clicking to access the website for videos that were displaying incorrectly.<br><br>In the second part of the reflection, Charlotte draws on 'I,' 'me' and 'my' to share a personal shift from a secret to sacred story. For Charlotte, the secret story reflecting a deflating belief about self was: ***I don't know anything about volcanos***. Through her sense of oughtness to attempt the activity, though, the resources seem to enable Charlotte to strengthen her content knowledge. In addition, when she says: 'but I have also improved my pedagogical content knowledge,' Charlotte indicates that she may feel a strengthened sense of agency to attend to her professional duty to structure the learning experience for students to better meet the learning outcomes. |
| Needing to summarize information<br>**Deflating Belief**<br><br>*I'm not killing them [students] with PowerPoint presentations. And so, I don't have that final summary at the end of it to say: 'Ok, so, here is our summary of what we have learnt today [...]'*<br><br>A month into the unit Charlotte and I were discussing a distinction between using digital technologies for *learning* science versus *doing* science. Here, *doing* science is defined as engaging in the practices of scientists. When she says: 'I'm not killing them,' Charlotte reflexively positions herself as a teacher who is not participating in what she perceives to be the accepted practices within the local moral order. Charlotte reflects on the secret story of student disengagement when tasked with note taking as teachers speak to PowerPoint slides, a practice that students may accept as *learning* science.<br><br>Although her students are *doing* science through their use of Google Earth, Charlotte expresses a deflating belief about self. Her perceptions seem to indicate that she has not attended to a duty to focus students' understanding toward the seminal purpose of the lesson, analyzing how geographical features of the landscape and types of rock under the soil influence the safety of man-made structures. However, Charlotte highlights an opportunity to use PowerPoint to explicitly draw students' attention to the learning outcomes. In this way Charlotte can attend to her personal and professional duty to teach science inquiry skills by scaffolding students to both *learn* and *do* science. The affordances of PowerPoint, used in conjunction with Google Earth and the CE3 curriculum, may strengthen teachers' capacity to enact the sacred story, the theory-driven view of practice, by drawing students' attention to what success looks like. |

Charlotte's reflections prior to teaching year nine geoscience appeared to indicate that developing her craft meant exploring technologies to teach science inquiry skills. Utilizing Google Earth and the CE3 curriculum seemed to strengthen Charlotte's capacity to

attend to this duty. She also identified an opportunity to use PowerPoint to explicitly communicate the intended learning outcomes. Drawing on her personal agency to use/modify digital technologies for purpose, Charlotte could respond to her need to teach inquiry skills with a feeling of self-efficacy in an OOF area. As such, Charlotte continues to reflectively integrate digital technologies into her practice.

Throughout our conversations Charlotte repeatedly reflected on developing geoscience pedagogical content knowledge. At the end of the unit, she explained:

> *[The] sequence makes much more sense to me now compared to the way I tried to do it last year.*

Charlotte reflects on the progression of knowledge development throughout the unit. Inspired by the creators of the CE3 curriculum, students began studying the observable and familiar, volcanos and earthquakes, before more abstract concepts such as the movement of seismic waves to understand Earth's structure. In this way, students are invited into the processes of discovery that 'scientific and lay communities have undertaken through the ages' (Blank et al., 2012, p. 42). The significance in this reflection lies, not so much in Charlotte's perception of self to utilize digital technologies, but in her understanding of how the affordances of digital technologies can be pedagogically curated to draw students into the epistemic practices of scientists.

Charlotte's self-identified development of her pedagogical content knowledge is significant because it seems to indicate her growing sense of empowerment to teach an OOF area of the curriculum. How then did Charlotte perceive self as she utilized digital technologies that were less familiar to her? Table 7.7 exemplifies some of these *reflections* alongside the analysis to show how Charlotte's attitude about self and digital technology use was shaped.

## Table 7.7: I am Exploring Pedagogical Possibilities with Less Familiar Technologies

<u>Creating Google Sheets to be more efficient and meet pedagogical goals</u>
**Enhancing Belief**

*[...O]ne of the questions asked, uh: 'What kind of volcano does everyone think Mount Fuji is? Do you agree with all your colleagues?' And we hadn't had a chance to discuss and share our thoughts on that so I put the Google Sheet, I made a Google Sheet, and I put the class list of student names in there and said: 'Please make sure that you,' um, 'put what you think in there so everyone can look at this and then answer the question.'*

Two and a half weeks into the unit, Charlotte explains that her students were gathering data to classify volcanos. When she says: 'And we hadn't had a chance to discuss and share our thoughts,' Charlotte is reflecting on the accepted secret story where teachers struggle to balance best practice with the realities of their lived experience. Charlotte may have been feeling a sense of urgency to manage her students' progress while meeting reporting deadlines. However, she seemed to feel a sense of oughtness to engage students in 'discussion.' Charlotte identifies an opportunity for digital technologies to help her make efficient use of class time and meet personal pedagogical goals. As such Charlotte was empowered to produce a Google Sheet where students were positioned with the duty to share responses and come to a consensus.

<u>Wanting to explore how to use the Geoscience Concept Inventory</u>
**Deflating Belief**

*Right now I'm not [using the responses from Socrative]. I haven't-I haven't taken that any further. So, I haven't been picking up on the stuff about, um, volcanos, for example, in here to say: 'Ok, when we did our quiz we didn't know this, this, and this. Do we now know these?' So, what I need to do is go through and say: 'Rightio, let's try and answer these again and how do we feel about this?'*

Charlotte reflects on a Socrative quiz comprised of 30 questions from the Geoscience Concept Inventory (Libarkin & Anderson, 2006). These questions were designed and validated to assess students' conceptual understanding about volcanos, earthquakes and Earth's structure. Although Charlotte was familiar with Socrative, using it in this way as 'a starting point' to track students' conceptual understanding was a new practice for her. Charlotte explains that she did not assume a duty to revisit the questions as students completed sub-topics. As such, this reflection seems to say little about Charlotte's technical capacity to utilize Socrative and more about her developing pedagogical practice as she articulates how she may be able to attend to the sacred story, aiding students' metacognition by explicitly linking past and present conceptual development.

<u>Taking more time to set up</u>
**Enhancing Belief**

*I probably took a little bit more time in that initial setting up, but I think it was well worth it because I didn't have my kids complaining about the technology at all. And I didn't have any problems with it.*

Charlotte began teaching geoscience at the expert level of digital technology use. At this level, attending to a personal and professional duty to teach students subject-specific digital skills seemed to be embedded within these teachers' practices. At the close of the unit, Charlotte explains that, at the expense of time, she continued to attend to this duty while teaching students how to use Google Drive such that both she and her students were well-equipped to access and engage with the geoscience resources. This reflection is significant because it illustrates Charlotte's success using a digital technology that is not directly associated with learning science. The sacred story that seems to emerge is: ***I'm developing my technological pedagogical content knowledge in ways that extend beyond my specialist area.***

Charlotte's reflections in Tables 7.6 and 7.7 could be placed at the intersection of the science and digital technologies curricula. While teaching geoscience Charlotte seemed to draw on her technological pedagogical knowledge (Koehler & Mishra, 2009) and her developing geoscience content knowledge to act on a sense of empowerment to manipulate digital resources in ways that enabled her to attend to her personal and professional duties. In addition, she also appeared to be empowered to explore pedagogical possibilities with less familiar digital technologies such as Google Drive, Google Sheets and Socrative.

Of note, however, is that at the close of the unit, Charlotte remained conservative in her self-assessment of her developing content knowledge when she explained:

> *[E]ven though I had taught it [a CE3 resource] last year, [...] I would cheat and look at the answers and then I'd come back to them [students] and pretend that I'd known all along.*

This reflection is significant because it is indicative of the vulnerability that even the most experienced teachers can feel in front of students despite having had practice and success with both content and digital technologies. For Charlotte, this lingering secret story seems to be: ***I have to keep up the appearance that I know what I'm doing even though I'm also a learner***.

In the final week of the unit Charlotte explained that, for her, teaching students the technical skills did not 'take quite as much effort' as teaching the content. This feeling may not have been shared by Rachel, Ethan and Isabelle. Of note, however, is that although Charlotte did not pursue the role of Science Coordinator, after one year in 2013, she still seemed to possess a sense of agency to affect change within the local moral order. For instance, Charlotte positioned Rachel, a research scientist and early-career teacher, with the duty to use data logging equipment. Appealing to her sense of oughtness, Rachel assumed a duty to explore classroom use of data loggers. As such, I invited Charlotte to reflect on her professional engagement with other colleagues as they taught geoscience.

Charlotte explained that she was able to 'catch up' with Ethan the most often because they taught year seven together. In addition, the CIDs and focus group interviews provided time for shared reflection. She continued:

> *Um, but the others I see-I when I walk past down the corridor, I see what they're doing in their labs, but I haven't had a chance to stop in and say: 'How are you going with*

> *that?' Um, 'I really enjoyed this bit, what do you think?' You know? I haven't had a chance to do that. And maybe I should push myself a bit further, but, you know.*

Here Charlotte reflexively positions herself with the duty to check in and model professional discussions with colleagues to possibly help them be better supported to teach OOF at the intersection of science and digital technologies. In the final sentence of the turn, when Charlotte says: 'And maybe I should push myself a bit further,' she seems to reflect that she 'should' attend to this self-identified duty, but indicated uncertainty as to whether this would be possible when she said: 'but, you know.' Thus, a secret story emerges: ***I'm in a position to help others, but I may not assume this duty as I negotiate administrative and professional duties toward my students in addition to developing my practice***.

### 7.3.3 Requiring Support to Make the Abstract Visible by Modeling Metacognitive Strategies

In section 7.2.3 Charlotte's reflections appeared to be more telling of her own use of digital technologies compared to her students' use. She seemed to position herself as a border crosser coming to terms with the evolving rights and duties of both teachers and students in connected classrooms. Charlotte identified students' rights to be academically extended and, for her, when the majority of students accepted this positioning, she took greater pedagogical risks in the classroom. Charlotte's reflections also indicated that she may require support to work across the digital and non-digital space. Here, Charlotte's perceptions of her students' use of digital technologies are revisited.

In the third week of the unit Charlotte expressed mixed perceptions about whether her students felt a sense of oughtness to assume duty to take responsibility for their use of digital technologies. Although instructional videos explaining how to use Google Drive and Google Earth were shared with students, Charlotte did not perceive students to be developing the capacity to solve their technical problems. Charlotte reflected that teachers needed to 'push' students to assume this responsibility, however expressing surprise she explained:

> *Although I've gotta say there were some i-in the initial lessons I had a couple of kids who'd missed that the very fir-very first lesson, um, and in the very next lesson when they were there, kids had, um, kids explained to them exactly what they had to do. I didn't have to do it myself.*

Charlotte reflects on the complexity of a teacher's lived experience where students' attendance can be disrupted due to co-/extracurricular activities, family responsibilities or health concerns. Frustrating secret stories can emerge for both students, who may have a fractured understanding of subject material, and classroom teachers who may struggle to meet other personal and professional duties as they are expected to keep students up-to-date.

Attending Charlotte's first geoscience lesson was imperative for students because, together, they watched instructional videos and Charlotte modelled setting up the Google Drive so that students could access resources throughout the unit. Charlotte's expression of surprise seemed to indicate a shifting responsibility from the teacher helping students to peers teaching each other. Students assuming the duty to teach peers appeared to strengthen Charlotte's ability to attend to the sacred story, the story of practice, focusing students' attention on the planned classroom activities and moving forward with the curriculum.

The reflection above is illustrative of the balance between Charlotte's enhancing and deflating beliefs about her students as they utilized digital technologies. Table 7.8 exemplifies more of these *reflections* including the initial coding, types of **belief** and analyses that were indicative of Charlotte's attitude toward her students' use of Google Drive and Google Earth. These attitudes and the secret and sacred stories emerging were raised to the focused code: Requiring support to make the abstract visible by modeling metacognitive strategies of self-directed learners.

**Table 7.8: Students Can Utilize Digital Technologies when Scaffolded but Continue to Require Support to Enact Metacognitive Strategies**

| |
|---|
| Students requiring teacher assistance despite having success<br>**Enhancing Belief**<br><br>*So, for example one of the reasons why I'm a bit behind Ethan is that, um, we had done folders-we had done the first two volcano folders in class, but they [students] didn't want to have to do the third one, the composite one, at home by themselves because they were worried that they wouldn't be able to remember how to do all the bits and pieces. E-they wanted to be able to ask questions when they got stuck. Even though they'd already done it with the cinder cone and shield [volcanos] they didn't want to be trying to do that at home.*<br><br>Two and a half weeks into the unit, Charlotte reflects on her students' use of Google Earth as they learn how to gather data and classify volcanos. Here, Charlotte defends her choice to spend more class time on the activity because she seems to feel a sense of oughtness to ensure that students are confident moving forward in their use of Google Earth.<br><br>Charlotte shares an enhancing belief about students, they are capable users of this technology, however attending to a duty to maintain students' self-efficacy and support them she chooses to change her planned practice. Of note is that Charlotte could have drawn students' attention to the Google Earth instructional video while encouraging them to take risks with their use of the technology at home. Charlotte's conservative approach, however, seems to be indicative of the sacred story: ***I'm trying to maintain a sometimes-fragile balance between my students' self-confidence and personal agency as learners***. |
| Students finding higher-order thinking difficult<br>**Deflating Belief**<br><br>*For me, I think, um, they tackled the questions where it's just finding the information far more confidently than the hypothesis, evidence, conclusion part at the end. So, I think they're feeling challenged by those higher order thinking skills definitely and possibly don't recognize that that is what they're being asked to do. And that maybe we should be looking at other units and seeing where we can get more higher-order thinking skills in there as well.*<br><br>Four weeks into the unit, Charlotte reflects on students' higher-order thinking. In addition to collecting data using CE3 .kmz files, students read explanatory text to extract information. Charlotte explains the ease with which students were able to attend to reading comprehension questions. However, her reflections and student work samples both indicate that they had difficulty making claims and providing evidence-based reasoning about geological phenomena.<br><br>Charlotte shares a deflating belief about students, they 'possibly don't recognize what they're being asked to do.' The last sentence in the turn is said slowly and deliberately and seems to indicate that the students are not at fault for their reticence to record their reasoning. Charlotte reflexively positions herself as part of a group of teachers who have a professional duty to revise other areas of the curriculum and incorporate more higher-order thinking activities. In this way she reiterates the secret story shared by Ethan and William in chapter five: ***We have a duty to better scaffold students' higher order thinking***. |

Charlotte's reflections in Table 7.8 seem to speak less about students' digital skills and more about the need to develop their metacognitive strategies as they use digital technologies in science. For instance, students may require more explicit modeling of how to utilize Google Earth instructional videos to troubleshoot technical problems. In addition,

modeling the use of Google Docs to inquire about geoscience conceptual difficulties may have enabled students develop self-directed learning strategies. As such there appear to be two areas where Charlotte requires support to develop pedagogical practices that could strengthen the sacred story to build the metacognitive capacity of her students:

1. Outside the classroom in the absence of a teacher toward troubleshooting technical issues; and

2. Inside the classroom in the presence of an OOF teacher to better understand the epistemic practices of geoscientists

Previous sections of this chapter have explained that prior to teaching year nine geoscience, Charlotte attended to a personal and professional duty to develop students' digital skills. However, for her, the most significant area of growth was developing her geoscience pedagogical content knowledge. As such the second point will be the focus of the following discussion.

Susan, Riverside's resident geoscientist, offered to guide both teachers and students in their understanding of geoscientific principles by responding to posts on a Google document. Charlotte described this opportunity as 'just fantastic.' In addition to offering students the opportunity to engage with a practicing scientist, this arrangement seemed to enable students' queries to be accurately responded to and in an accessible language for their literacy levels. During class, Charlotte was observed to position the students with the duty to ask Susan questions. Figures 7.3 and 7.4 exemplify the two interactions Charlotte's students had with Susan at the beginning and the end of the unit.

[redacted] and I have a friend named [redacted] who suffers from motion sickness every time she uses Google Earth. Since I've heard that Google Earth makes it easier for geoscientists to observe and also save money and time in travelling, how would a motion sick geoscientist go about observing unreachable locations?
Thanks,
[redacted]
P.S - 9G is pretty sure you don't exist so could you please send a convincing photo of yourself?

Haha! To be honest I have never thought about that problem before! I am not really sure how to stop Google Earth causing motion sickness, maybe the expertise of a Doctor rather than a Geologist! While I do sometimes use Google Earth for looking at large scale structures and geomorphology (the shape of the Earth) nothing beats actually being able to see the rocks in person and being able to describe the minerals and textures.

As for the second part of your question...this is a picture that I sent to 9F to try and prove that I am a real person! If this isn't good enough then I don't know what is!? Hope you are enjoying your studies in Geology.

**Figure 7.3: Interaction with Geoscientist Susan at the Beginning of the Unit**

[redacted] my name is [redacted] I was just wondering, were the tectonic plates all joined together and have broken apart or have they always been separate plates?

I was also wondering with the Mariana trench, is it getting deeper due to the underwater ridges placed on the other side of the world that rise and have to push the land either side of the mountains.

[redacted] thanks for your question!

Most of the tectonic plates were joined together and then broke apart. 225 million years ago there was a supercontinent known as Pangea, this has then split into the smaller supercontinents Gondwana and Laurasia by about 150 million years ago. These supercontinents further split into the countries we know today (see the maps below). It is important to remember though that plate boundaries do not always stop right at the edge of land but extend into the oceanic crust too. There are even some tectonic plates that exist totally in the oceanic crust (Scotia Plate, Nazca Plate, Philippine Plate). The second picture shows the location of the major tectonic plates.

**Figure 7.4: Interaction with Geoscientist Susan at the Close of the Unit**

Charlotte is a teacher who is deeply respectful of the intellectual capacity of her students. She reported that the majority had 'really inquiring minds' and 'very high curiosity levels.' However, they did not take the opportunity to ask Susan more than two questions over seven weeks. To account for this, Charlotte reflected on the lived experience of many Riverside students when she reported that they have 'too much to do' and 'not enough time to do it in.' Within the Riverside local moral order parents and teachers expect students participate in a range of co-/extracurricular activities that may take them out of class and/or limit their time to follow up with work as they negotiate commitments outside of school. As such, students may not perceive following up with geoscience questions to be an immediate duty requiring attendance.

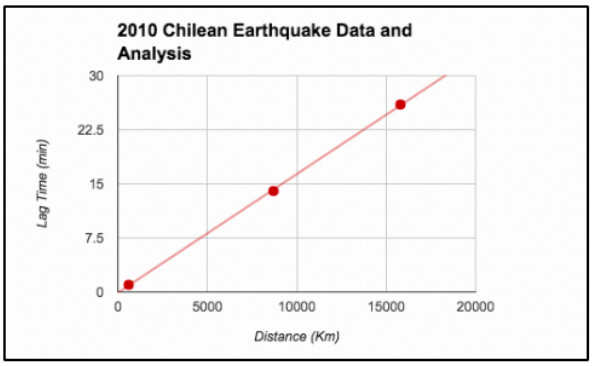
In Table 7.8, Charlotte reflected that students seemed to find the higher-order thinking questions of the CE3 activities the most difficult. Both Ethan and Rachel reported similar difficulties. Although some students suggested that using the Google search engine could help them overcome these difficulties, this is improbable because the CE3 curriculum was designed for students to collect and interpret their own data. Figure 7.5 shows a sample of student work where students were required to read information and collect data from seismographs. This student was able to extract definitions from text as well as record and graph data from a Chilean earthquake. However, when it came to interpreting how these data could be utilized to understand the structure of the Earth the student was unable to provide evidence to support her reasoning.

**Observations**

| | |
|---|---|
| How many seismograph stations are there worldwide - tens, hundreds, thousands, or tens of thousands? | Tens of thousands |
| What pattern does the distribution of the stations show? | They are located around the edges of the tectonic plates and around coastlines. |
| Which seismograph station is closest to your Melbourne? How far away is it? | 2.11 km called Melbourne |
| What is lag time? | The time interval between S and P waves. |

2010 Chilean Earthquake Data

| Station | Lag Time (min) | Distance (km) |
|---|---|---|
| Paso Flores, Argentina | 1 min | 600 km |
| Llaves, New Mexico | 14 mins | 8700 km |
| Tiksi Russia | 26 mins | 15800 km |




| | |
|---|---|
| Is the relationship between lag time and distance relatively constant? | Yes, as distance increases, lag time increases. It is a perfect linear relation. |
| What approximate distance does each minute of lag time represent? | 600 km |
| Distance from London, UK to the Chilean earthquake epicenter (to the nearest 1000 Km) | 12000 km |
| What lag time would be expected at a seismograph station in London recording the Chilean earthquake? | 20 minutes |

**Interpretation**

What could affect the lag time between the arrival of S and P waves, other than distance from the epicenter? Do you think the computer models scientists use to locate earthquakes should consider this?

| | |
|---|---|
| Hypothesis | **I think that what material the seismic waves are travelling in will affect the lag time.** |
| Evidence | |
| Conclusion: | |

**Figure 7.5: Student Work Sample of Seismic Wave Interpretation Activity**

Overall, Charlotte expressed satisfaction in her students' digital technology use and she reflected that they had 'a lot of willingness to overcome the steepness of the learning curve.' Charlotte and her colleagues' reflections on their students' work and the example shown in Figure 7.5, however, suggested that perhaps teachers needed to model accessing the Google document to draw on Susan's assistance as they were completing classroom activities to strengthen understanding of abstract geoscientific concepts. As such, Charlotte's attitudes toward her students' digital technology use and the secret and sacred stories emerging have been raised to the focused code: Requiring support to make the abstract visible by modeling metacognitive strategies of self-directed learners.

### 7.3.4 The Emergence of a Theoretical Category: Pedagogy Maintaining Equilibrium

At the beginning of this research Charlotte suggested that she approached teaching as an ongoing pedagogical experiment. Drawing on her sense of agency she was able to explore opportunities utilizing digital technologies to enhance both her own and her students' learning experiences, in particular the inquiry processes of scientists. As such, Charlotte's reflections seemed to indicate that, for her, professional development is an ongoing, dynamic process reflecting a personal duty to craft her pedagogical practices.

Although Charlotte appeared to be an agent of change within the Riverside local moral order, her reflections are indicative of the premise that even the most experienced teachers require support to cross borders between multiple areas of the curriculum they are expected to be able to negotiate. Charlotte, like her colleagues, continued to develop her digital skills using Google Earth and Google Drive as she explored new pedagogical practices. However, unlike her colleagues, the importance of pedagogy seemed to be a recurrent theme as she negotiated the intersection between the non-/digital space and development of students' metacognitive skills.

Although Charlotte was able to identify and explain the possibilities to produce, manipulate and transform (Foucault et al., 1988) lessons with digital technologies, she may still require support to strengthen her pedagogical practices to more effectively meet learning outcomes. Reflecting on some of her students' experiences, Charlotte explained:

> *Um, it was interesting that they [students] felt like conversations were not much of a focus. Yeah. It's-it-I'm really interested to hear that they value it so much more than I*

*thought that they did. Really, there's obviously a clear value that they place on those conversations.*

Just before the conclusion of the unit, Charlotte explains her surprise when she learns that students identified a right to be better supported to understand the material through classroom discussion. Although one of the intentions of this unit was to support teachers to better employ the principles of dialogic teaching (Alexander, 2006), this had not become apparent to Charlotte until the end of the unit.

Pedagogy maintaining equilibrium is a theoretical category that has emerged from the focused codes grounded in Charlotte's positionings of the digital technologies, self and her students while teaching geoscience. In a reversible chemical reaction at equilibrium the rates of the forward and backward reactions are equal. Pedagogy maintaining equilibrium evokes an image of balance as a teacher utilizes digital technologies, with which s/he may not have a personal history, to teach an OOF area of the curriculum. Positioning teachers with the duty to utilize digital technologies while teaching OOF places the system into disequilibrium and the pedagogies teachers feel a sense of empowerment and agency to employ enable her/him to re-establish balance.

Although Charlotte began the unit of work as an expert digital technology user, she repeatedly reflected on areas for extension of practice with and continual growth across both the geoscience and digital technologies curricula. Pushing the equilibrium toward utilizing digital technologies for which a teacher does not yet have a personal history may mean sacrificing geoscience content understanding as s/he takes time to adjust pedagogical practices to re-establish the balance. For Charlotte, a confident agentic user of digital technologies with an acting awareness of their potential in the geosciences, she seemed to constantly challenge herself to shift this equilibrium to further develop her practice.

## 7.4 Conclusion: Toward a Conceptual Development of Geoscience Pedagogy

Sections 7.2 and 7.3 have explained some of Charlotte's reflections about her experiences teaching science with digital technologies. At the beginning of this research, Charlotte reflexively positioned herself as part of a group of professionals who seemed to be unsure of whether 'we've come to terms with what having a digital device means in the classroom.' However, Charlotte assumed a personal and professional duty to experiment with digital technologies to enhance her own and students' classroom experiences.

Unlike her colleagues who appeared to be developing their digital skills and knowledge of how to integrate digital technologies, the most significant area of growth for Charlotte seemed to be at the pedagogical intersection of the geoscience and digital technologies curricula. During our final interview in 2016, Charlotte explained that this unit was distinct from others because there were:

> *[...] a range [of experiences offered to students and teachers]. You know, you've got the digital, um, aspects of it, you've got the external aspects [museum excursion] of it and then you've got the non-digital aspects of it and I think it's important to have a balance. You know?*

This reflection is significant, because Charlotte suggests that she has ascribed herself a duty to bridge the digital and non-digital space with sound pedagogical practices using a range of resources and experiences. For Charlotte, Google Earth and the CE3 curriculum seemed to enable her to better understand how this balance could be achieved in an OOF area by providing sign systems to signal what otherwise would not be possible without the use of digital technologies.

Two years on, Charlotte reported that teaching science inquiry skills continued to remain her most important duty as a science educator. Throughout 2017 and 2018, Charlotte seemed empowered to draw on the technology of the self to continue to develop her geoscience pedagogical content knowledge using digital technologies. In addition to seeking support in her continued use of Google Earth and Google Drive, on several occasions Charlotte emailed me articles from The Guardian reporting geoscientific news. She also shared a simulation enabling students to trigger earthquakes and then collect and analyze data, in similar ways to geoscientists, to locate the epicenter. As Charlotte

explained her motivations to engage in self professional development, she deferred to her perception of the purpose of schooling that began this chapter:

> *And, for me, it's all about me learning something new 'cause that's what I like. I like to-I <u>really</u>-I can't keep doing the same thing over and over. I don't think I have perfected anything in particular, but the more n-the more innovative I can be, the more, I think, I can get kids go: 'Oh, we have science!'*

This deeply personal reflection is indicative of Charlotte's sense of empowerment to transform her teaching practice as she attends to a personal duty to 'learn something new' and a self-identified professional duty toward instilling a love of science in her students. As such the most significant area of growth for Charlotte is not the technical skills that her colleagues developed but growth on a more conceptual level of utilizing digital technologies for technology-enabled learning.

Unfortunately, in 2018 Charlotte's teaching allotment did not include year nine. Reflecting on this, she explained:

> *I felt, um, look, I have little control over the load I'm given so I go where I am sent in that respect. I had the year eights, but I didn't have the year nines which-but I would have preferred to have kept the year nines so that you can continue to refine your skills in and, you know, make it that, you know, just keep working on my own skills and developing the kids in those [...]*

This reflection is indicative of an accepted secret story of frustration in a teacher's lived experience as she is positioned by the school timetable. Charlotte is an agent of change with respect to her own and offering others support to develop their pedagogical practices. 'I go where I'm sent' seems to reflect a lack of personal agency Charlotte feels toward being able to experiment with and enhance her pedagogical practice. As such she may be prevented from refining her geoscience pedagogical content knowledge.

Apart from Google Earth and the CE3 curriculum, Charlotte identified her use of Google Drive in 2016 to be distinct from her usual practice. In 2018, she was able to incorporate cloud computing as part of her senior chemistry class to help students organize their research for a major assessment task. Charlotte explained:

> *[T]hat was just a very simple way of going: 'Ok, I'm-I wanna be able to check,' you know, 'date-wise and,' you know, 'work-wise who's done what.' [... S]o that I could, um, type in and comment on it, uh, and that they could get that feedback immediately as well.*

Charlotte's use of 'just' implies that this use of Google Docs came easily while enabling her to assume a professional duty to check that students were up-to-date with their work and offer them feedback. Charlotte's use of Google Docs seems to have become a practice that is transferrable across subject areas, yet the conceptual gains for her students in this sense compared to those in her geoscience class may not be nearly as great.

Of note is that in 2018 new administrative practices marked a shift in Riverside's approach to utilizing digital technologies across subject areas. The cloud computing software adopted by Riverside would be Microsoft OneDrive and Office 365. Although Charlotte was 'frustrated' by this shift, she was confident in her own digital skills, 'I'll get my head around it.' Her sense of self-efficacy was also noticed by the administrative staff and she explained how she reluctantly accepted this positioning:

> *Edwin has asked me to be on the committee of, you know, what the school needs and how we can best, you know, serve the teachers, uh, I-I don't necessarily think I'm the best person for that, but, like, I don't know, he I thi-he sees me as willing to try anything, which-which is fine, um, and that's great.*

Unfortunately, Charlotte's willingness to explore using digital technologies in the classroom seems to have positioned the administration with a right to assign her the duty to scaffold her colleagues toward using Microsoft OneDrive. When Charlotte says 'I don't necessarily think I'm the best person for that,' she appears to relinquish this duty perhaps because she perceives it to be beyond the border of her classroom, a private space where she has the freedom to experiment and draw on her own personal sense of creativity to enhance her lessons.

# Chapter 8: Interpreting an Apprentice Teacher's Perceptions of Agency Utilizing Digital Technologies in Science

> ***Interviewer:*** *What do you believe is the purpose of schooling?*
>
> ***Rachel:*** *It's just, like, well to educate students. But, like.. to make them-to be able to give them skills to be functioning adults and not just people who laze around and don't know how to solve problems themselves. I think, you know, sure you can teach them a bunch of facts, but it's not the facts that they'll remember it's the skills that they learn from it.*

## 8.1 Introduction

Rachel, introduced in chapter four, entered the teaching profession following a 10-year career contributing to medical research projects about traumatic brain injury, depression, cochlear implants and the bionic eye. Although she was in her first year of teaching, Rachel and I had already developed an effective professional relationship as I taught into her initial teacher education program and as she completed a teaching round at Riverside with mentorship from Mary, introduced in chapter four.

Rachel participated in this research by constructing a personal meaning making map (PMMM) and follow-up interviews before and after teaching geoscience. She volunteered to pilot the geoscience teaching sequence and resources with her year nine class. Of note is that Rachel taught this unit alongside Jeremy and I. Jeremy, a non-participant in this research, was serving at Riverside on a fixed-term contract substituting for a teacher on leave. While teaching the unit Rachel participated in three interviews and I was able to observe six of her classes. I also recorded memos of my observations and interactions with her. In 2018, two years after teaching geoscience, Rachel participated in a final interview.

Through the positioning triad (Harré & van Langenhove, 1999), shown in Figure 8.1, and complementary analytical tools, this chapter introduces Rachel and examines her sense of agency to utilize digital technologies in science. Constructivist grounded theory coding procedures (Charmaz, 2014), pronoun grammar analysis (Mühlhäusler & Harré, 1990; Redman, 2013a; Redman & Fawns, 2010) and Rokeach's (1968) five types of beliefs are utilized to track changes in Rachel's discursive practices (Harré & van Langenhove, 1999). These changes highlight tensions and shifts between cover, sacred and secret stories

(Clandinin & Connelly, 1996) as Rachel positioned the digital technologies as material objects (Harré, 2002b), herself and her students. As such, they are indicative of the extent to which she felt empowered (Foucault et al., 1988) to act autonomously while teaching with digital technologies.

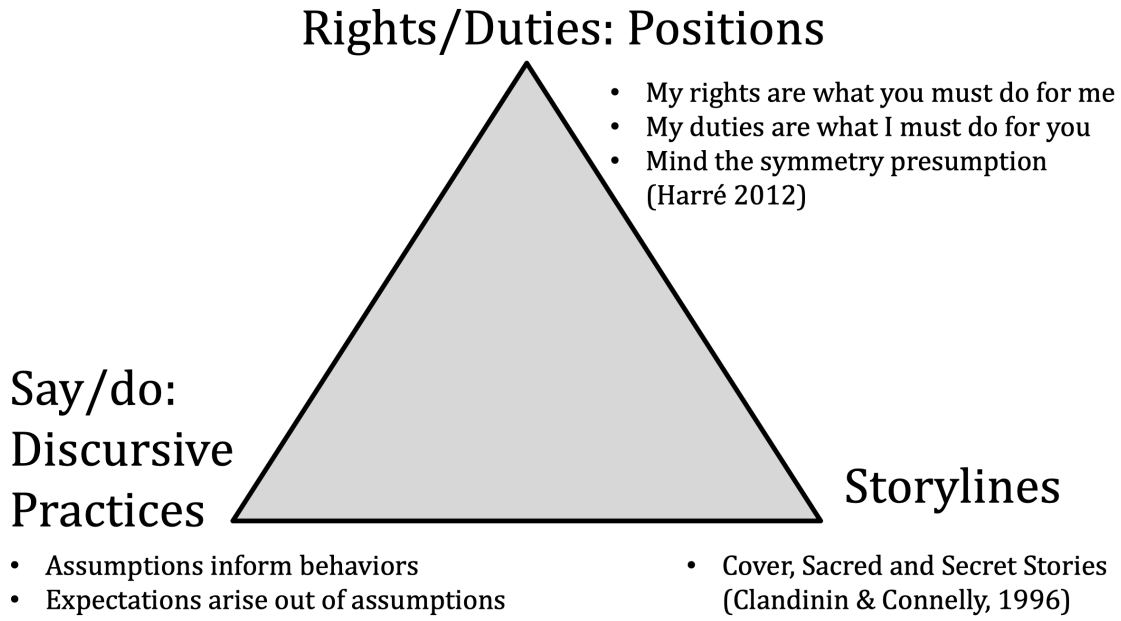



**Figure 8.1: The Positioning Triad Adapted from Harré and van Langenhove (1999)**

Table 8.1 shows the focused codes and theoretical categories (Charmaz, 2014) derived from Rachel's discursive practices. Prior to teaching geoscience, Rachel's self-assessments of her digital technology use placed her at the apprentice level on the continuum explained in chapter four. Apprentice users were able to identify digital skills that students were expected to develop and, to the best of their capacity, had assumed the professional duty (Harré & van Langenhove, 1999) to teach these skills. At the same time, they seemed to feel conflicted about translating their perceptions of the pedagogical possibilities for digital technology use into practice. As such, apprentices seemed to require support incorporating digital technologies for technology-enabled learning (Brantley-Dias & Ertmer, 2013; Ertmer & Ottenbreit-Leftwich, 2013).

**Table 8.1: Overview of the Focused Codes and Theoretical Categories**

| | **Prior to Being Offered Support** | **Being Offered Support** |
|---|---|---|
| **Development of Focused Codes** | **Positioning of Digital Technologies** | |
| | Approaching digital technologies with caution | Digital technologies enabling the transference of skills |
| | **Positioning of Self** | |
| | Holding back unless success is guaranteed | Moving forward with continued support |
| | **Positioning of Students** | |
| | Requiring professional strategies to develop students' digital skills | Developing a script for digital technology use |
| **Theoretical Category** | **Being Caught Between a Rock and a Hard Place** | **Being at the Strike-Slip Fault** |

Rachel's sense of agency to utilize digital technologies seemed to be strengthened by social signs (Foucault et al., 1988) and the professional expectations of science teachers within this local moral order (Harré & van Langenhove, 1999). Drawing on her technological knowledge (Koehler & Mishra, 2009) Rachel was empowered to transform lessons when students were required to manipulate digital technologies for assessment. Rachel's self-identified duty to teach students' how to perform Internet searches appeared to be informed by her research experience, yet she did not seem to plan for lessons scaffolding these transferrable skills. In addition, without a planned program for digital experiences social signs from institutional expectations and colleagues were not in place for Rachel to identify other transferrable research skills. After being positioned (Harré & van Langenhove, 1999) to explore data logging by an empowered colleague, Rachel seemed to reposition herself as a capable user of data loggers. Rachel's sense of personal agency also appeared to be compromised by beliefs about her students' perceptions of digital technologies, preventing her from deviating from the established script.

Rachel cautiously utilized digital technologies in her classroom. However, her sense of agency teaching out-of-field (OOF) with them seemed to be strengthened by her technological knowledge and reflexive positioning (Harré & van Langenhove, 1999) of

herself as a learner. In addition, Rachel attended to the sign systems (Foucault et al., 1988) offering strategies to manipulate digital technologies and, to an extent, was able to transform her pedagogical practices with those previously unexplored. Unexpectedly, Rachel's reflections of her experience two years later indicated that the most significant area of growth for this apprentice digital technology user resulted from the relationships she developed with colleagues through peer-to-peer mentoring and the pedagogical growth that came from *dialogic planning*. Despite areas of growth, Rachel seemed to require additional avenues to explore pedagogical possibilities for digital technology use with continued support from colleagues in the subject-specific use of technologies, a fragile area where her sense of agency could possibly be compromised without minimizing first-order barriers (Brickner, 1995; Ertmer, 1999) in this technology-rich environment.

### 8.2 Before Teaching Year Nine Geoscience: Caught Between a Rock and a Hard Place

Prior to teaching year nine geoscience Rachel constructed a PMMM, shown in Figure 8.2, and she participated in a follow up interview to reflect on her use of digital technologies. Rachel's PMMM indicated that she used digital technologies to develop students' content knowledge and inquiry skills. Some uses seemed to evoke an affective response (Krathwohl et al., 1980). Rachel perceived online quiz software such as Kahoot! and Socrative to be 'AWESOME' and she qualified dataloggers as a 'good use of technology.' Rachel was driven to utilize digital technologies to make her classes 'just a bit more interesting,' suggesting an ease to incorporate them into her teaching, and the Internet enabled her to attend to students' curiosities as she modelled how to search for information.

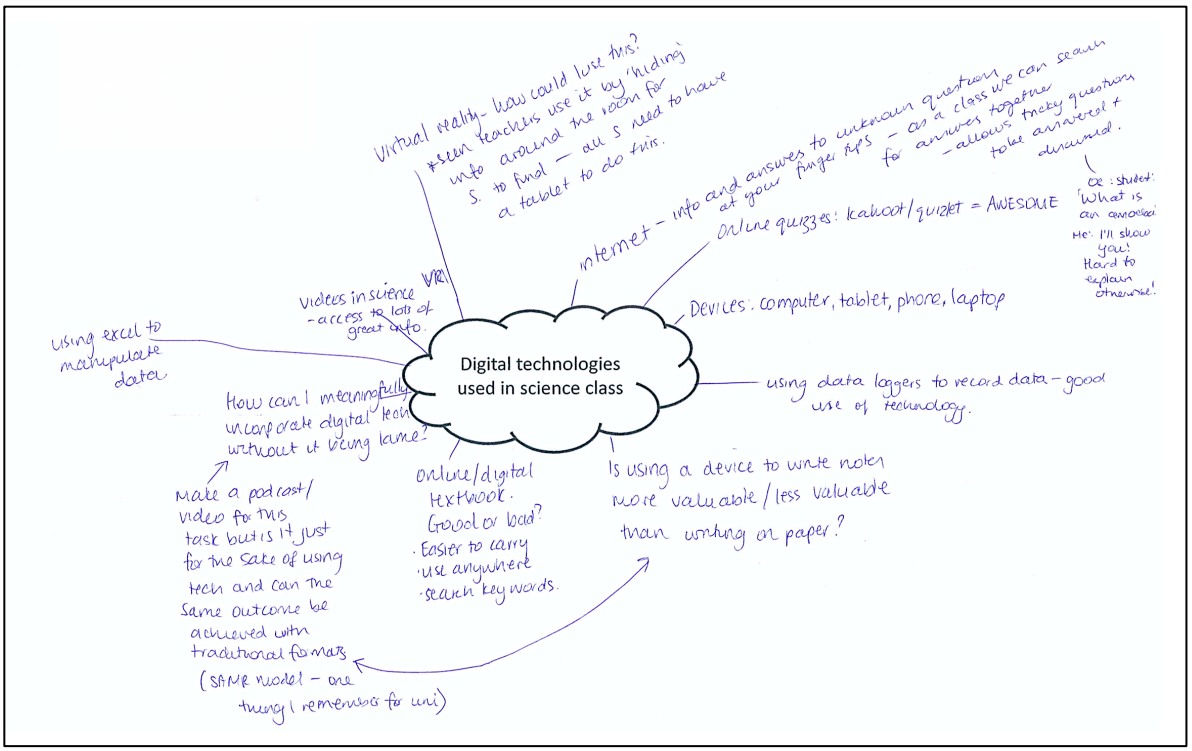



**Figure 8.2: Rachel's Personal Meaning Making Map from July, 2016**

Although Rachel responded with satisfaction (Krathwohl, 2002), she seemed to question how she could meet her self-identified professional duty to enhance student learning with digital technologies. Rachel used videos and simulations, technologies prevalent within this local moral order, to teach scientific phenomena that she would otherwise be unable to explain or demonstrate due to lack of available resources. However, she wondered whether prevailing practices such as students' use of digital textbooks and devices to write notes were more valuable than using physical textbooks and writing with pen and paper. Rachel was also intrigued by digital technologies introduced in her teacher training program, yet she questioned how to integrate these into her classes because students may perceive them as 'lame.' Overall Rachel's reflections were indicative of the sacred story, the story of practice: ***I'm using technology commonly employed by colleagues and, at times, seeking out additional technologies, but I require support to incorporate them in ways that align with my pedagogical philosophy***.

### 8.2.1 Approaching Digital Technologies with Caution

Beliefs are predispositions to action with cognitive, affective and behavioral components (Rokeach, 1968). Attitudes arise out of clusters of beliefs that can advocate action or inaction. Table 8.2 exemplifies some of Rachel's *reflections*, their initial codes and her **beliefs** about digital technologies alongside analyses framed by the positioning triad to form the focused code: Approaching digital technologies with caution.

## Table 8.2: Approaching Digital Technologies with Caution

| |
|---|
| Having technology available makes class more meaningful<br>**Enhancing Belief**<br><br>*[H]aving that [technology] there all the time is really useful 'cause sure I can go: 'Oh, I'll just look it up later,' but then it's not-it's just-it doesn't-it isn't as meaningful. Like, 'Oh remember yesterday when you asked me about blah?' Like, they're not… Like, they're like: 'Oh, ok. Great,' and then move on [to the] next thing. Whereas it's right there, you go: 'Ok, let's look it up right now just so that we know the answer,' then, you know, that's really useful 'cause they're [students] in the moment of knowing [...]*<br><br>Rachel explains how digital technologies enable her to promptly assume a professional duty to address students' questions about subject-specific material. Rachel's use of 'just' suggests that finding answers to questions came with ease and the prevalence of digital technologies in the classroom enabled her to attend to students' rights (Harré & van Langenhove, 1999) to have continuity in their learning experiences as they are 'in the moment of knowing.' In this way, digital technologies strengthened Rachel's capacity to attend to the sacred story***: I use the Internet to answer students' questions as they arise modeling the curiosity of scientists***. |
| Wondering how to use technology effectively<br>**Deflating Belief**<br><br>*So, they [students] have them [digital technologies] we might as-might as well take advantage of them and use them. It's just, like, how do I use it the most effective-in the most effective way is the question that I have. Like, you know, how do I really harness the use of technology for everyone in the class that I know get distracted by it but they actually use it for what they're meant to be [using it for]? Yeah.. It's definitely a good thing to have it, but, yeah. I'm just, like, it always comes back to this question for me, like, is it more useful and how-and how do I make it more useful?*<br><br>Using the pronoun 'we' initially Rachel begins this turn by positioning herself as part of a group of teachers with a sense of oughtness (Linehan & McCarthy, 2000) and professional duty to utilize digital technologies. Her reflection takes a personal turn as she draws on the pronoun 'I' to narrate tension between the sacred and secret stories. Rachel, an early-career teacher, shares deflating beliefs about self when she positions digital technologies as distractors for some students, yet she must negotiate her professional expectations and personal capacity to harness the affordances of digital technologies with pedagogical value. As such, Rachel's willingness (Krathwohl et al., 1980) to take risks with technology may be compromised because she seems to be unsure how to negotiate this liminal space. |
| Wondering if podcasting enables students to learn more<br>**Enhancing/Deflating Belief**<br><br>*A podcast is a different thing. So, like, maybe it allows them to interact with the material in a different way so that they can learn more-more about it. [... E]ven this podcast thing I was like uh, it's good, like, it's interesting, it's a different thing to do, but, like, is it gonna make any difference to what they've learnt? Like, maybe it will, like, you know, I don't know, but […]*<br><br>Rachel reflects on a major assessment task year nine students complete by designing experiments and creating a podcast about their research. Sharing an enhancing belief about the technology, she explains the learning potential of podcasting, interacting with the material in a different way. Yet Rachel draws on her professional duty to question the pedagogical value of the task in terms the learning gains for students. Having completed this task with her students Rachel reflects on a tension between the sacred and secret stories: ***Podcasting might invite students to interact with material in different ways, but I'm not sure it made a difference to their learning***. |

In her PMMM, Rachel recorded an opportunity to explore teaching science with digital technologies due to their prevalence and possibilities to make lessons more interesting. Rachel's sense of oughtness to take risks with previously unexplored technologies seemed to be strengthened by the expected uses of them within the local moral order, for instance using podcasting software for assessment. However as this early-career teacher developed her technological pedagogical knowledge (Koehler & Mishra, 2009) to produce (Foucault et al., 1988) lessons with digital technologies, Rachel appeared to assume a professional duty to avoid taking risks with her students' learning, establishing a cautionary approach to digital technology use. As such, Rachel's reflections in Table 8.2 are indicative of a sacred story, the theory-driven view of practice frequently articulated by teachers, policy-makers and theoreticians: ***As professionals we must be mindful of and reflect on what we do in the classroom to ensure students participate in meaningful learning experiences***. How, then, did Rachel assess her own use of digital technologies in her classroom?

### 8.2.2 Holding Back Unless Success is Guaranteed

During our first follow up interview Rachel drew on her research career to explain her digital technology use. She was invited to reflect on a technology that could enable students to do something new, pausing for four seconds Rachel explained:

> *.... Um, I guess, like, Excel, like, they could just work out, um, you know, calculate an average but then with Excel they can then get the average, get the standard deviation and then compare that to other data that they've got.*

Using 'just,' Rachel seems to qualify the use of Microsoft Excel as straightforward. Students could calculate the standard deviation to compare how close their data are to an average. This affordance is not typically taught to junior students within the Riverside local moral order. Rachel was speaking hypothetically, but this reflection indicates her capacity to manipulate Excel, a skill from her research experience that appears to be transferrable to the classroom and could possibly strengthen her ability to teach inquiry skills.

Rachel also deferred to her research experience when reflecting on teaching students how to search the Internet for reliable information. She explained:

> *I mean even, like, researchers, you know, don't always use reliable sources of information. So, um, it's just a skill they [students] have to develop on top of all the other things they have to learn [...]*

Rachel explained that, at times, researchers might use websites like Wikipedia to look up information. Again, her use of 'just' seemed to indicate that developing this skill is straightforward, however a cover story appears to emerge. Researchers, as opposed to high school students, possess an acquired body of knowledge to judge the reliability of information found on the Internet. Although Rachel's reflection may appear to indicate that she relinquishes a duty to develop this skill, she did not overclaim for students' capacity to critically evaluate Internet searches. Rachel assumed a professional duty to responsively teach students how to interpret the meaning of domain names such as .org, .edu and .com while modeling Internet searches in her classroom.

In addition, Rachel drew attention to the complexity of teaching science alongside digital skills. Learning how to critically evaluate information found on the Internet was a skill to be developed 'on top of all the other things they have to learn,' including science inquiry skills. As Rachel reflected on what a 'good use' of digital technologies looked like, she shared a sacred story:

> *[W]ell, in terms of, like, data loggers, something that can reliably, um, acquire information? Accurately acquire information. Um, good use of technology, so it's not-it's not too complicated to use that it's affecting how you're doing your experiment.*

Rachel's inflection at the beginning of the turn seems to indicate that she was unsure of the benefits of data logging suggesting that she has not developed a personal and professional history using them. Like William, Rachel accepted that teachers have a professional duty to employ digital technologies that are user-friendly and work reliably enabling students to access accurate information. Despite her research experience, however, Rachel continued by sharing a secret story:

> *[W]hen someone [Charlotte] said to me: 'Use the data loggers,' I was like: 'Hunh? I don't want to use them!' and then I used them and I was like: 'Oh, this is easy! It's simple to use.' So, um, it has to be that way.*

The first part of this reflection could be interpreted as a gentle nudge by a colleague encouraging Rachel to use data loggers. However, this interpretation would simplify the complexity of the social situation unfolding. As Science Coordinator in 2013, Charlotte had

organized professional development for data logging and although no longer in this role, she continued to occupy a position of authority.

'Use the data loggers' seemed to have an illocutionary force (Austin, 1975) appealing to Rachel's sense of oughtness aligning with her perceptions about the purpose of schooling expressed at the beginning of this chapter: 'to give them the skills to be functioning adults and not just people who laze around and don't know how to solve problems themselves.' As such, Rachel seemed to feel empowered, repositioning herself to ameliorate a tension between the secret story, ***I'm not sure how to use data loggers***, and the sacred story, ***I have a duty to incorporate them into lessons***. In doing so Rachel seemed to be surprised by the ease with which data loggers could be used.

Prior to teaching geoscience, Rachel's beliefs about self and her digital technology use seemed to depend on and align with her self-efficacy (Bandura, 1982) to incorporate digital technologies in pedagogically valuable ways. At the same time, however she was willing to experiment with digital technologies through the accepted practices of the local moral order. Table 8.3 exemplifies how Rachel's *reflections* were initially coded and her **beliefs** about self identified and analyzed. The emergent cover, sacred and secret stories were raised to the focused code: Holding back unless success is guaranteed.

## Table 8.3: Holding Back Unless Success is Guaranteed

| |
|---|
| Making activities interesting is a battle<br>**Deflating Belief**<br><br>*[Y]ou don't have to use an online thing to do that [make revision quizzes]. But it just, it makes it just more interesting, I guess, you know. So, which is, you know, half the battle making it interesting (laughs). Make it interesting and then they might-maybe will learn something from it.*<br><br>Using 'you know,' Rachel seems to position me to be in agreement as she reflects on tension between the sacred and secret stories. She identifies a professional duty to help students revise material which can be met both non-/digitally. Using 'I guess' Rachel qualifies her use online quiz software as possibly strengthening her capacity to make revision lessons interesting. Rachel's use of 'just' seems to indicate that she is empowered to employ this strategy as she attends to the secret story, ***I struggle to make lessons interesting***. At the same time, Rachel continues to reflect on the sacred story, ***using digital technologies should not only be interesting but also foster student learning***. This reflection is reminiscent of the social rhetoric in which teachers are positioned as *edutainers* and seems to be contradictory to Rachel's self-identified duty to utilize digital technologies for added value. Here Rachel confides that creating online quizzes may not be worth her while, which also seems to be in tension with her professional duty identified in the beginning of this chapter: teaching students skills rather than facts. |
| Confidence of teacher affecting confidence of students<br>**Deflating Belief**<br><br>*Maybe 'cause, like, w-w-well I can just speak for myself, but I'm not-maybe if I'm not super confident in using it it will-they'll [students] see that and they're like: 'Well, if she's not confident then I am-I'm not gonna use it.'*<br><br>Drawing on the pronoun 'I,' Rachel personally reflects on the intersection between the secret and sacred stories. She has a personal history utilizing digital technologies, yet as an early-career teacher, Rachel does not have a professional history using them in the classroom. Despite her skills and the social rhetoric behind students' rights to be taught how to utilize digital technologies by competent practitioners, Rachel's lack of professional history may compromise her sense of agency to enact the sacred story drawing on these skills to produce lessons with digital technologies. |
| Worrying about the technology being lame<br>**Deflating Belief**<br><br>*I just wonder if, like, yeah, the-in terms of being lame, just I don't know if they'll [students] think like: 'Oh, it's dumb,' like, and then in that case, they won't use it.*<br><br>Despite being intrigued by a virtual reality software introduced in her teacher training program, Rachel explains why she did not explore using it. With this software teachers could 'hide' virtual clues and information at different global positioning system (GPS) locations. Students could use their mobile devices to interactively learn about subject-specific material. Although Rachel was able to identify some pedagogical possibilities for using this technology, without a personal history she deferred to her perceptions of her students' willingness to learn with technology. The Riverside enacted curriculum did not specify a program for students' digital experiences and without the social signs in place positioning Rachel to explore this technology, her personal agency to do so seemed to be compromised, thus a secret story emerges: ***I'm not going to put my lessons at risk because students will find my digital technology use lame***. |

Rachel's tentative approach to incorporating digital technologies in her classes appeared to be informed by both her personal and professional history and how she perceived her students' willingness to utilize them. When Rachel was unable to anticipate positive outcomes aligning with her duty to enhance students' learning experience, her sense of agency to incorporate digital technologies seemed to be compromised. Reflecting on her teacher training and the Substitution Augmentation Modification Redefinition (SAMR) model (Puentadura, 2013) introduced there, Rachel explained:

> *So, it's the-it doesn't matter if it's that map on paper or if it's Google Maps, it's how you then use Google Maps to then work out even not distance but just, like, I dunno I can't think of an example. But how you then use that technology to enhance your experience to go into the more application kind of uses of technology rather than just it replacing what you are already doing anyway.*

This reflection is indicative of the sacred story and Rachel's self-identified professional duty to strengthen students' application skills. Even though she may have used digital technologies as research tools, for this early-career teacher these experiences do not appear to be seamlessly transferrable to her teaching practice. Taking cues from the social signs Rachel's beliefs about her students' possible reactions seemed to compromise her sense of agency to take risks exploring pedagogical possibilities for digital technology use.

### 8.2.3 Requiring Pedagogical Strategies to Develop Students' Digital Skills

The analyses of Rachel's reflections in sections 8.2.1 and 8.2.2 explained tensions between the cover, sacred and secret stories as Rachel articulated her professional duties, pedagogical possibilities and beliefs about students' perceptions of her digital technology use. When elaborating on what a meaningful use of technology meant, Rachel explained:

> *Students, like, talking and helping each other out. Asking me questions if they're not sure.. Not being too distracted by other things on their computers which doesn't happen. I mean, the year sevens are actually quite good, but year nines are more distracted by their computers.*

This reflection illustrates Nespor's (1987) notion of alternativity which refers to teachers' perceptions of ideal situations, differing significantly from current circumstances, yet serving to inform practice.

Rachel's reflection began with the ideal situation, the professionally recognized and perpetuated sacred story: ***Using digital technologies means students take an agentic approach to their learning***. Rachel ascribed her students duties to help each other, seek teacher assistance and monitor their level of distraction while working on their devices. Overall these were duties that some of Rachel's year nine students also accepted and ascribed for themselves. The second half of this reflection seems to indicate that this ideal was rarely achieved. Rachel's year nine class had a school-wide reputation for being challenging in terms of classroom management and many students were known to struggle with completing work to the standard that the school expected.

Rachel continued to enact her duty to incorporate digital technologies into her classes, albeit with caution. Of interest is that Rachel did not ascribe her students with the duty to help her with digital technology use in the classroom. If Rachel utilized digital technologies in the public space only after feeling sufficiently competent to do so, then at what point did she expect her students to be able to assume the duty to help each other? Table 8.4 exemplifies some of Rachels's *reflections* about students' digital technology use, shows how these reflections were initially coded and identifies the types of **beliefs** she expressed.

Overall, Rachel's beliefs about her students were conservative, like Charlotte, Ethan and Isabelle, she did not overclaim for students' capacities to utilize digital technologies in science. The reflections in Table 8.4 exemplify Rachel's overarching attitude to students' digital technology use: Students know how to use some technologies but require tuition to back up data, use the sharing affordances of cloud computing software and learn digital skills for subject-specific technology-enabled learning. Together Rachel's attitude toward her students' digital technology use and the emergent cover, sacred and secret stories have been raised to the focused code: Requiring pedagogical strategies to develop students' digital skills.

**Table 8.4: Students Know How to Use Some Technologies but Still Require Tuition**

| |
|---|
| Feeling unsure if students know how to use their devices for school<br>**Deflating Belief**<br><br>*… Um, I'm not sure. I'm not sure, but I'd-I think they [students] haven't been taught how to, you know, back up their data. You know, back up their things and use sharing, like-like, Dropbox or Google Drive or something like that. Like, when I've mentioned things like that, they're like: 'Yeah, we know what it is but we don't really use it.' So, no maybe not then, maybe they don't know how to use, um, their things properly [...] it's something that they are just assumed to know how to use that they don't actually use properly.*<br><br>In the beginning of our follow up interview Rachel reflects on whether students know how to use their devices for school purposes. Rachel demonstrates her technological knowledge by ascribing students the right to be taught how to back up data and use the sharing affordances of cloud computing software. Rachel's students seemed to share a cover story with her: ***We know about cloud computing but choose not to use it***. As Rachel articulates this explanation, her perceptions of students' capacity seem to change from being unsure to accepting that students do not know how to use their devices 'properly.' Despite having a personal history using Dropbox, Rachel has not assumed the duty to teach students this skill possibly because sign systems within the local moral order have not yet been established permitting her to do so. |
| Using technology well for educational purposes<br>**Enhancing Belief**<br><br>*Um, students do [inaudible], um, the majority of the students would use it [technology] well, like, in terms of they use it for educational purposes in the class, like, to search [for] something or to write what they're, you know, or to write some notes from the teacher or whatever.*<br><br>Later in the same interview, Rachel expresses an enhancing belief about students' capacity to utilize digital technologies explaining that 'the majority' are able to use them well to complete Internet searches and write notes. Rachel also explained that students are able to create PowerPoint presentations and use Compass, Riverside's attendance and learning management system, to access resources posted by teachers. However, in the absence of an established program of digital experiences for students these skills seem to reflect a low-level use of digital technologies as they are integrated (Brantley-Dias & Ertmer, 2013; Ertmer & Ottenbreit-Leftwich, 2013) into lessons. A cover story seems to emerge: ***Riverside students are capable digital technology users***. In addition, these low-level expectations do not seem to provide the sign systems permitting Rachel to deviate from the accepted script and assume the duty to explore technology-enabled learning, which could include using Microsoft Excel to teach students about standard deviation. |

The sacred story, ***students should take an agentic approach to learning with digital technologies***, the secret story, ***this may not be happening in my classroom***, and Rachel's attitude about her students' digital technology use were combined to form the focused code: Requiring pedagogical strategies to develop students' digital skills. This focused code seems to be more telling of Rachel's pedagogical capacity to utilize digital technologies rather than her students' ability to use them. Rachel was personally empowered to back up data, use cloud computing and draw on the affordances of digital technologies in her own research. Although she seemed to identify these skills as

transferrable, in the absence of social signs Rachel has not yet developed a pedagogical strategy to produce lessons reflecting these self-identified duties beyond the accepted practices within the local moral order.

### 8.2.4 The Emergence of a Theoretical Category: Caught Between a Rock and a Hard Place

From her research experience, Rachel could be assumed to have a sophisticated understanding of a variety of digital technologies for collecting, storing, sharing and analyzing data. Rachel's self-assessments of her own and her students' use of digital technologies seemed to indicate that she was able to interpret the technology of sign systems to identify some skills as transferrable to the classroom. However, Rachel questioned the potential of digital technologies and her students' use of them to contribute to the sacred story: ***Classroom activities should enable students to achieve desired learning outcomes***. As such, Rachel seemed to be at an introductory level of the technology of production (Foucault et al., 1988). Attending to the accepted practices of the local moral order, Rachel was able to manipulate digital technologies in similar ways to her colleagues, but seemed to be caught between a rock and a hard place negotiating a distinct use of digital technologies.

Caught between a rock and a hard place is a colloquialism used as a theoretical category to describe the difficult situation Rachel seemed to find herself in as she negotiated her professional duties *and* personal capacity to teach science with digital technologies. For Rachel, incorporating digital technologies in the classroom meant that she could:

1. Take a risk to employ technologies which might be perceived as 'lame' by the students, have minimal added value or both; and/or

2. Set aside possible uses of new technologies in favor of practices, digital or non-digital, that she perceived to enhance students' learning

At this stage Rachel did not have a lived script for how to pursue her own self-ascribed professional duties to transform and/or produce (Foucault et al., 1988) classroom activities with digital technologies. Her tentative approach to utilizing the data loggers, explained in section 8.2.2, was telling of the personal support Rachel required to take ownership of her capacity to use digital technologies and draw on her sense of agency to

incorporate them for technology-enabled learning. How, then, could Rachel be better supported to teach OOF while incorporating digital technologies? The next sections draw on Rachel's perceptions of digital technologies and both her and her students' use of them as she piloted the year nine geoscience unit.

## 8.3 Teaching Geoscience: Being at a Strike-Slip Fault

Even though Rachel was not yet empowered to transform or produce lessons with digital technologies beyond the accepted practices of the local moral order, her willingness to respond (Krathwohl, 2002) indicated that professional growth would be possible. In the previous section Rachel's reflections signaled that she required a model of professional learning to possibly strengthen her technological pedagogical content knowledge (Koehler & Mishra, 2009) and support her to assume her self-ascribed professional duties.

As a participant in this research, Rachel was an apprentice digital technology user who did not yet have personal or professional history learning and teaching geoscience. In chapter five Rachel indicated that without support her use of digital technologies in geoscience would be informed by her existing practices. This section exemplifies how Rachel's perceptions of her digital technology use may have changed as she was offered support to incorporate a range of technologies into her OOF teaching practice.

Over six weeks, Rachel taught year nine geoscience alongside Jeremy, a non-participant in this research, and she participated in three interviews. I observed six of Rachel's classes and regularly conversed and debriefed with both her and Jeremy as they sought my support. Vignettes 8.1 and 8.2 exemplify memos that I recorded after two conversations with Rachel.

### Vignette 8.1: Teaching Students How to *Be* in this Space

It's the second week of the pilot and I caught up with Rachel at lunchtime. She seems overwhelmed and unsettled by her class because some students arrive without their devices or without Google Earth installed. She's staying one step ahead of them and I reminded her that it's about attending to the sacred story, teaching students how to *be* in this space: ***We use tech to do science***. We need to teach the students that Google Earth is the toaster and the .kmz files are the toast, that's my technological knowledge coming through, but how do we build teachers' knowledge and then empower them to invite students into this sacred story?

### Vignette 8.2: Making the Unit Her Own

It's the third week and Rachel seems to be making the unit her own. Today's lesson focused on Earth's structure to prompt students' thinking about why earthquakes and volcanos occur. As an introduction, two natural disasters were revisited: tsunamis and lahars. Rachel added some notes to the PowerPoint defining these terms and she incorporated videos showing the events. Why? Rachel explained that until yesterday she didn't know that a lahar is a mudflow caused by a volcanic eruption. Signposting these terms in the teacher resources seems to have provided the social signs to inspire Rachel's interest to learn about and then attend to a professional duty to better prepare students toward understanding these terms.

Two technologies, distinct from her teaching practice, seemed to stand out for Rachel: Google Drive and Google Earth, classified in chapter six as organizational and subject-specific technologies respectively. During our second interview, approximately three weeks after the pilot began, Rachel reflected on Google Drive:

> *So, you know, making them [students] use this one folder to put all your geoscience notes in, you know, maybe some of them were already doing it, but probably not all of them and it's a new-it's a skill to learn to organize your things on a computer. You know, and I don't think a lot of them-so I think doing this has definitely taught them-well at least taught them and showed them you can do this whether you choose to, it's up to you.*

Section 8.2.3 indicated that Rachel identified a right for students to be taught how to utilize the sharing affordances of cloud computing software, but she did not yet have the pedagogical strategies to be able to assume this duty. In this reflection, Rachel explains how this unit of work has enabled her to attend to the sacred story sharing files with students and teaching them how to organize their work after being offered a pedagogical script to do so. At the end of the turn, Rachel positions the students as agentic digital technology users but is careful not to overclaim for their capabilities. Tension between the sacred and secret stories emerges: ***I've taught sharing and organization using cloud computing, but whether or not students have taken on these lessons is unclear***. Rachel's reflection, however, seems to indicate a significant moment of peer-to-peer mentoring where Rachel has interpreted sign systems to employ pedagogical strategies to learn about and teach students how to manipulate new software.

Of note is that although Rachel identified the right for students to be taught the sharing affordances of cloud computing software, she did not seem to engage in these practices herself. Rachel's edited PowerPoint presentation, introduced in Vignette 8.2, was not shared with her colleagues. Although Rachel was an apprentice digital technology user and capable of sharing her resources in this way, perhaps as an early-career teacher teaching OOF and developing a personal history with this technology Rachel was not yet empowered to make her work public.

Five weeks after the pilot began, Rachel reflected on Google Earth:

> *I didn't realize how much-what you could use on it [Google Earth]. I just had no idea that there's all this, um, information that you could get from it and these-particularly these, like, CE [Cyber-Enabled Earth Exploration] folders [...]*

Prior to teaching with the Cyber-Enabled Earth Exploration (CE3) curriculum (Almquist et al., 2012; Blank et al., 2016; Blank et al., 2012) Rachel used Google Earth for students to passively participate in her lessons, 'look at these places,' rather than more active endeavors such as data collection. Using the qualifying word 'just,' this reflection appears to signal a shift in Rachel's beliefs about the pedagogical power of Google Earth and a sacred story seems to emerge: ***The CE3 resources strengthen my use of Google Earth for teaching science inquiry***.

Rachel's reflections and the vignettes at the beginning of this section seem to exemplify her willingness to explore digital technologies distinct from her regular classroom practice. A scaffolded use of Google Drive and Google Earth has appeared to strengthen Rachel's awareness of geoscience concepts and the pedagogical strategies for utilizing these technologies. The following sections exemplify and explain how Rachel positioned the digital technologies as well as herself and her students as she taught the year nine geoscience unit to form the theoretical category: Being at the strike-slip fault.

### 8.3.1 Digital Technologies Enabling the Transference of Skills

Prior to teaching geoscience, Rachel positioned digital technologies as material objects to be approached with caution. This section draws on Rachel's reflections about digital technologies that she seemed to perceive as the most significant: Google Drive and Google Earth. Tables 8.5 and 8.6 exemplify these *reflections,* their initial codes and types of

**belief** (Rokeach, 1968) expressed alongside their analyses. Rachel's overarching attitudes and the emergent cover, sacred and secret stories were raised to the focused code: Digital Technologies Enabling the transference of skills.

## Table 8.5: Frequent Use of Google Drive Enables the Teaching of Organizational Skills

<u>Helping students keep organized</u>
**Enhancing Belief**

*I think using Google Drive has been good, 'cause it, they [students] can start to see, like, how a folder should be organized on a computer. [...] Um, that, like, this is showing them like you can have some kind of organization in a Google Drive folder and it makes it easy to see 'cause, and I've noticed, like, now when I say: 'Open the Google Drive,' just even this lesson today, it was like: 'Ok, I know what to open and I know where to go.'*

Rachel shared this reflection after the first week teaching geoscience. She expresses satisfaction using Google Drive because she perceives this structured approach as strengthening her ability to attend to the duty to help students organize digital files and 'know how to use' their computers. Using 'even' Rachel seems to indicate a shift in her beliefs after a week of use as she perceives students be able to interpret the social signs to effectively manipulate Google Drive. Thus, a sacred story emerges: ***I'm developing a script for teaching digital skills***.

<u>New technologies can hinder students</u>
**Deflating Belief**

*I think it's just initially it was just, like, un-the unknown is what hindered them. But, like, yeah. It's only been a week, 3 lessons, you know, so hopefully, like, by 6 more-6 lessons [2 weeks later] it might be a bit different if we use it more frequently. I think it's, like, gotta be used frequently for them to really use it, you know, like understand how to use it.*

This reflection is more telling of Rachel and her students' capacity to utilize the digital technologies rather than Google Drive itself. Continuing the reflection above, Rachel explains that using Google Drive came with frustration. Most of Rachel's students did not have a personal history using cloud computing software and, at times, were unable to interpret the sign systems to access a shared folder unless these skills were frequently revisited.

At the same time, however, Rachel seemed to be empowered to draw on her technological knowledge engaging students in what I term *troubleshooting talk*: 'Ok, well have you looked in *shared?* Have you looked in *my drive*? Have you looked in *recent documents*?' Rachel talks through what she perceives to be important inner speech (Vygotsky, 1962) to model the practices of agentic digital technology users. As such, this apprentice user seems to shift the secret story toward a sacred story: ***I'm using this unsettling experience to model meta-cognitive problem-solving processes***.

<u>Helping students catch up</u>
**Enhancing Belief**

*And a lot of them just miss things and 'I missed this and I-what do I catch-how do I catch up,' and-having, I think having the Google Drive was good because I just said: 'Go to this folder and that's the PowerPoint we used,' so they were use-they were-that was fine, but.. it's just been really hard (laughs).*

Rachel shared this reflection five weeks after the unit began, explaining that the Google Drive offers students opportunities to catch up after being absent from class. Although Rachel assumes a professional duty to help students negotiate Google Drive, she seems frustrated as students make the transition from using Compass, Riverside's attendance and learning management system, to Google Drive. As such a sacred story emerges: ***Settling on a digital technology with the desired affordances for both teachers and students would be easier***.

## Table 8.6: Provided it Works Google Earth Enables Understanding and Application of Geoscience Knowledge

<u>Malfunctioning technology is a hinderance</u>
**Deflating Belief**

*[I]f I'm-I can see that if it works it's gonna be great but it's not working as well as it should and so it's a hinderance more than anything else at this point [...]*

In the first week, Rachel explains her shifting perceptions about the benefits of Google Earth. Although she was provided lesson plans with instructions, Rachel required more support to feel empowered to manipulate Google Earth with students. As such a secret story emerges***: I'm frustrated with the technology and I don't know how to solve these problems***. This reflection seems to be more telling of Rachel's technological pedagogical content knowledge than the software itself and is significant because without the support of an insider-researcher, Rachel's professional duty to make meaningful use of class time may have compromised her exploration of Google Earth. Offering Rachel the time and space to reflect on problems enabled me to provide technical support by explicitly teaching Rachel and her students troubleshooting strategies.

<u>Google Earth and CE3 are enabling students to apply knowledge</u>
**Enhancing Belief**

*[T]hey're [students] not just simply writing down a definition of what a volcano is and what makes up a volcano. They're actually exploring the volcano, having to think about that [...] I think it's a really good task, the volcano one, the CE3 activity we did, because, like folder four, they had to go to Mt. Fuji and go: 'Using the information, I'm able to say that this is a composite volcano.' And when I read over their papers, a lot of them used that knowledge.*

In the same interview as the reflection above, Rachel shares a sacred story elaborating on what she perceives to be the benefits of Google Earth. Rachel compared students' use of Google Earth to textbooks explaining that Google Earth enables students to develop inquiry skills by gathering and analyzing data. Attending to her professional duty to hold students accountable for their progress, Rachel expresses satisfaction because she is able to confirm that the CE3 program challenges students to apply their knowledge. As such, utilizing Google Earth in this way may provide sign systems to signal how Rachel might transform her pedagogical use of Google Earth for teaching inquiry skills.

Of note is that Rachel shared positive reflections about Google Earth with students' repeated use of it. In the fifth week of the unit, Rachel explained:

> *I think that's, like, that's some good information they can learn using technology from Google Earth. So, um, looking at whether a trench forms or if volcanos formed an island arc or whatever it is, um, you know, that-that's something they can learn from using digital technology in this unit [...]*

Rachel reflects on students collecting data at plate boundaries to explain the formation of geographical features. Perhaps reflective of her own lack of personal history utilizing Google Earth for inquiry, Rachel seems to distill the pedagogical importance of the activity to a passive learning experience reflecting on 'good information' being offered and 'looking at' landscape formations. As such, Rachel appears to be traversing a new pedagogical environment to strengthen her capacity teaching inquiry skills using digital technologies and she may require continued peer-to-peer support to do so.

Rachel's reflections presented in Tables 8.5 and 8.6 seem to be more telling of her capacity to teach with digital technologies than the technologies themselves. Rachel's ability to teach transferrable digital skills, such as cloud computing, appeared to be strengthened when she was offered a strategy to do so. Rachel also drew on her sense of personal agency to model the inner speech of agentic digital technology users to help students solve technical problems when peer-to-peer support was not immediately available. In addition, Google Earth resources and assistance to use them seemed to juxtapose Rachel's professional history with a distinct pedagogical approach focusing on inquiry skills putting in place sign systems to possibly transform her future pedagogical practices.

Before piloting the year nine geoscience unit of work, Rachel positioned digital technologies as material objects to be approached with caution as she attended to her professional duty to make meaningful use of students' time in science. Being supported to use Google Drive and Google Earth in this unit seemed to offer this early-career teacher and former researcher the social signs to manipulate these digital technologies in pedagogically distinct ways from her previous personal and professional uses. As such, Rachel's attitudes toward Google Drive and Google Earth and the secret and sacred stories emerging were raised to the focused code: Digital technologies enabling the transference of skills.

### 8.3.2 Moving Forward with Continued Support

Prior to teaching geoscience, Rachel's beliefs about self and her digital technology use seemed to depend on and align with her self-efficacy to incorporate digital technologies in what she perceived to be pedagogically valuable ways. Despite being willing to experiment with digital technologies, Rachel's beliefs about how students would respond to her digital technology use seemed to compromise her sense of agency to take risks exploring those outside the accepted practices of the local moral order. Tables 8.7 and 8.8 exemplify some of Rachel's *reflections* about Google Drive and Google Earth and explain how they were analyzed to form her overarching attitudes toward using these digital technologies. In both tables the initial codes are presented and the types of **beliefs** Rachel expressed are identified. These attitudes and the secret and sacred stories emerging have been raised to the focused code: Moving forward with continued support.

## Table 8.7: Although Initially Difficult to Manage, Google Drive is Transferrable

Helping too much?
**Deflating Belief**

*I don't know if it's just maybe because I am, like, helping them too much and I should let them do a bit more on their own. You know, like, maybe it's that I just want to progress the class and get it done, but it's very hard, like, with 26 students in the class (laughs nervously) to do that for everyone.*

After teaching geoscience for a week, Rachel reflects on her use of *troubleshooting talk*, explained in Table 8.5, illustrating the complexity teaching at the science and digital technologies curricular intersection. Rachel understands that learning is a developmental process and, for her, appropriate teaching practice means evaluating when to let students 'do a bit more on their own.' At the same time, she seems to feel pressure to keep the pace of the lesson. Modeling inner speech to scaffold students' digital skills is time-consuming and possibly overwhelming for this early-career teacher developing her technological pedagogical content knowledge with 26 students. Of note is that Rachel seemed to assume this duty herself rather than drawing on students' developing skills to model the approach with their peers. As such the sacred and secret stories seem to be in tension: ***I personally assume a duty to develop students' digital skills, but it's hard teaching at the science and digital technologies intersection***. As such, this reflection seems to indicate that Rachel continues to require sign systems offering her pedagogical strategies easing this tension.

Considering using Google Drive in the next unit but feeling unsure
**Enhancing/Deflating Belief**

*I think it's a useful tool. I'm even considering using it for the next unit as well. So, like, perhaps I don't know if I'm willing to take that step, but, um. No, but maybe, 'cause, like, now they know how to use it, I think, like, if I just go: 'Ok, so we're just going to continue on the next unit in the same way,' you know, so it's not them having to relearn it and at least they know how to use it now.*

Three weeks after beginning the pilot, this turn exemplifies the moment-to-moment shifts in Rachel's perceptions about her sense of personal agency to utilize Google Drive. She begins by expressing satisfaction and uses 'even' to signal a shift in her perception of the transferability of Google Drive. In the next sentence Rachel seems to reflexively position herself re-evaluating her commitment to Google Drive. Then, in the final sentence, Rachel appears empowered to produce a unit plan with the software, deferring to students' capacities to utilize Google Drive she proposes 'we're just going to continue on the next unit in the same way.' Of interest is that Rachel does not elaborate on changes she would make to offering a unit structured in this way, possibly indicating that she may not be empowered to transform her use of this software to suit her pedagogical values. Again, tension emerges at the boundary between the sacred and secret stories: ***I'm willing to explore the pedagogical practices I've learned, but I'm not confident to change my approach yet.***

## Table 8.8: Confidence with Google Earth Enables Reflection on Teaching Practice

Having confidence to change pedagogical approach

**Enhancing Belief**

*I was just getting so many questions that I had to, like, go out and help them anyway. So, I just thought: Ok, this is how you start, read the instructions and then go on your own and if.. Yeah, like, that was-the idea was for me I would've gone at the front, done it with them, they would have followed along, but there was just too many problems that I had to go help them. So, I had to do it another way at that point.*

In the first week, Rachel explains her approach teaching students how to use .kmz files and Google Earth. Following the social signs in lesson plans to begin with whole class instruction, interruptions from students prompted Rachel to draw on her personal agency and change her pedagogical approach. Using the phrase 'had to' Rachel prioritizes efficiently attending to her professional duty to offer students individual assistance. Of importance is that this apprentice digital technology user was able to take a pedagogical risk and deviate from the lesson plan to assume her professional duty. Notably, Rachel also assumed a personal and professional duty to complete the CE3 activities herself and thus develop a personal history with Google Earth before lessons. Attending to the sacred story in this way, ***I've got a duty to know what I'm doing so I can teach the students***, possibly strengthened Rachel's capacity to feel empowered to personally support her students.

Identifying an opportunity beyond subject specific teaching

**Deflating Belief**

*Maybe it's got to be more of a culture of it's ok to get it wrong from the start, you know, maybe I haven't implemented that enough with them, but-it's ok to just give it a shot and if it doesn't work, that's fine try something else.*

Rachel continued to reflect on her pedagogical capacity to teach students digital skills. Although empowered to personally attend to students' technical difficulties, Rachel's sense of agency seemed to pose an additional dilemma. After three weeks using Google Earth, some of Rachel's students continued to be unsettled by small problems. For instance, failing to click radio buttons to reveal placemarks with information to record and analyze. Some students appeared to be apprehensive about making mistakes with the technology and opted to wait for Rachel's assistance. As such, Rachel began to doubt whether she had fully attended to a professional duty to create a classroom environment that empowered positive risk taking. Rachel did not appear to be disempowered by this reflection, rather it signifies an unexpected turn in the sacred story, ***I'm questioning my pedagogy beyond teaching at the intersection of subject-specific content knowledge and digital skills.*** This seems to signal an opportunity for Rachel's professional learning that is transferrable to her future practice regardless of the subject taught.

Rachel's reflections in Tables 8.7 and 8.8 seem to indicate a shift from the secret to the sacred story, ***I was feeling unsettled scaffolding students' use of technologies new to my practice, but now I'm reflecting on and possibly evolving it***. Prior to participating in this research, wary of the potential for success and students' perceptions, Rachel may have refrained from teaching students cloud computing. Without a personal history studying geoscience, Rachel may have relied on low-level uses of digital technologies to teach this OOF area, using students' devices to look up terms rather than gathering and analyzing data with Google Earth.

Reflecting on her PMMM two months after the conclusion of the unit, Rachel explained that digital technologies are:

> *[N]ot hard to use, but it's just, like, there's no time to, like, figure out how incorporate it in the class. You know? That's-that might be a reason. Um… I think we're gonna have to, because students-it's just gonna be the way of the future (laughs).*

Rachel reflects on an accepted secret story in the teaching profession: ***There's never enough time for me to do what I need to do!*** Deferring to lack of time may be perceived to be an indisputable argument to reason why teachers may attend to some duties in favor others at certain times and places. Although time is undoubtedly a factor, Rachel's reflections in Tables 8.7 and 8.8 speak more about the complexity of a teacher's lived experience than distilling it to time alone. For Rachel, provision of time, continuous support to reflect on her technological pedagogical knowledge and her personal duty to act on these reflections seemed to strengthen her personal agency to teach OOF with digital technologies.

### 8.3.3 Developing a Script for Digital Technology Use

Section 8.2.3 explained that emergent cover stories about students' digital technology use seemed to be in tension with Rachel's perceptions of the intended sacred and enacted secret stories of her classroom practice. Prior to teaching geoscience Rachel's self-ascribed professional duty to teach digital skills indicated that she required pedagogical strategies to develop students' capabilities beyond the limited experiences offered within the local moral order. The previous section seemed to indicate that offering

time, resources and continuous support strengthened Rachel's capacity to manipulate digital technologies and reflect on her future practice.

In this section, Tables 8.9 and 8.10 exemplify some of Rachel's reflections about her students' use of Google Drive and Google Earth. These *reflections* including the initial codes, types of **belief** and analyses seem to indicate that Rachel positioned her students as capable but not yet proficient users. These attitudes and the secret and sacred stories emerging seemed to be more telling of Rachel's developing technological pedagogical content knowledge, as such they were raised to the focused code: Developing a script for digital technology use.

## Table 8.9: Students Can Use Google Drive, but to Varying Extents

Questioning whether students know how to use Google Drive
**Deflating/Enhancing Belief**

*I-I just said-I-I opened with saying: 'I know this unit has been a bit frustrating for some students,' and [...] a lot of them just said: 'No, it's fine.' I'm like: 'Are you serious? Like, it's been fine?' And, like, I mean, and I think the ones that came to parent-teacher are the ones who are doing their best to try and use it properly. [...] And I think they probably knew how to use it before, but they didn't know that they could use it. Like, that it was available to them? Like, they know how to organize folders I think. I think. I think. I don't know actually.*

Five weeks into the unit, Rachel describes her surprise during parent-teacher conferences when students seemed to challenge her perception of their experience. As a professional, Rachel has been trained to be acutely aware of students' behavior and progress toward achieving learning outcomes, yet she expresses a cautious cover story with an inflection: ***Students knew how to use Google Drive, but possibly didn't realize it was available?*** In the final part of the turn, however a secret story emerges: ***I'm not sure students know how to use Google Drive***.

This reflection is significant because it seems to indicate the fragility of Rachel's sense of empowerment to accurately assess her students' digital skills as she develops her technological pedagogical content knowledge. As such, Rachel may continue to evaluate her success as a teacher based on students' perceptions of digital technology use. Thus, tension appears to arise at the intersection of students' cover story and Rachel's secret story: ***My observations indicate that using Google Drive wasn't as easy as students would like me, and their parents, to believe, yet I'm left doubting my evaluation of their experience***.

Many students are unable to find files
**Deflating Belief**

*I just think a lot of them [students] didn't have it, you know, they had the shared folder and the shared section but never actually copied it into their own drive and so whenever they went to try and find it they couldn't [...].*

Two months after teaching geoscience, Rachel expresses a more conservative assessment about students' use of Google Drive. Despite explicit tuition from both Rachel and I, some students continued to struggle organizing their work. Attending to the sacred story, Rachel explains what she perceives to be a significant barrier to success: Ensuring that shared files have been downloaded and saved to personal drives.

As an apprentice technology user who modelled inner speech for successful troubleshooting strategies, Rachel appeared to require additional support developing students' habitus (Burkitt, 2002) using Google Drive. I created a video demonstrating troubleshooting strategies across Macintosh and Windows operating systems with the intention of strengthening teachers' capacity to teach for technology-enabled learning. Both teachers and students could revisit these videos in/outside the classroom. Rachel's participation in the pilot was significant because reflections like this informed the improvement of resources and their sign systems that would possibly enable Rachel's colleagues to better manipulate digital technologies new to their practice.

## Table 8.10: Students Can Use Google Earth to Varying Extents and Levels of Metacognition

| |
|---|
| Students having difficulty making observations<br>**Deflating Belief**<br><br>*But they [students] didn't-they didn't even think about slope. They didn't think that they-all they did from those graphs, um, all they did was press analyze and look at the number and write it down. They didn't even look at the graph. To l-what does the graph mean at all?*<br><br>Rachel reflects on a CE3 activity from the second week of the unit. Students were using Google Earth to take elevation profiles to classify volcanos and explain different types of eruptions. Rachel positions her students as competent Google Earth users, they are able to obtain the necessary information, however she seems frustrated because students did not seem to use the data to calculate slope, a significant part of the activity.<br><br>With a limited personal history in geoscience but the digital skill set to be a proficient user of Google Earth, this reflection highlights the complexity of Rachel's experience. As an early-career teacher, Rachel is still developing her pedagogical content knowledge (Shulman, 1986b) and this task challenges her to teach not only across the science and digital technologies curricula but also mathematics, for which Rachel has been trained to teach from years seven to ten. Of significance is that although Rachel spent ten years as a career research scientist, she requires additional sign systems to turn the secret story into a sacred story: ***I can't believe they didn't use slope, and now I need to employ pedagogical strategies to help students achieve the learning outcomes***. |
| Students getting better at higher-order thinking through Google Earth<br>**Deflating/Enhancing Belief**<br><br>*[T]hey-they [students] do rely on just the teacher to go: 'This is what you need to know.' And I know that I do that, like, it's just been easier for me to do that this year. If-I don't want to do that-I don't want that to be how I teach u-ultimately, you know? This being my first year, it's just that's been the easy path [...] but to give them more, like, like the tasks we've been doing with Google Earth are so much better. Like, I really like them because, you know, they go through the content and then they have to do this analysis question which they struggle with, but they're getting better at doing that.*<br><br>Five weeks into the unit, Rachel reflects less on students' abilities with Google Earth and more on her own teaching, students' metacognition and the accepted practices within the local moral order. Chapter five explained that some Riverside science teachers identified a need to focus more on teaching higher-order thinking. As an early-career teacher, Rachel reflects on an accepted secret story: ***I want to teach for higher-order thinking, but I struggle to negotiate my personal and professional duties***. As such, Rachel's capacity to enact what she perceives to be sound pedagogical practices may be compromised. However, in the second part of the turn, Rachel expresses satisfaction with Google Earth because this software, when used with the CE3 curriculum, seems to provide sign systems to strengthen her capacity to teach metacognitive skills and enable her to attend to the sacred story: ***Students are improving their higher-order thinking because I have a resource showing me how this might look.*** |

The reflections in Tables 8.9 and 8.10 seem to be telling of Rachel's sense of agency to scaffold digital skills more so than students' digital capacities. To varying extents, Rachel's students were able to use both Google Drive and Google Earth software, yet surprisingly in the final weeks of the unit, some of Rachel's students were still unable to find their files in Google Drive, a low-level expectation. Perhaps Rachel did not assume a duty to teach digital skills with Google Drive to the same extent as those associated with Google Earth. This conclusion seemed to emerge in section 8.3.2 as Rachel reported that scaffolding 26 students using Google Drive was 'very hard.' A similar reflection did not arise for Google Earth. However, these levels of commitment may be unsurprising for early-career teachers who are developing their pedagogical content knowledge across sub-disciplines of science. An accepted secret story appears to emerge: ***I've got to get my head around the science, subject-specific digital skills and metacognitive strategies before anything else***.

The sacred and secret stories emerging from Rachel's reflections in Tables 8.9 and 8.10 seem to indicate that, although she was taking risks to develop her sense of agency using technologies new to her practice, this early-career teacher would continue to require peer-to-peer support to develop practices at the science and digital technologies curricular intersection. As such, these secret and sacred stories and Rachel's attitudes toward her students' use of Google Drive and Google Earth were raised to the focused code: Developing a script for digital technology use.

### 8.3.4 The Emergence of a Theoretical Category: Being at the Strike-Slip Fault

Prior to teaching geoscience, Rachel's digital technology use appeared to be compromised by her perceptions of students' possible reactions toward them and her cautious uptake of digital technologies reflected a professional duty to enhance students' learning experiences. Rachel was caught between a rock and a hard place, as such it seemed that she had not yet established a personal script for developing students' digital skills outside the accepted practices of the local moral order.

Approximately half way into the year nine geoscience unit, Rachel reflected:

> *I haven't heard, you know I don't-I'm not with them every second of the day, but I haven't heard anything of like: 'This is so boring, uh, we've done this before, this is the*

> *same as we've done in year eight,' kind of stuff. So, it's all new information and I can-by them struggling with doing these things and l-learning what a fracture is, um, they obviously haven't done this before so, yeah. I think-I think they are enjoying it.*

As a participant in this research, this personal reflection seems to indicate that the professional risks Rachel took to pilot the unit seem to be paying off. She reports that her students enjoy learning geoscience with digital technologies. By reflexively positioning herself as a learner, Rachel also responded with satisfaction: 'The fact that I've had to teach it and learn about it beforehand, I've enjoyed that,' indicating that her capacity to teach OOF with digital technologies may be strengthened through a personal commitment to learning.

While teaching geoscience, Rachel shifted her positioning of digital technologies as material objects originally to be approached with caution toward strengthening her capacity to enact pedagogies associated with technology-enabled learning. Rachel interpreted sign systems to manipulate digital technologies and transform her current and possibly future pedagogical practice. As such, her sense of agency to utilize digital technologies seemed to shift from holding back unless success was guaranteed toward being empowered to explore distinct pedagogical practices with continued support.

Being at the strike-slip fault is a theoretical category emerging from Rachel's positioning of the digital technologies, self and her students. A strike-slip fault is a geoscience term defined as the horizontal motion of rock and serves as an analogy to explain that although Rachel has made progress using digital technologies while teaching OOF, new challenges seemed to arise. Rachel's perceptions of her students' use of digital technologies highlighted that this apprentice technology user was empowered to develop a script for teaching digital skills, but she faced unanticipated dilemmas to teach metacognitive skills she expected her students to critically evaluate their findings. Although Rachel indicated commitment to producing a unit of work using Google Drive, she did not seem to have a personal sense of agency to enact this endeavor, reverting to Compass, Riverside's attendance and learning management system.

## 8.4 Conclusion: Toward the Principles for Dialogic Planning

Sections 8.2 and 8.3 have explained how Rachel's sense of agency to utilize digital technologies in science seems to have shifted from being between a rock and a hard place toward being at a strike-slip fault where she was developing a script for teaching OOF with both organizational and subject-specific technologies. Two years after piloting the unit, Rachel and I were sharing an office when she made a surprising reflection about participating in this research. Vignette 8.3 presents a memo of this conversation that provided the incentive for a follow up interview.

### Vignette 8.3: Avoiding Fractured Curriculum Delivery

Rachel and I were debriefing about unit planning. She teaches maths and science, and so experiences different styles of collaboration. In science, teachers are tasked with updating units of work, professional duties that tend to be enacted just prior to and during the teaching sequence. While balancing administrative duties, this approach results in a fractured delivery of the curriculum. It was then that Rachel said: 'That's what I enjoyed about participating in that study.' Rachel's statement appeared to indicate that her ability to teach geoscience with digital technologies was possibly strengthened by attending planning meetings and sharing resources in advance of delivering the unit. I also recalled that Rachel seemed to position herself as a learner during this time. She read the text, contributed to the unit plan and tried the activities while expressing a sense of job satisfaction in doing so.

When we met for a follow up interview two years later, Rachel explained her frustration with the school-mandated use of Microsoft OneNote, introduced in 2018 to replace the obsolete curriculum mapping software discussed in chapters five and six. Rachel explained:

> *I'm still not 100% sure [about OneNote], I know how to use it, but it doesn't sync properly on my computer, so, I'm just like: This is too much. I can't use it. And this could be a really good tool, especially, like, [in the] the classroom, um, whatever application for it, um, but I just haven't had the time to, like, sit there and really, like, figure out what's wrong.*

Rachel draws on the pronoun 'I' to share a deeply personal reflection that is indicative of her personal and professional duty to utilize digital technologies mandated by the Riverside leadership team.

Of significance is that this apprentice digital technology user's ability to explore OneNote seems to be compromised by first-order barriers, Rachel cannot access updated

versions of the files. Although Riverside teachers attended a 40-minute professional development session intended to instruct them toward using OneNote, Rachel expressed frustration because she could not access the 'one-to-one' help she required to feel empowered to explore this software. Although Rachel indicates that OneNote 'could be a really good tool,' without a pragmatic approach offering her the sign systems toward an agentic classroom use of it, she seems disempowered to pursue using OneNote.

As a participant in this research, Rachel contrasted her current lived experience with the support she received while teaching geoscience:

> *You know, one really good thing was that I realized that collaborating really closely and having the time to work with colleagues [...] maybe we kind of had time to sit together and think of and talk about the unit. That was really useful. So, it really showed me that, I knew that already, but, like, talking to colleagues and-and planning together is really, really beneficial to the students.*

Unexpectedly, the focus of this reflection is not on the digital technologies but the relationships Rachel identifies as important when teaching OOF with them. Rachel's sense of agency to teach at this curricular intersection seems to be strengthened by close collaboration with colleagues through talking and thinking together.

Dialogic teaching has been explained by scholars such as Barnes (2008); Mercer, Dawes, and Staarman (2009); Mortimer and Scott (2003) and Wegerif (2013, 2016). In chapter six, section 6.6.3, the principles of dialogic teaching (Alexander, 2006) were presented to explain how they informed the planning of Riverside's year nine geoscience unit. Here Rachel seems to indicate an extension of these ideas toward principles for *dialogic planning* that is:

1. **Collective:** Learning tasks are approached by teachers together;
2. **Reciprocal:** Teachers listen to each other, share ideas and consider alternative points of view;
3. **Supportive:** Teachers are free to articulate their ideas and help each other reach common conclusions;
4. **Cumulative:** Teachers build on their ideas and link them into coherent lines of thinking for planning; and
5. **Purposeful:** Teachers plan to achieve educational goals

Although Rachel was already aware that speaking to colleagues and planning together is an important part of teachers' professional duties, this unit of work appeared to cement her belief by engaging Riverside science teachers in a planning process that seemed to be distinct from their day-to-day practices. In addition, Rachel finishes the turn with what she perceives to be the seminal duty of the teacher, appealing to students' rights to have meaningful learning experiences.

Unfortunately, after 2016 Rachel was not allocated another year nine science class preventing her from refining her pedagogical practice teaching geoscience with digital technologies. However, Rachel seemed to draw on her personal agency to explore additional uses of Google Drive. She reflected on teaching senior biology in 2017:

> *[L]ast year in year-in year 11 biology we did kind of a sim-not similar as they, like, had to access various articles on, um, Google Drive and then worked with other students and then collaborated on one document and to-to answer-answer the various questions [...]*

Rachel explains how her students used Google Drive to collaboratively access and discuss ethical issues in biology. Although Rachel's use of the Google Drive was not as extensive as it was in year nine geoscience, utilizing it for this purpose was a new practice for both Rachel and her biology students. Rachel seemed to signal that she was becoming a more agentic user of digital technologies, after having had practice and success herself, she took a risk to explore using them in ways beyond the accepted practices within this local moral order. At the conclusion of our follow up interview, however, I could not help but wonder how this apprentice digital technology user and former career research scientist's pedagogical approaches could be further strengthened with continued *dialogic planning* and timetabling support to teach repeated units of work.

# Chapter 9: Interpreting a Novice II Teacher's Perceptions of Agency Utilizing Digital Technologies in Science

***Interviewer:*** *What do you believe is the purpose of schooling?*

***Ethan:*** *The purpose of schooling? Ooh (laughs). Uh, if you are-if you are a government official, it's about getting people ready for work. Um, if you are a parent or a student it's probably about getting ready for work. Um, for me, [the] purpose of schooling is to teach students about life. How to interact with people and life and know how to maneuver your way through life.*

## 9.1 Introduction

Chapter four introduced Ethan as a research scientist who worked in immunology for over 10 years before becoming a secondary teacher. At the time of our conversations, Ethan had been employed at Riverside for over two years; first as a laboratory technician and then as a classroom teacher substituting for staff taking long service leave. It was during this time that I developed a professional relationship with him. By 2016, Ethan was a full-time teacher with his own classes.

Ethan participated in this research by constructing a personal meaning making map (PMMM) and follow-up interviews before and after teaching year nine geoscience. Of note is that he taught this unit alongside Charlotte, an expert digital technology user whose experiences were exemplified and an analyzed in chapter seven. Ethan and Charlotte had already developed an effective professional relationship through Ethan's work as a laboratory technician and during his first teaching year. At the time of data collection, Ethan and Charlotte were co-teaching a year-long combined year seven science class of 52 students. They both contributed to five collaborative interactive discussions (CIDs) and focus group interviews. Following each focus group, they participated in follow-up individual interviews. I was able to observe Ethan's class three times and was asked to teach it once. I also recorded memos of my observations and interactions with him. In 2018, two years after teaching geoscience, Ethan participated in a final interview.

In this chapter Ethan's sense of agency to utilize digital technologies to teach science is examined through the positioning triad (Harré & van Langenhove, 1999), shown in Figure 9.1, and complementary analytical tools. Constructivist grounded theory coding procedures (Charmaz, 2014), pronoun grammar analysis (Mühlhäusler & Harré, 1990;

Redman, 2013a; Redman & Fawns, 2010) and Rokeach's (1968) five types of beliefs are utilized to track changes in Ethan's discursive practices (Harré & van Langenhove, 1999). These changes highlight tensions and shifts between cover, sacred and secret stories (Clandinin & Connelly, 1996) as he positioned the digital technologies as material objects (Harré, 2002b), himself and his students. As such, they are indicative of the extent to which he felt empowered (Foucault et al., 1988) to act autonomously while teaching with digital technologies.

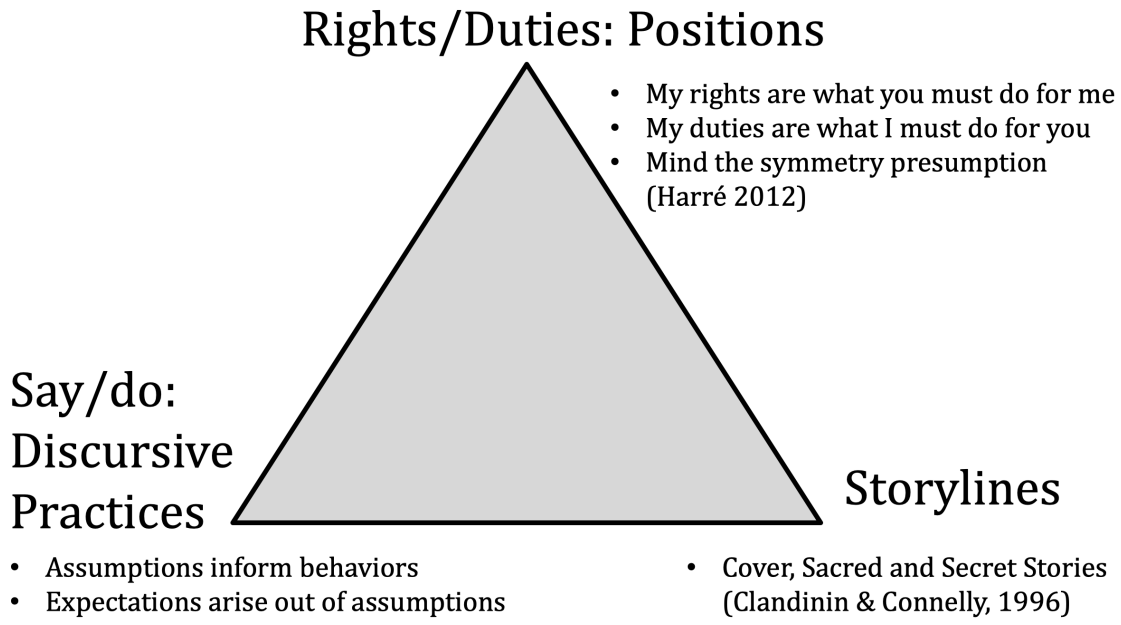



**Figure 9.1: The Positioning Triad Adapted from Harré and van Langenhove (1999)**

Table 9.1 shows the focused codes and theoretical categories (Charmaz, 2014) derived from Ethan's discursive practices. Prior to teaching geoscience, Ethan's self-assessments of his digital technology use positioned (Harré & van Langenhove, 1999) him as a novice II user. Novice II users seemed to have the technological knowledge (Koehler & Mishra, 2009) to utilize digital technologies and identified digital skills they expected students to develop. However, they did not assume the professional duty to teach these skills and, like apprentice users, appeared to be conflicted about translating their professional duties into practice. Ethan's sense of agency to utilize digital technologies seemed to be strengthened by state-mandated requirements for teacher registration but

waned as he appeared to place more value on a self-ascribed professional duty to teach science understanding and deferred to his personal and professional rights to plan efficiently.

While teaching out-of-field (OOF) Ethan was able to manipulate and, at times, transform (Foucault et al., 1988) geoscience lessons with digital technologies. However, he did not appear to be an agent of change. Although Ethan reflected on a greater awareness for teaching digital skills and positioned his students with a duty develop and utilize them, he continued, to varying extents, to relinquish a duty to teach them. Ethan's perceptions of the digital technologies seemed to determine which skills he assumed a duty to teach. Cloud computing skills were not taught to the same extent as those that were examinable and directly connected to subject-specific learning outcomes. Overall, Ethan seems to require continued support to develop pedagogical practices to teach the 'hidden' digital curriculum and transfer his skills as a research scientist to the classroom.

**Table 9.1: Overview of the Focused Codes and Theoretical Categories**

| | **Prior to Being Offered Support** | **Being Offered Support** |
|---|---|---|
| **Development of Focused Codes** | **Positioning of Digital Technologies** | |
| | Digital technologies enabling efficient planning for responsive teaching of science content | Requiring continued support to develop pedagogical practices with digital technologies |
| | **Positioning of Self** | |
| | Being accountable for student understanding of science content | Negotiating a balance between teaching content and the 'hidden curriculum' |
| | **Positioning of Students** | |
| | Accepted practices enable waving responsibility to teach digital skills | Accepted practices continue to enable waving responsibility to teach digital skills |
| **Theoretical Category** | **Wading Through a Pre-developed Script for Teaching Science** | **Being at a Crossroads between Sacred Stories** |

## 9.2 Before Teaching Year Nine Geoscience: Wading through a Pre-Developed Script

Ethan's PMMM, shown in Figure 9.2, is distinct from those of his colleagues'. Ethan did not list any specific digital technologies or seek to explain how he used them. Instead he reflected on the complexity of teaching with digital technologies and the logistics of utilizing different devices in the classroom. Ethan seemed to feel conflicted about using technology because some students could be engaged and at the same time distracted by it. Using the pronoun 'we' Ethan reflexively positions (Harré & van Langenhove, 1999) himself as part of a group of teachers with a duty to use digital technologies. However, he explains that teachers may rely on them 'too much in place of practical, hands-on activities' while assuming that 'students know how to use the tech well.' As such, Ethan's PMMM seems to highlight tension between Riverside's accepted sacred story and his personal secret story: ***We can't assume students know how to use digital technologies and they shouldn't be used in place of good teaching, but I'm finding it difficult controlling students' use of them.***

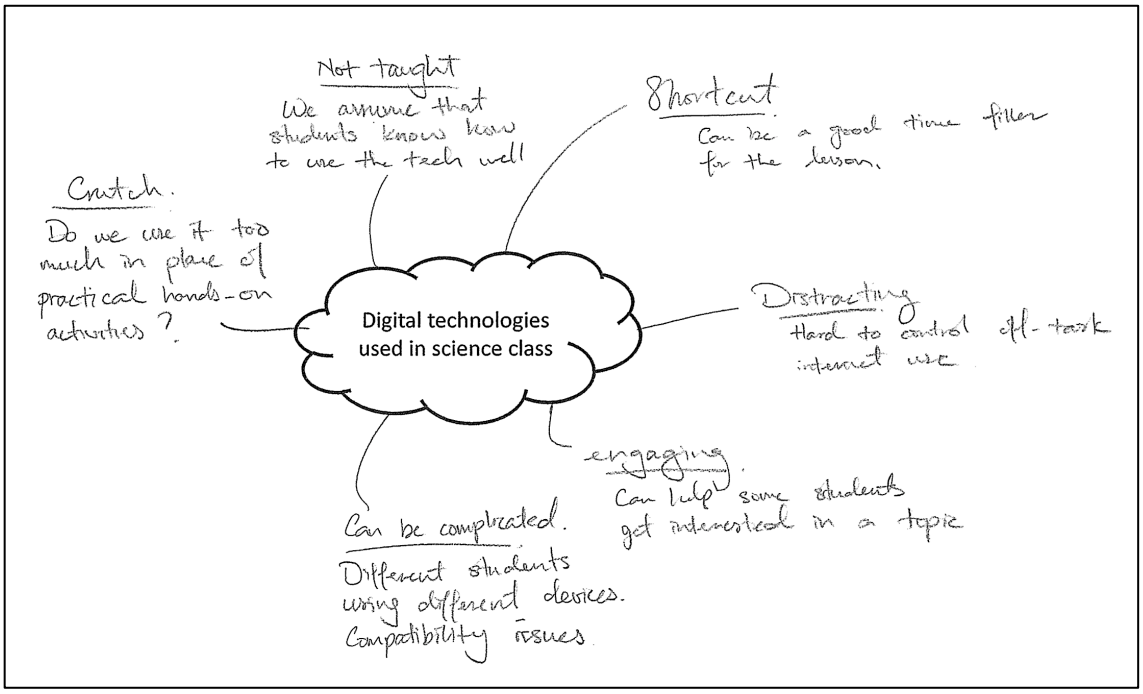



**Figure 9.2: Ethan's Personal Meaning Making Map from July, 2016**

In a follow up interview Ethan drew on the pronoun 'we' to speak on behalf of Riverside teachers as he reflected on the absence of a program to develop students' digital skills within science. He explained:

> *[T]here's no formal.. like IT [information technology] classes here at Riverside, like, we don't teach the students how to use Word properly, we don't teach them how to use Excel, you know, these sort of basic softwares. Um, so, yeah, um, yeah we assume that they already know how to do it, um, but occasionally I might have to stop a lesson because I find that the student doesn't know how to use a particular function on their-their computer.*

This reflection highlights an assumption about children growing up in the digital age which may have contributed to a decline in Australian students' digital capabilities (Fraillon, Schulz, Gebhardt, et al., 2015): Students already have adequate digital skills, so core classes devoted to teaching digital technologies are unnecessary. This assumption does not appear to be held by all Riverside teachers as explained in previous chapters where, to varying extents, Charlotte and Rachel assumed the duty to teach digital skills. Even though Ethan seems to acknowledge that holding onto this assumption does lead to best practice, his intergroup self-positioning (Harré & van Langenhove, 1999) appears to have enabled him to relinquish his sense of responsibility to *plan for* teaching digital skills.

In the second half of the turn Ethan draws on the personal pronoun 'I' to explain that his classes can be interrupted because some students struggle using their devices. Ethan describes Microsoft Word and Excel as 'basic' indicating his technological competency with these programs which may strengthen his sense of agency to *responsively* attend to students having difficulty. Responsive attendance is significant because, at times, Ethan seems to be unable to anticipate and/or absconds from a professional duty (Harré & van Langenhove, 1999)to prepare for the types of difficulties students may have prior to entering the classroom. Ethan reflected 'if this was just a Mac school or if this was just a Windows school,' compatibility issues would be minimized as teachers and students would no longer be utilizing different operating systems. At the same time, however, if Ethan is aware that his students require support using cross-disciplinary software such as Microsoft Office, why does he not plan for teaching digital skills?

### 9.2.1 Digital Technologies Enabling Efficient Planning for Responsive Teaching

For Rokeach (1968) beliefs are predispositions to action with cognitive, affective and behavioral components. Attitudes arise out of clusters of beliefs that can advocate action or inaction. Despite explaining that some technologies could be distracting for students and reporting compatibility problems between his own and students' devices, Ethan expressed more enhancing than deflating beliefs about digital technologies. He explained: 'I need something in there that can fill up the time and in a meaningful way.' Ethan reflects on a personal duty to utilize digital technologies to avoid lecturing for the duration of the 75-minute lessons, specifying a professional duty to meaningfully use technology. Ethan defined meaningful use of digital technologies to 'deepen their [students] understanding' or 'helping them if they don't understand it.'

At the same time, Ethan reflected on how the digital technologies could inform the teaching sequence but also act as a 'crutch' and 'shortcut' for lesson planning and preparation. Of note was that web-based digital technologies seemed to be the most valuable for Ethan in terms of saving time and enabling him to efficiently deliver the content as he negotiated the personal and professional duties of an early-career teacher. Table 9.2 exemplifies some of Ethan's *reflections* and how they were initially coded, his **beliefs** identified and analyzed to form the focused code: Digital technologies enabling efficient planning for responsive teaching of science content.

## Table 9.2: Digital Technologies Enabling Efficient Planning and Responsive Teaching

| |
|---|
| Technology enabling a way around resource shortage<br>**Enhancing Belief**<br><br>*Uh, I think the most valuable thing is you can-you can show things that I can't show in a classroom I-I, um, maybe experiments that use equipment that we don't have if we can show a video of it, you know, that's better than, um, than like a picture from a textbook or me describing it.*<br><br>Ethan positions web-based content as enabling him to attend to a professional duty to introduce students to experiments he is unable to physically demonstrate. Using 'show' Ethan seems to indicate that students passively watch videos. In addition, he did not reflect on his pedagogical practice in terms of using questioning, for example, to draw out students' understanding of the material. Ethan's enhancing belief about the technology also signals a deflating belief about self: 'a video [...] is better than [...] me describing it.' At the same time, however Ethan's use of video also seems to enable him to relinquish a duty to plan for science inquiry that could be possible through the use of simulations as students complete experiments, collect and analyze data. Thus, tension between the sacred and secret stories seems to emerge: ***I use digital technologies to scaffold students' understanding when resources aren't available, but I don't seek out technology to build inquiry skills***. |
| Technology providing a shortcut for preparation<br>**Enhancing Belief**<br><br>*If I can find something quickly or if I've already found something and I go back to it again and again and again as I teach it every year, um, it means I may not be spending two hours doing a lesson plan whereas the digital resource is my lesson plan. So, in-in a sense it's short-it can be a really good shortcut.*<br><br>Here, Ethan positions digital technology as a 'shortcut.' Ethan was teaching his own classes for the first time and required to attend to the professional duties of a second-year teacher. An accepted secret story for early-career teachers is emerging***: I'm managing my duties by efficiently finding resources and planning lessons***. 'The digital resource *is* my lesson plan' also seems to be telling of Ethan's sense of empowerment to produce and/or modify (Foucault et al., 1988) digital resources. While planning lessons Ethan may have relinquished a responsibility to manipulate the digital technology or use it in a pedagogically distinct way from its intended purpose. Thus, the digital technologies Ethan chose to incorporate into his lessons seem to act as shortcuts for him to meet his self-identified professional duty to deliver science content. |
| Technology enabling teacher to check in with Students<br>**Enhancing Belief**<br><br>*I like to go around and see what and, uh, see what they're doing an-and talk to them just to discuss and see where their mind's at and what they're thinking as they're-they are looking through the content, so ba-basically checking to see if they're understanding it.*<br><br>Ethan explains that digital technologies can be used as a 'time-filler' when students engage in self-directed learning by 'looking through' web-based content. This approach seems to enable Ethan to teach students through small group discussion, a personally empowering method, 'I teach best in a smaller group.' Of note is that Ethan describes students 'looking' through the content suggesting a passive use of digital technology. In addition, he does not elaborate on his pedagogy as he sees 'where their mind's at.' Although Ethan positioned students as having a duty to question the credibility of information found on the Internet, this does not seem to translate into a right (Harré & van Langenhove, 1999) to be taught these skills because Ethan provides the web-based resources for students. Thus, tension between the sacred and secret stories emerges: ***I'm harnessing my personal strengths to teach students, but also relinquishing a duty to teach digital skills I believe they should have***. |

In Table 9.2 Ethan positioned the digital technologies as enabling him to responsively teach science content while balancing his professional duties to efficiently plan lessons. In this way Ethan was able to enact the sacred story: ***I'm responsible for my students' content understanding.*** In his junior science classes, this seemed to mean teaching the science understanding strand of the Australian Curriculum (ACARA, n.d.-d). Ethan was also able to enact an accepted secret story faced by early-career teachers: ***I'm balancing my professional duties while planning what I perceive to be meaningful lessons.*** Of note, is that despite coming from a career in scientific research, apart from using simulations and video to model microscopic biological processes, Ethan did not seem to be empowered to draw on this experience to develop students' digital skills for science inquiry.

Ethan's reflections in Table 9.2 seem to be more telling of his personal preferences rather than the pedagogical possibilities for digital technology use. Ethan also reflected: '[M]y preference is to teach to the textbook if there is one.' As such his students' use of web-based software, to read text and complete activities and quizzes, appears to replace the physical textbook with a virtual one. Teaching to the textbook is significant because although this may enable Ethan to plan lessons efficiently, teach to assessment tasks and compensate for a lack of knowledge in OOF areas of science, this preference also seems to compromise attending to his duty to teach students digital skills.

At this stage, Ethan does not yet have access to a script for recognizing the sign systems (Foucault et al., 1988) signaling the possibilities for exploring alternative classroom pedagogies through the manipulation and/or production of digital activities. The secret story appears to be: ***I'm unsure of how to harness digital technologies in pedagogically distinct ways and I don't assume the duty to teach students the digital skills I identify as important to learn.*** As such the codes presented in Table 9.2 and the emergent secret and sacred stories were raised to the focused code: Digital technologies enabling efficient planning for responsive teaching of science content.

### 9.2.2 Being Accountable for Student Understanding of Science Content

Unlike Rachel, whose reflections were exemplified and analyzed in chapter eight, Ethan did not draw on his research experience to reflect on the pedagogical possibilities for

digital technology use to teach science inquiry. Similar to Rachel, however, Ethan harnessed his technological knowledge to identify digital skills he felt students should be able to demonstrate. These included using Microsoft Office, performing effective and efficient Google searches and recognizing the sign systems to navigate the Internet. Ethan began working at Riverside after 2013, when Charlotte had organized professional learning opportunities to introduce teachers to datalogging. Since then these teachers had not been offered similar opportunities to collectively embed digital technologies into their units of work. Apart from the accepted practices of utilizing Microsoft Excel to analyze small datasets, students' digital experiences seemed to depend on teachers assuming a self-identified professional duty to seek out professional learning and harness the affordances of digital technologies to produce and transform (Foucault et al., 1988) lessons.

Perhaps Ethan's preference to teach to the textbook, ongoing negotiation of self as researcher who became a teacher and/or lack of professional learning compromised his sense of agency to develop his students' science inquiry skills and explore pedagogies to teach additional digital skills. Table 9.3 exemplifies how Ethan's *reflections* were initially coded, **beliefs** about self and digital technology use identified and how these were analyzed and raised to the focused code: Being accountable for science content understanding.

## Table 9.3: Being Accountable Science Content Understanding

| |
|---|
| Using technology to play to strengths<br>**Enhancing Belief**<br><br>*In-in a way I'm playing to my strengths. Um, I'm time-poor, as all teachers are, I guess, um, I teach best in a smaller group that's just my nature so if I can get the students doing busy work that means I can go around and if someone's really struggling I've got time to attend to them.*<br><br>Ethan identifies his strength, teaching in small groups, and a sacred story about classroom practice, informed by personal practical knowledge (Connelly & Clandinin, 1984), seems to emerge: ***I'm drawing on my experience and pedagogical philosophy of what works to attend to my professional duty to help students understand content.*** Using digital technologies like 21st century textbooks seems to enable Ethan to produce lesson plans with digital technologies. Although students' digital technology use seems to be low-level, this appears to be an accepted practice within the Riverside local moral order (Harré & van Langenhove, 1999) and Ethan draws on a right to plan efficiently, while perpetuating a cover story: ***I'm attending to my professional duty to utilize digital technologies in my classes***. |
| Using quiz software often to provide feedback<br>**Enhancing Belief**<br><br>*I tend to use [quizzes from Socrative] a lot. [...] Um, so if I'm using websites like Socrative, I'm putting that [feedback] in and when they answer a question, um, that, uh, an explanation would come up. So, in a lot of-in a lot of the questions I set I do that so not just the correct answer but some sort of explanation as to why it's correct or why the others are wrong. So, it has a[n] extra-extra meaning in there if you like.*<br><br>Ethan's use of paraverbals and hesitations seem to indicate that he is working toward developing a script for using online quiz software. Ethan explains how he harnesses an affordance of Socrative, entering explanatory feedback, to achieve a self-identified professional duty to enhance students' content understanding. Notably Ethan has experience manipulating and transforming Socrative to produce classroom activities. In the state of Victoria teachers are required to complete action research to maintain professional registration. In 2015, Ethan explored using Socrative to not only assess student content understanding but also to promote equitable classroom participation through virtual discussion, a distinct practice from his colleagues' use of Socrative. |
| Feeling insecure without the technology<br>**Deflating Belief**<br><br>*[If] I don't have it [technology] or if I'm not using it then maybe I might feel a little bit insecure about how am I gonna go in this lesson. [S]o, uh, there-there are particular websites that I like to use if I don't know what I'm going to do for a particular lesson or if I don't know how I want to teach it or how I want to approach it, then my first thought would be, maybe, just do a Google search and see if there are any resources online, maybe someone's already created a kind of webpage or a resource that I can just direct the students to.*<br><br>Ethan begins with a secret story, ***without websites I feel insecure***, which seems to be more reflective of his preferred pedagogy than his capacity to utilize technology. For Ethan websites also seem to be a source of sign systems informing his lesson sequences strengthening his capacity to attend to the sacred story. Another sacred story seems to emerge as Ethan positions digital technologies to deliver content. Directing students to online resources to keep them 'busy,' Ethan can then teach through small group discussion, facilitating content understanding. Of note, is that despite being a member of an established science faculty, rather than seeking peer-to-peer support this early career teacher turns to the Internet to inform his practice. |

Throughout my conversations with Ethan and his colleagues, time was recurrently raised in their reflections. Teachers identified rights to be afforded time to plan for effective teaching, attend professional learning and complete the administrative duties of the profession. Ethan explained:

> *Um, when I'm really, really stuck in how to present this lesson, um, if there's a website out there that has all of the content that I'm trying to teach, if I can just say to the students: 'Have a look at this, play around with the animations,' um, 'I've got a sheet here, you can answer some questions,' you know, 'off you go.' You know, that is a really easy lesson. [...] Um, but if I-if I wanted to formally teach it like a chalk and talk and, you know, whatever, you know, other-other non-computer-based strategies, then I might have to make resources, I might have to make a PowerPoint, I might have to think of my narrative and organization of the class, how is it going to run, um, and that takes a lot more time [...]*

Ethan's struggle with time management, an accepted secret story in the teaching profession, seems to be more telling of his pedagogical beliefs and the accepted practices within the local moral order. Ethan seems to define computer-based pedagogies as 'looking' at websites, 'playing' with animations and 'answering questions,' qualifying the approach as straightforward using 'just.' He contrasts this approach with another accepted practice, the use of PowerPoint, which for this early-career teacher may take too long to plan for. As such Ethan seems to replace one low-level digital technology use, PowerPoint, with another, using the Internet as a 21st century textbook.

Perhaps Ethan did not draw on his research experience to reflect on the pedagogical possibilities and utilize digital technologies in more sophisticated ways because this was not yet an established practice at Riverside. Recall Rachel's surprise, in chapter eight, when she reflected on using dataloggers for the first time. Without these social signs (Foucault et al., 1988), Ethan deferred to practices he believed would enable him to meet his professional duty to enhance science content understanding. As such the secret, sacred and cover stories emerging were raised to the focused code: Being accountable for science content understanding.

### 9.2.3 Accepted Practices Enable Waving Responsibility to Teach Digital Skills

In the absence of social signs and without a personal history teaching science inquiry with digital technologies, the previous sections seemed to indicate that Ethan

positioned himself with a duty to teach science content. Using some digital technologies as 21st century textbooks enabled Ethan to plan efficiently. When I asked Ethan how students utilize digital technologies to create new ideas, he sought clarification. To explain, I suggested that students studying the chemistry of soap might research and learn how to make an environmentally friendly soap, then create a webpage to teach the wider community of Internet users about their soap and finally invite people their age to comment on the webpage. Reflecting on this Ethan explained:

> *Um, I've never personally done anything like that, but I-I guess the only thing that's where they've had to create something was maybe a-a video or some sort of other kind of visual presentation or a podcast. [...] I'm-I'm not entirely sure if they're creating new ideas may-I-I think the reality is they're just taking the information that they-they've learnt or they've-they see and repackage it.*

Summarizing information in audio-visual format using Microsoft PowerPoint, Audacity and video software from mobile phones, for example, was and remains common practice within the Riverside local moral order. Although Ethan was a second-year teacher and working within these boundaries, his evaluation of these tasks indicated the emergence of a secret story: ***Students are tasked with using technology to 'repackage' information for the teacher***. Instead of challenging students to learn content and inquiry skills *with* and *through* the technology while possibly engaging with a wider community of learners, digital technologies were used to regurgitate information for a limited audience. Despite these uses, students could potentially develop some digital skill sets to better use these technologies to communicate required text types.

In chapter four, Table 4.6 Ethan listed the digital skills he expected his students to use. These included formatting documents and creating charts using Microsoft Office, interpreting Internet sign systems, buttons and hyperlinks, to efficiently navigate the World Wide Web and critically evaluate information found there. Despite the straightforward nature of some of these tasks, Ethan did not claim that his students' capacity to accomplish them was well-developed and suggested that perhaps these skills 'need to be formally taught.' Table 9.4 exemplifies and explains how Ethan's *reflections* of his students' digital technology use were <u>initially coded</u> and his **beliefs** identified and analyzed to form the overarching attitude: Students are proficient using provided websites and technologies they choose to use for major assessment tasks.

## Table 9.4: Students Are Proficient Using Provided Websites and Technologies They Choose to Use for Major Assessment Tasks

Students using online resources to understand content

**Enhancing Belief**

*[S]o if I can get a whole class to do something like that [use a website to learn subject-specific content] that means I'm free to target some students, um, those that are struggling, maybe those that, um, already know all this stuff and, you know, I can sort of steer them to: 'Oh what do you think about this idea?' Try and extend them a little bit more. So, um, that's my ideal scenario.*

Ethan shares an enhancing belief about students' ability to self-manage as they access web-based resources. Ethan's year nine class had a reputation for being a 'good class,' because many students were studious and could be trusted to follow instructions. So, Ethan seemed to able to meet a professional duty to help struggling students and try to extend those more able. However, at the end of the turn, 'that's my ideal scenario,' indicated that alternativity (Nespor, 1987) was a structural feature of this belief. Ethan deferred to an ideal situation that, although informing his practice, may be distinct from what is enacted in the classroom.

In a follow up interview, Ethan reflected that students were distracted by numerous tabs open in their web-browsers and shared an existential presumption (Nespor, 1987) beyond his control:

> *Um, I-I think that's just the way-it's just the way it is, you know? They don't look at things one at a time. They look at 10 or 15 things at a time.*

It appears the ideal scenario does not come to fruition in Ethan's classes. As such a secret story seems to prevent Ethan from enacting the sacred story: ***I've planned for students to learn the content, but they're unable to self-manage***. Of note is that Ethan does not seem to actively plan to implement specific strategies focused on struggling students or those more able. Utilizing visual organizers for note taking would indicate planning for student understanding by drawing attention to seminal concepts. Ethan's question: 'What do you think about this idea?' is low-risk and may not enable him to diagnose or plan for the differentiated instruction he has identified as a professional duty to enact.

Students working with technologies they are comfortable with

**Enhancing Belief**

*Uh, a lot of the times when we do project work stu-students sort of already have an idea of what technology they want to use to-to do it. Um, I think it's quite rare for us to say: 'Oh, you have to present this for using,' um, 'PowerPoint,' or 'you have to present this using PowToons.' [...Q]uite often I personally give them, um, like, a choice. [...] So, in that sense because students go with what they're familiar with you don't have to teach it. And there-and there's a reason why they're going with what they're familiar with 'cause they think it's-they feel more comfortable with using it. Um, so, I think because of the way I implement projects I think that aspect's not gonna change.*

Despite suggesting digital skills students should know and be formally taught, Ethan identifies a right for students to use technologies with which they already appear to be proficient. Ethan speaks on behalf of Riverside teachers: 'I think it's quite rare for us to say [...]' In doing so, he draws attention to accepted practices within the local moral order where students are offered voice and choice in the technologies they use. Although this reflection seems to be indicative of Ethan's respect for his students' capacity to self-manage, in the absence of a planned program for digital technology use the sacred story, ***teachers have a duty to teach digital skills***, seems to be compromised enabling Ethan to relinquish a duty to teach them.

Ethan's reflections in Table 9.4 seem to be less telling of students' abilities to utilize digital technologies and more telling of his self-identified professional duties. These include teaching science understanding while offering students choice in their digital technology use. Although not all Riverside teachers would agree with Ethan's assessment about students' rights to choose, without formal documentation of the expected digital experiences for students this early-career teacher seems to interpret the social signs to produce lessons with digital technologies to the extent that his personal and professional capacity enable him to do so.

Ethan cautioned overclaiming for students' skills when he reflected:

> *[W]e think that they're [students] digital natives or whatever the buzz words are [...], but that doesn't mean they know how to, um, navigate a particular website or how to, you know, use a particular software.*

However, when Ethan permitted students to choose digital technologies for project work, he seemed to assume they already had the skill set to produce the required text type:

> *Um, so I focus a lot on the planning [of the project], um, and not so much on actually teaching them how to do it in terms of the technical stuff.*

By attending to the sacred story, ***students should be offered a sense voice and choice in their learning***, a secret story seems to emerge: ***I'm not teaching students digital skills.*** As such, Ethan may defer to the assumption that students' skills are adequate for the task as a coping mechanism to pragmatically abscond from the responsibility of teaching them in an effort, or under pressure, to save time. The secret and sacred stories above have been raised to the focused code: Accepted practices enable waving of responsibility to teach digital skills.

### 9.2.4 The Emergence of a Theoretical Category: Wading through a Pre-Developed Script

Nespor (1987) describes episodic storage as a structural feature of beliefs that are informed by teachers' experiences in which the cultural and institutional sources of knowledge are transmitted to them. Ethan's preferred pedagogy, small group teaching focused on science content with textbook-like digital resources, may have been informed by his secondary education in Singapore as he prepared for high-stakes examinations at a time when digital technologies were not prevalent in classrooms. This should not suggest

that Ethan lacked the capacity to use digital technologies. His personal history and evaluations of digital technology use at Riverside were indicative of his technological knowledge.

The theoretical category wading through a pre-developed script is grounded in Ethan's positionings of the digital technologies, self and his students. It serves as a metaphor to explain how Ethan negotiated what legitimate science teaching meant to him and the acceptable practices within the Riverside local moral order. When provided the time and incentive to meet the Victorian state expectations for teacher registration, Ethan's sense of agency to explore the technology of production (Foucault et al., 1988) seemed to be strengthened as he utilized Socrative online quiz software in pedagogically distinct ways. Yet, despite the expectation for science teachers to teach information and communication technology as a general capability (ACARA, n.d.-b) and apply technology 'flexibly and creatively to meet the needs of all learners' (DEECD, 2014), for Ethan teaching science seemed to remain a separate entity and accepted responsibility from teaching digital skills.

In the absence of social signs beyond the state-mandated teacher registration process Ethan seemed relinquish professional duties to draw on his personal history using digital technologies and empower his students to develop skills in distinct ways from their pre-existing practices. Ethan waded through a pre-developed script, responding to students' digital queries as they arose. As such, his reflections signal that this early-career teacher requires a script for teaching science understanding and inquiry alongside digital skills with both un-/familiar technologies to possibly strengthen his pedagogical capacity teaching across science and digital technologies.

## 9.3 Teaching Geoscience: Being at a Crossroads between Sacred Stories

The previous sections indicated that Ethan held himself accountable for student understanding of science content. As a novice II digital technology user, Ethan positioned the technologies as material objects enabling him to plan efficiently for responsive teaching. Although he could identify digital skills he expected his students to know, he seemed to abscond from teaching those for which he was not held accountable. In addition, without a personal or professional history learning and teaching geoscience, Ethan's

reflections indicated that he may rely on external support to manipulate subject-specific digital technologies and to produce or transform lessons with them.

As a participant in this research, Ethan volunteered to teach the year nine geoscience unit alongside his colleague and year seven co-teacher, Charlotte, an experienced teacher and expert digital technology user. Section 8.2.2 explained that Charlotte's discursive practices seemed to have an illocutionary force (Austin, 1975) strengthening Rachel's personal agency to explore digital technology use in science. Over seven weeks in term four, both Ethan and Charlotte participated in five CIDs and focus group interviews. Each focus group was followed by an individual interview. During this time, I was invited to observe three of Ethan's classes and offer him support as needed. Vignettes 9.1 and 9.2 exemplify memos written after brief informal conversations with him.

### Vignette 9.1: Keeping to the Schedule

It's about a week and a half into the unit. Last week when I observed Ethan's class, he had modified one of the lesson plans by showing a video presenting the history of the Earth as a calendar year. When I caught up with him today, I reiterated that he could modify lessons as he saw fit. Ethan said: 'I'll try to keep to the schedule because it's easier for me.'

This reminded me of Isabelle who seemed to relinquish a professional duty to modify of lesson plans when she said: 'I'll just deliver.' After interviewing and having informal conversations with Ethan, however, 'I'll try to keep to the schedule because it's easier for me' seemed to highlight that provision of a planned unit may enable him to negotiate a safe space between two accepted secret stories within the profession:

1. ***I'm a second-year teacher, planning lessons efficiently can be a struggle***; and

2. ***Classroom pedagogies are unique to each teacher, yet inconsistency between classes may cause tension within the science faculty***

Early-career teachers must balance their time negotiating professional duties to students and administrative duties. In addition, teachers continue to develop their pedagogical philosophy and practice, two deeply personal elements of a teacher's lived experience. As such, different teachers interpreting and attending to state-mandated curriculum standards may offer their students distinct experiences in the classroom. Tension can arise, for example, when students share their experiences with peers in different classes and, at times, parents assert a duty to protect their children's rights to receive a high-quality education by communicating discrepancies to the teachers and year level leaders. Thus, keeping to the schedule may enable Ethan to avoid this tension while also attending to his professional and administrative duties in a timely manner.

### Vignette 9.2: The Importance of Proximity

It's week five, Ethan and I were discussing a PowerPoint prompting students to unpack Wegener's evidence for continental drift. Ethan's class had just watched The Deepest Place on Earth (2009). To accompany the video, teachers were offered resources for demonstration and discussion, including models of magnetic field reversal. Charlotte even volunteered to show her colleagues how use data loggers to model sea floor mapping. Ethan works closely with Charlotte in year seven and so I was surprised that he didn't draw on Charlotte's offer.

This situation seems to reflect tension between Riverside's cover and secret stories: ***We're a well-resourced school***, ***but when we don't share an office resources may remain underused.*** This tension highlights the importance of teachers' informal conversations, happening at recess, lunchtime and during 'free periods.' When teachers are in close proximity these conversations serve as impromptu professional learning opportunities as colleagues reflect on and support each other to develop classroom practice. Unfortunately, Ethan and Charlotte don't share an office, an additional barrier preventing Ethan from receiving support to use data logging equipment for technology-enabled learning (Brantley-Dias & Ertmer, 2013; Ertmer & Ottenbreit-Leftwich, 2013).

As Ethan taught geoscience he made small changes to lesson plans while being offered support by me and some his colleagues with whom he shared an office. These included adding information to PowerPoint slides and seeking out videos to help students understand scientific concepts. Ethan transformed (Foucault et al., 1988) one PowerPoint slide, designed to engage students in small group discussions about earthquakes, into a digital discussion using Socrative. These modifications were not unexpected. Although teachers were taking pedagogical risks teaching OOF alongside digital technologies, they were encouraged to use their professional judgement to modify lessons. At times this meant asserting a right to defer to established pedagogical practices teachers perceived to enable themselves and their students to approach topics with a sense of self-efficacy (Bandura, 1989).

Reflecting on the unit, Ethan suggested that Google Drive and Google Earth 'stand out [...] just because we use-used them so much.' Prior to teaching year nine geoscience, Ethan had not developed a professional history utilizing these technologies in the classroom, yet his use of 'just' seems to suggest that repeated use set these technologies apart from others. As such, the following sections exemplify and explain how Ethan positioned the digital technologies, himself and his students as he taught with these technologies. The focused codes emerging were raised to the theoretical category: Being at a crossroads between sacred stories.

### 9.3.1 Requiring Continued Support to Develop Practice with Digital Technologies

Prior to teaching geoscience, digital technologies seemed to enable Ethan to plan efficiently and responsively teach science content. The secret story emerging from his reflections was: ***I can identify digital skills important for students to learn, but I don't teach them***. Tables 9.5 and 9.6 explain how Ethan's *reflections* were initially coded, classified using Rokeach's (1968) five types of **belief** and analyzed to form his overarching attitudes toward Google Drive and Google Earth. Of note is that these reflections seem to speak more about Ethan's pedagogical practices than the digital technologies themselves. As such Ethan's emergent attitudes, cover, sacred and secret stories were raised to the focused code: Requiring continued support to develop practice with digital technologies.

## Table 9.5: Google Drive Can Be an Intermediary for Content Delivery but Isn't Distinct to What We Already Use

Assuming structure detaches the teacher from the lesson

**Enhancing Belief**

*Um, so essentially, it's a set of work that they [students] can actually do outside of class. They don't actually physically need to be in class to do this work.*

A week and a half into the unit, Ethan defers to students' duty to catch up with school work when absent from class. He uses 'essentially' and 'actually' to qualify a shift in his perception of Google Drive, positioning the software as an intermediary in the content delivery process and possibly strengthening students' sense of agency to follow up with schoolwork. As such, a sacred story seems to emerge: ***Digital technologies can be utilized by educators to scaffold students' organizational skills***. At the same time, however, a cover story emerges as Ethan overemphasizes the learning benefits of Google Drive by assuming that students could teach themselves the content by simply accessing the material.

Google Drive not enabling different affordances to Compass

**Deflating Belief**

*Um, so it's not so much the platform itself, it's more so that the content is real-really structured in that way. And so, I could put the same documents in Compass and I think the lessons would still work. Um, unless there's an activity where there needs to be a kind of collaborative, um, whole class editing, you know, presenting or ideas kind of work, then I would need Google Docs. But for the majority of the lesson[s] so far, um, we can actually use other platforms that are more familiar to the students like Compass.*

Continuing the turn above, Ethan's perceptions of the benefits of Google Drive now seem more conservative. The cover story, ***Google Drive enables students to engage in different practices***, erodes as Ethan explains that Compass, Riverside's attendance and learning management system, provides similar affordances.

Ethan was still becoming acquainted with Google Drive just as his students were. As such, he created copies of documents and experimented with editing tools by deleting and restoring text. Although Ethan identifies the real-time collaboration tools as a distinct affordance, he defers to students' rights to work with more familiar digital technologies. Ethan's caution seemed to reflect a personal duty to avoid unsettling students, however it may have enabled him to continue to relinquish a duty to teach students digital skills possibly useful in the future.

Of note is that Ethan did not identify an opportunity to provide the links to the collaborative files on Compass to harness the affordances of these tools within an environment students were already familiar with. In this way the secret story seems to remain: ***I'm unsure how to harness the affordances of technologies to engage in new pedagogical practices.*** As such, Ethan's personal agency to harness these affordances seems to be compromised without the sign systems present to marry the two technologies.

## Table 9.6: Google Earth Enables Interactive Lessons Yet Teachers and Students Require Additional Support to Use It

Google Earth enabling interaction
**Enhancing/Deflating Belief**

*So, you know, all those things that we've talked about before, um, being able to look at the-the tectonic plates, investigate the movement, um, formation of the volcanos and where they're located, you know, and-and look at that in relation to the tectonic plates. Um, you-all of those interactive things that you can't do in a kind of textbook or PowerPoint or chalk-and-talk, you know, thing. Um, yeah. I mean that's really-it's still a really good tool.*

This reflection was shared at the end of the unit as students studied plate tectonics. Utilizing Google Earth and the Cyber-Enabled Earth Exploration (CE3) curriculum (Almquist et al., 2012; Blank et al., 2016; Blank et al., 2012) seemed to offer Ethan the sign systems to better understand how he could utilize digital technologies for technology-enabled learning. At the end of the turn Ethan's use of 'still' suggests that tension may exist between an enhancing and deflating belief about Google Earth. When Ethan says 'it's still a really good tool,' he refers to an earlier reflection comparing the conceptual difficulty of Riverside's chemistry and geoscience units:

> *There was-wasn't as much opportunity in the way it was taught to go: 'Yeah that answer's right,' or '[Y]our thinking is right.'*

Here, Ethan reflected on students' rights to know if their reasoning is correct. Absent from his reflection are personal pronouns such as 'I' or 'me' and Ethan's use of passive voice, 'the way it was taught,' seemed to enable him to relinquish a pedagogical duty to attend to these rights in the geoscience unit. Notably Ethan did not draw on his self-identified preference to help small groups of students understand the content. As such a secret story emerges: ***Although I'm taking risks with my pedagogy, I require support to draw on my strengths while negotiating new practices.***

Ethan's class completed four inquiry-based activities, yet when he explains that students 'investigate' using 'interactive things' he does not stress the value of these activities in terms of inviting students into the inquiry practices of scientists. Ethan's reflections seem to indicate that he may require additional support to harness his skills as a research scientist to manipulate and transform his pedagogy toward teaching inquiry.

Google Earth helping the teacher learn content
**Enhancing Belief**

*I would agree with Charlotte. Um, but more in the sense of, um, doing the activities first myself all the Google Earth activities helped me learn the stuff. So, uh, from that sense that was beneficial for me then made it easy for me to teach.*

Four weeks into the unit, Ethan agrees with Charlotte who lauded the CE3 inquiry-based activities. Ethan draws on a sacred story, ***teachers must explore classroom activities prior to introducing them to students***, and a secret story, ***I need to learn the material, too.*** Ethan explains that these activities seem to be significant, strengthening his personal agency to deliver the lessons by helping him prepare and learn 'the stuff.' Ethan's meaning of 'stuff,' however, remains unclear. I wondered whether he was referring to the content, inquiry skills and/or technological skills to use and troubleshoot Google Earth. As such, Ethan seems to be traversing a new language environment and may require continued support to transform his pedagogical practices with this digital technology.

Before teaching geoscience, Ethan positioned digital technologies as enabling him to plan efficiently and responsively teach science content. The reflections in Tables 9.5 and 9.6 illustrate both enhancing and deflating beliefs about Google Drive and Google Earth which Ethan seemed to carry with him throughout the unit.

Reflecting on his students' use of Google Drive, Ethan suggested that he required support to produce and transform lessons harnessing the collaborative affordances of it:

> *[T]here's some benefit [to real-time editing in a small group], but for a whole class I-I don't know how-how that works, how-how the dynamic would work.*

Ethan's uncertainty about the benefits of Google Drive seem compromise his sense of personal agency to explore this technology enabling him to defer to his preferred method of delivering resources to students, using Compass. Of interest, however, is that although Ethan seemed to seek out strategies to better manage his preparation time, a first-order barrier to utilizing technology (Brickner, 1995; Ertmer, 1999), he did not yet identify the real-time editing tools of Google Drive to enable him to do so. For instance, sharing a link to a file in Google Drive would enable Ethan to make changes to the file while his students work with the most updated version. This has advantages in terms of preparation time because Ethan could edit a file in one place rather than deleting older versions and uploading new ones to Compass.

When Ethan reflected on Google Earth he seemed to overclaim for the learning benefits of the technology and his sense of personal agency to monitor students' understanding through his preferred practice of teaching in small groups seemed to be compromised.

Although Ethan was able to identify affordances that both Google Drive and Google Earth offered students and teachers, at this stage he seemed to require support interpreting the sign systems indicating the transferability of his preferred pedagogies while developing his practice to teach OOF with digital technologies. Ethan's attitudes toward Google Drive and Google Earth as well as the cover, sacred and secret stories have been raised to the focused code: Requiring continued support to develop pedagogical practices with digital technologies.

### 9.3.2 Negotiating a Balance between Teaching Content and the 'Hidden Curriculum'

In section 9.2.2, Ethan's perceptions about self and his digital technology use seemed to indicate a primary duty to develop students' understanding of science content. In this section Tables 9.7 and 9.8 exemplify some of his *reflections* and explain how they were analyzed. In both tables the initial codes are presented and the types of **beliefs** Ethan expressed are identified. These reflections were analyzed to form Ethan's attitudes about self as he utilized Google Drive and Google Earth. These attitudes and the secret and sacred stories emerging were raised to the focused code: Negotiating a balance between teaching content and the 'hidden curriculum.'

## Table 9.7: I'm Interested in Exploring New Affordances of Google Drive, but it Isn't My Duty to Teach Them

| |
|---|
| Still exploring how to use Google Docs effectively<br>**Deflating/Enhancing Belief**<br><br>*Um, it's the collaborative nature of Google Docs that I've never really explored in my teaching, um, so I'm not really sure yet how I can use it effectively.*<br><br>Following our first focus group, Ethan explains how he was exploring new pedagogical practices by interpreting the sign systems within the provided resources. Of significance is Ethan's use of the pronoun 'I' which seems to indicate a personal willingness to respond (Krathwohl et al., 1980). Prior to teaching year nine geoscience, Ethan had not developed a professional history using cloud computing with students. He expresses a deflating belief about self, 'I'm not really sure,' which seems to metamorphose into an enhancing belief with 'yet,' possibly suggesting that Ethan's sense of agency to utilize this affordance may be strengthened by the professional learning offered throughout this unit. Ethan is not merely expressing acquiescence (Krathwohl et al., 1980) to use Google Drive, but seems to be committed to trying the new pedagogical practice. |
| Not helping students organize notes<br>**Deflating Belief**<br><br>*Um, and perhaps I didn't help things either, because for one of the Google Earth activities I printed out the-the-the sheet for them [students] and then after that I didn't. Um, and then told them to just work of the-the .pdf, um, and record their answers, um, in there. So, that-that probably didn't help either. So, they had multiple forms of notes, I suppose, um, rather than one common accessible thing.*<br><br>Ethan shared this reflection as his students prepared for the unit test. He explains that students struggled to access the notes they were required to store in their Google Drive. Ethan positions himself to be partially responsible for students' disorganization. Of note is that the lesson plans provided were structured to build students' capacities to organize their work offering a number of sign systems for teachers to interpret and draw on to do so. Lesson plans included instructions for teaching students how to use photocopiers to scan hand-written notes and transfer them to Google Drive. Instructional videos and written explanations with pictures were also provided with the intention of positioning teachers to assume a professional duty to teach these digital skills. Both the library staff and I offered teachers technical support to do this.<br><br>Ethan's reflection seems to indicate that he did not accept this positioning. Earlier in the turn, reflecting on one student's experience, he suggested 'she-she didn't have a plan' to organize her work. In this way, Ethan seems to have relinquished a duty to teach students these digital skills, thus perpetuating the secret story: ***I'm not responsible for teaching digital technologies.*** |

## Table 9.8: I'm Able to Utilize Google Earth and I'm Working Toward Developing Best Practice

| |
|---|
| Learning how to teach technologies to students<br>**Enhancing Belief**<br><br>*That's [teaching students how to use the technology] something that I've never really had to do before because most of the technology platforms that I've used, the students already are familiar with it so, I've never really had to teach them to say: 'Click here, do this.' With Google Earth there's been a lot of that so, you know, 'How do you change the settings? This is where it is. How do you do measurements,' you know. Um, and work out some of the quirks between PC and Mac. So, um, so yes, I've actually had to teach some of those things, um, and I'm still working it out whether the best thing is to actually guide them, so I do it and the students actually follow-follow along, or I leave them to work it out and then I go help students that need-need more help.*<br><br>Two weeks into the unit, Ethan explains that utilizing new software like Google Earth seemed to draw students out of their comfort zone. Ethan's repeated use of 'actually' in the last sentence is significant because it may signal a shift from the secret to the sacred story. 'I've actually had to teach some of those things' suggests that Ethan has repositioned (Harré & van Langenhove, 1999) himself and now recognizes and assumes a professional duty to teach digital skills as students utilize Google Earth to collect data. In addition, Ethan also questions his pedagogical practice. Would best practice mean to 'actually guide them' by modelling how to manipulate Google Earth or would it mean to assist students as they use the technology independently? Teaching science inquiry skills with Google Earth seems to shift the secret story from: ***It's not my duty to teach digital skills***, to a sacred story: ***I have a duty to teach digital skills and I'm exploring best practices to do this.*** |
| Being better prepared after completing student activities<br>**Enhancing/Deflating Belief**<br><br>*[S]o I-I've actually did the whole lesson as a student. So, I've actually done it. Um, so I-I'm-I think, I'm better prepared for this one, um, and I know, uh, how I want to run the lesson now?*<br><br>A month into the unit, Ethan's reflection seems to indicate another shifting position. In a CE3 activity, students explore the structure of the Earth through the movement of seismic waves. Ethan's use of 'actually' may indicate that completing the activity as a student may have been a new practice for preparation that enabled him to negotiate his classroom pedagogy. Ethan's inflection at the end of this reflection, however, signals a deflating belief about self suggesting that he is still exploring best practices in his classroom. The secret story seems to shift from: ***I'm trying to balance my preparation time with the other duties I'm expected to attend to*** toward a sacred story of better planning: ***Running through the activities as a student enables me to explore best practice***. |
| Controlling Google Earth to circumvent technical problems<br>**Enhancing Belief**<br><br>*Um, I'm probably going to be the Google Earth controller, so, rather than have them working in pairs, um, I'm probably gonna do all of the Google Earth stuff and they're, um, getting the information as we work through it, um, just to circumvent a lot of the technical issues that which I know the girls will, some of them will, still have particularly with the videos.*<br><br>This reflection continues the turn above which seemed to suggest that Ethan may assert his personal agency to explore best practice. Ethan has personally developed the capacity to utilize Google Earth yet, in an attempt to progress with the content, he seems to have reverted back to the secret story, relinquishing a duty to teach digital skills 'just to circumvent' technical problems that may arise. |

Ethan reported that over time he became more confident using both Google Drive and Google Earth. Self-confidence to utilize digital technologies however may not equate to teaching competence. Ethan's reflections in Tables 9.7 and 9.8 seem to indicate that the purpose of the software, organization versus data collection, may play a part in Ethan's decision to assume a duty to teach digital skills. Although Ethan was willing to take risks introducing his students to Google Drive, his reflections seem to indicate that he did not assume a duty to teach them how to utilize the affordances of cloud computing.

Teaching at the intersection of the science and digital technologies curricula is a complex endeavor. Ethan reflected on what he termed the 'hidden curriculum' to describe his experience:

> *Um, it's different in that I don't know what the students don't know. [...] Whereas with [science] content there is, you know, there's a curriculum. The students would have come from a particular base. Um, now I may not know exactly what they don't know, but I know where they've come from. Um, but with technology, um, I don't necessarily know that.*

When Ethan reflected on the benefits of utilizing Riverside's attendance and learning management system, Compass, over Google Drive, he seemed to overcome the unknown by using a technology they were familiar with at the expense of teaching the affordances of cloud computing. Thus, Ethan's sense of personal agency to teach digital skills seemed to be compromised when the technology was not explicitly linked to learning science.

For Ethan, the shifting secret and sacred stories in his reflections of Google Earth seemed to suggest tension between teaching digital skills required for science inquiry and timely content understanding. As the unit was ending, Ethan reflected:

> *So, um, you know, it-doing one Google Earth activity on average already takes more than a lesson. I might need an extra lesson on top of that to just talk about, um, the questions and the answers. So, to do that for a string of Google Earth activities would probably, um, extend the lessons by too much. We would-probably wouldn't be able to finish by the, uh, end of the term. Or, um, before we-we needed to get those reports out.*

Ethan explains how he perceives his classroom duties, ensuring students' questions and answers are attended to, stand in contrast to administrative and parental expectations, completing the teaching sequence before the end of term for assessment and reporting.

The pressure of time is a well-known rationale that teachers can enlist to justify dismissal or outright rejection of some duties in favor of others. Negotiating these decisions

is a complex process that is shaped by teachers' beliefs about what it means to teach and learn. The following reflection may be indicative of a shifting perception toward Ethan's understanding of what it means to teach science using digital technologies:

> *It [teaching technology] might just get, um, ignored, you know, a teacher goes into a class thinking they're teaching this, but actually they're teaching that. Um, so, yeah, I-I think maybe you need-you need to be more aware that there're-there're things that you'll have to teach in or-before you can teach the curriculum. It's not always about the content.*

Prior to teaching geoscience, Ethan held himself accountable for teaching science content. In this reflection Ethan speaks from the 'you,' in contrast to the personal 'I,' explaining to a group of teachers that there is a necessity to be 'aware' of teaching skill sets beyond the subject-specific content. In addition, Ethan's reflection seems to suggest a systematic approach to teaching science with digital technologies: First learn the digital skills *then* inquire as opposed to learning the digital skills *to* inquire

For Ethan, at this stage, an awareness of the 'hidden curriculum' and articulation of the complexity of teaching at the intersection of science and digital technologies does not seem to manifest in commitment to teaching digital skills. Yet Ethan's reflections do suggest that he is beginning to recognize the social signs to begin transforming his practice toward teaching digital skill sets for subject-specific uses of digital technologies. As such, the initial codes and secret and sacred stories have been raised to the focused code: Negotiating a balance between teaching content and the hidden curriculum.

### 9.3.3 Accepted Practices Continue to Enable Waving of Responsibility

In section 9.2.3 Ethan's reflections seemed to indicate that he had expectations for the transferability of his students' digital skill sets from the personal to the academic domain. Although Ethan suggested that '[digital literacy] needs to be formally taught,' prior to teaching geoscience the accepted practices of the local moral order seemed to enable him to relinquish this duty. In this section Tables 9.9 and 9.10 exemplify the initial coding, types of **belief** and analysis of some of Ethan's *reflections* that were indicative of his attitudes toward students' use of Google Drive and Google Earth. These attitudes and the cover, secret and sacred stories emerging were raised to the focused code: Accepted practices continue to enable waving of responsibility to teach digital skills.

## Table 9.9: Students Have the Right to Exercise Choice When Using Google Drive

<u>Students not looking back on what they have missed</u>
**Deflating/Enhancing Belief**

*Um, I do tell the students: 'If you miss a class, then you know where to go to-to see what you've missed.' I don't think any of mine do that either, um, 'cause they ask me: 'What did I miss?' So, um, they know the-the material's there, it's the-the behavior hasn't developed around that.*

A month into the unit, Ethan and Charlotte were participating in a focus group interview reflecting on the extent to which students' personal agency may have changed with the use of Google Drive. Both Ethan and Charlotte ascribed students duties to follow up with material when absent. Ethan's class was known for having 'motivated' students who would make 'the most of the opportunities,' yet they did not seem to assume the duty to catch up despite knowing the material was available. Ethan's deflating and enhancing beliefs about students seem to indicate a secret story in tension with the sacred story: ***Students have the capacity to take on this duty, but don't assume it***.

<u>Students not having collaborated outside set activities</u>
**Deflating Belief**

*Um, I'm not sure my students collaborated a lot outside of the set activities that we had to do. [...] Like, I don't think they shared their notes with each other or their, um, uh, their answers from all the Google Earth activities. Uh, I seem to recall seeing only one or two students put their notes on Google Drive [...] A lot still preferred to do it on paper.*

Shortly after the unit had ended, Charlotte and Ethan were discussing the digital skills students might be able to employ across science subjects. Charlotte expressed satisfaction (Krathwohl et al., 1980) as students organized their notes and became more familiar with the collaborative affordances of Google Drive. Ethan's observations, however, seemed to inform a more conservative reflection. When using digital technologies for organizational purposes, Ethan defers to students' rights to choose how to organize their notes and thus his students do not seem to have developed a personal history utilizing the affordances of cloud computing to the extent expected. A secret story seems to emerge: ***I didn't focus on teaching digital skills that weren't subject-specific, because students should be able to choose how to organize their work***.

<u>Students not knowing how to re-access information to revise</u>
**Deflating Belief**

*When they are revising for a test, they don't know how to re-access their information. I think that is where the struggle is.*

During a CID at the close of the geoscience unit, Ethan shares a secret story indicating that his students did not develop the capacity to utilize Google Drive as anticipated. As such they appeared unsettled while revising for the test. Although Ethan affirmed that being 'exposed to the technologies' is 'the important thing,' deferring to students' rights to choose how to organize their work may have compromised Ethan's personal agency to draw on his technological knowledge to teach digital skills.

## Table 9.10: Students Don't Know How to Use Google Earth as Well as Expected

| |
|---|
| Students may not be extending their ideas as much as Charlotte's class<br>**Enhancing/Deflating Belief**<br><br>*Yeah, they're having less technological problems. [...] I think the girls are just chugging along, they're not, um, they're not really, what's the word I'm after, um, extending their ideas and analyzing as-as you feel your kids are.*<br><br>Ethan shared this reflection during a focus group interview with Charlotte. Two and a half weeks into the unit, Charlotte reported that students asked less about manipulating the software and more 'big-picture questions' including why earthquakes occur far from plate boundaries. For Ethan, his students were developing their digital skills in similar ways, but despite being a 'motivated' class he shares a deflating belief about students as he does not perceive them to extend their thinking toward analysis. Ethan's use of 'just' in 'the girls are just chugging along' promotes a cover story implying that once students have developed the capacity to utilize the technology grasping the scientific concepts comes with ease. This reflection seems to speak less about students' technical abilities and more about Ethan's struggle to develop pedagogies inviting students into metacognitive dialogue. Ethan did not appear to assume the duty to guide his students' metacognitive reflections while using digital technologies to learn science. As a result, his students may be unaware of what success could look like. |
| Students being unaware of how to use the technology<br>**Deflating Belief**<br><br>*Uh, j-probably the…. you know, there's-there's-there's conventions in using computers. There're things like right clicks. What does right clicks do? Um, and it's one of the things that people often forget, that you can right click on an object and more instructions or commands will come up. You know? [...] You know, all of these little, little things combined. And, you know, these are little skills that you kind of pick up as you use the computer, right?*<br><br>This reflection alludes to the prevalence of a cover story. Ethan reflects on 'little skills' that may have prevented students from understanding geoscience. He explains how students forgot troubleshooting procedures when embedded animations failed to appear. By right clicking, students could access the web address from the menu and use a browser to view these visual tools. Ethan concedes that these are 'little skills.' However the reflection indicates that Ethan's students may require social signs through explicit instruction to develop a personal agency to solve their technical problems, a professional duty that Ethan may not have fully assumed. |

Ethan's reflections of Google Drive are indicative of the extent to which he assumed a duty to scaffold students' digital skill sets beyond their familiar practices. Bruner (1996) defines skills as ways of dealing with things but only being useful when descending into habit. How did Ethan perceive students' development of their cloud computing skills? By the end of the unit, Ethan seemed confident that students would be able to draw on these skills in other subjects when he reflected:

> *[T]hey-they-I think they'll recognize that they'll-there'll be times when it's required and it's easier to do things using this sort of technology. Um, yeah, I'm-I'm sure they will.*

Ethan's moments of hesitation and use of paraverbals in the above reflection seem to indicate that he is traversing a new language environment. His reflections in Table 9.9 demonstrate that he deferred to students' preferred practices, even though sign systems to teach digital technologies were embedded within the lesson plans and instructional videos. As such Ethan seemed to abscond from assuming a professional duty to explicitly teach transferrable digital skills. As a result, Ethan's students did not appear to adopt and routinely draw on these skills such that they became habitual practices. As such, the reflection above seems to overclaim for students' capacity to utilize cloud computing and conveys a cover story: ***Students will be able to draw on these new skill sets in their future learning.***

In Table 9.10, Ethan's reflections of students' use of Google Earth seemed to suggest that they did not assume duties to reflect on their application of knowledge through the use of digital technologies nor did they develop their technical skills to troubleshoot the software. In our final interview in 2016, I explained that during some of my classroom observations students seemed to rely on the Google search engine to respond to inquiry questions that would otherwise challenge them to analyze and interpret their data collected using Google Earth. Ethan reflected:

> *It's, I think, embedded in their culture. Everything is a search through Google. Um, Google supplies all the answers. Um, so, uh, per-perhaps we've lost that critical thinking aspect of it.*

This reflection seems to indicate that Ethan does not perceive himself to be an agent of change and thus may relinquish a personal and professional duty to challenge students'

existing practices. Prior to beginning this unit, Ethan reflected that students should know how to conduct and evaluate their Internet searches. When he says: 'It's, I think, embedded in their culture' and 'we've lost that critical thinking aspect of it,' Ethan expresses an existential presumption (Nespor, 1987), a perception about student ability, maturity and motivation that is beyond the control or influence of teachers. Although Ethan is able to manipulate the digital technologies himself, he is not yet at the stage of producing lessons that challenge students to further develop their digital skills.

Ethan's attitudes toward using Google Drive, students have the right to exercise choice when utilizing digital technologies, and Google Earth, students fall short of teacher expectations, seem to indicate that for Ethan not all digital technologies are valued equally. Ethan's higher expectations for students utilizing subject-specific Google Earth seems to be indicative of his deeply held belief that his primary duty is to teach science. This is a personal and professional duty linked to science teachers' subject identity and is unlikely to be challenged within the local moral order. Surprisingly, however, Ethan did not seem to extend his pedagogies to explicitly draw students into the metacognitive practices of science inquiry by guiding them toward what successful application of knowledge looked like while completing CE3 activities. After teaching the unit of work, Ethan still seemed to position students in ways that enabled him to wave his responsibility to teach digital skills. As such, the focused code emerging is: Accepted practices continue to enable waving of responsibility to teach digital skills.

### 9.3.4 The Emergence of a Theoretical Category: Being at a Crossroads

At the beginning of this research Ethan seemed to be wading through a pre-developed script as an early career teacher working toward crafting a pedagogical philosophy for teaching science. Of note is that although a teacher's pedagogical philosophy is deeply personal how this philosophy is enacted in the classroom is also informed by the acceptable practices within the local moral order. As Ethan taught the year nine geoscience unit, he took pedagogical risks teaching out-of-field with a team of his colleagues to explore teaching at the intersection of the science and digital technologies curricula. In doing so he appeared to have accepted a duty to teach digital skills. As such Ethan offered the following advice to future colleagues:

> *Uh, try it out before they teach it. Try out the technology. Actually do it. Yeah, that, especially if they haven't, you know, used, like, Google Drive or Google Earth before, um, they'll-they need to try it and then they need to actually think about how to teach the students how to use it and structure their lesson around that, um, 'cause the-the kids won't know what to do. So, you can't just give them a bunch of files and then they'll get to it. You know, you have to teach that stuff. So, the teacher will have to plan for that.*

Of significance is Ethan's affirmation of the duty to plan for teaching digital technologies as he advises teachers to 'actually think about how to teach the students how to use it' and reflectively structure lessons teaching digital skills. Ethan's reflections of his own use of digital technologies while teaching geoscience, however, seem to indicate that not all digital technologies are of equal value. He seemed to place less emphasis on planning for and teaching with Google Drive compared to Google Earth. As such, Ethan's sense of personal agency to teach digital skills may have been strengthened when offered the social signs to do so in ways that enabled him to teach science-specific content. Thus, he appears to have assumed a greater responsibility to plan for and teach digital skills for the use of Google Earth.

Ethan took pedagogical risks to manipulate digital technologies with which he did not have a personal and professional history. To an extent, he also transformed aspects of the lessons drawing on familiar pedagogies and technologies he perceived to be of value to students' learning. He identified new practices such as teaching science inquiry skills with Google Earth, but continued to struggle implementing these lessons while supporting students to better understand whether they met the learning outcomes. Ethan explained:

> *So, if I have to teach in this style, if I have to teach geoscience using all of this technology, using this particular style that I'm using and the kids don't like it, like, a few of them don't, um, how do they get around that? Or is it a write-off?*

This reflection seems to be indicative of the extent to which Ethan felt empowered in this unit. He signals that overall the pedagogies employed to teach science and digital technologies are distinct from his usual range of practices. Twice he repeats 'if I have to' which seems to indicate that Ethan may be skeptical of the value of the approach. Ethan continued to defer to his students' rights to voice and choice when he reflected on their preferences for particular pedagogies suggesting that the unit might be a 'write-off' if students do not come to terms with a different way of thinking and learning. Ethan's

deference to his students to 'get around that' may also be an indication that, at this early stage of his career, he is still negotiating his duty to invite students to explore and reflect on distinct epistemic practices both within the science community and in terms of what it means to be a student in a digital world.

Being at a crossroads between sacred stories is a theoretical category that has emerged from the focused codes grounded in Ethan's positionings of the digital technologies, self and his students throughout the geoscience unit. Being at a crossroads evokes a picture of indecision and hesitance to move forward as an individual interprets the road travelled and choice of roads ahead. Throughout his time teaching an OOF area of the science curriculum with digital technologies, Ethan seemed to struggle to negotiate a balance teaching at this curricular intersection while drawing on familiar pedagogical practices enabling him to enact sacred stories, the theory driven view of practice, to the best of his ability. These sacred stories included attending to student voice and choice while teaching for science content understanding. As such Ethan seems to require continued support to become more empowered to manipulate the digital technologies and transform lessons in ways that enable him to teach the 'hidden' digital technologies curriculum without sacrificing time devoted to student understanding of the science content.

## 9.4 Conclusion: Toward Continued Guidance of a Novice Teacher

Sections 9.2 and 9.3 have explained some of Ethan's reflections of what it means to teach science using digital technologies. While he was wading through a pre-developed script prior to teaching the unit, Ethan appeared content to relinquish a duty to teach digital skills in favor of teaching science content understanding. Teaching geoscience with digital technologies seemed to provide Ethan with some sign systems to better understand the possibilities to attend to a professional duty to teach digital skills. Ethan's reflections indicated that teaching digital skills directly related to students' subject-specific understanding and inquiry may be more important than teaching those he perceived to be unrelated to these learning outcomes. As such Ethan seemed to reside at a crossroads requiring continued support to draw on successful pedagogical practices to attend to the

professional expectations of parents, school administrators and government policy to scaffold students' digital skills.

At the beginning of this chapter, I quoted Ethan as he explained that the purpose of schooling is to teach students how to 'maneuver' their 'way through life.' I wondered how Ethan continued to manage teaching at the intersection of the science and digital technologies curricula while maneuvering between his research scientist and early-career teacher identities. Two years after teaching geoscience, in 2018, I met with Ethan for a follow up interview. At this time, he was acting Science Coordinator and would continue in this role in 2019. Unfortunately, the timetable did not permit Ethan to be allocated year nine science after 2016.

During our final interview in 2016, Ethan suggested he would still defer to students' rights to choose which digital technologies to use when completing projects as summative assessment. Reflecting on his duties to teach digital skill sets for these tasks he said: 'I think because of the way I implement projects I think that aspect's not gonna change,' suggesting that he would continue to relinquish a duty to develop students' digital communication skills. Two years later, I invited Ethan to reflect on how teaching geoscience in 2016 may have influenced his current teaching practices if at all. Ethan reflected:

> *Uh, I-I think what it's done is it's given me an insight as to what's possible. Um, how something can be sort of discovery-based kind of learning, how to-how to do that and how to do that well. Um, and in saying that, I haven't sort of gone to try to do something like that since. Um.. I recognize that it takes a lot of effort to plan something like that. Um, and I don't feel that I've, in the two years since, had the time or the energy to be able to embark on, um, something like that. Um, and I-I wonder, you know, just having think-having thought about that now whether it's because I haven't come across a-a-a topic or a unit that inspires me to go: 'Oh, ok, actually we can do this this way.'*

In the first sentence, Ethan signals that teaching geoscience has strengthened his awareness of the possibilities for 'discovery-based' learning in an OOF area. As such, he recognizes the pedagogical value that inquiry-based activities bring to the science classroom. However, Ethan continues to reflect on the pragmatics, responsibilities and demands of teaching day-to-day that compromise his personal agency to achieve this. At the time of this conversation, Ethan had been teaching for four years. He continues to reflect on his lack of time, energy and motivation that prevent him from utilizing digital

technologies for inquiry-based learning despite having spent over 10 years as a career research scientist and being positioned by curriculum documents and the wider school community to do so.

Ethan continued his reflection:

> *Um, and also that we already have established ways of teaching various units from seven to nine and, I guess, there's no push to really change things in a major way. [...] I might introduce one or two little new things or maybe little tweaks in a PowerPoint or little tweaks in a prac[tical activity]. Um, but not the kind of unified, um, unit long kind of, uh… piece of work that is, you know, linked so well to a digital technology the geoscience unit. Um, yeah. So, something major like that, I think, uh, it's hard to achieve in the current work environment that we've got. It needs something with a drive to be able to do that and then introduce it to the teaching staff and then the staff go: 'Yeah, it's great and it's all done, let's do this.'*

Here Ethan explains that the accepted practices of the local moral order may act to disempower Riverside staff by reducing their personal agency to draw on modelled practices explored in geoscience and change their approaches to teaching other science topics. At this stage, Ethan seemed to be able to manipulate digital technologies for inquiry practices provided he is introduced to and supported to utilize the technology. However, Ethan is not yet empowered to produce and transform his lessons to employ digital technologies for inquiry purposes. In the final sentence of the above quotation, Ethan says: 'It needs something with a drive to be able to do that,' but what he seems to imply is that *he* needs *someone* to assume the duty to guide staff toward achieving this endeavor.

Reflecting on his duties as Science Coordinator, Ethan deferred to the complexity of working in one of the largest faculties at Riverside:

> *I don't see myself as the science leader to do those sorts of things. [...] I really rely on, um, the other teachers in whatever, um, subject teams they're teaching into if they come across stuff to be able to share that and go: 'This site looks interesting,' um, 'have a look,' or 'I've developed something around this, use if you wish.' You know? And so, I think we're sort of dependent on the good will and the chance, I suppose, of other teachers when they come across this sort of thing to pass it on.*

Here Ethan relies on teachers, working as part of a team, to assume the personal and professional duties to seek out and share resources that better enable them to teach science. Yet, within this reflection lie two assumptions adding to the complexity of the lived teaching experience:

1. Teachers assume the duties to seek out and share additional resources; and
2. The resources that are shared/developed are not only of high quality enhancing conceptual change, but also that teachers will assume the duty to utilize them

The local moral order has been shaped by multiple social, cultural and historical events as well as the beliefs and values of the people working within it. As such, accepted practices exist that may appear to be publicly attended to promoting cover stories. For instance, teachers may appear to be embracing digital practices by integrating (Brantley-Dias & Ertmer, 2013; Ertmer & Ottenbreit-Leftwich, 2013) digital technologies on a regular basis for science understanding, ways that novice digital technology users seem to employ them. When offered digital technologies that promote technology-enabled learning, enacting these practices in the classroom in the absence of support may compromise a teacher's self-efficacy to do so.

In chapter eight, Rachel, another career research scientist who became a teacher, was inspired by a colleague, Charlotte, who continued to occupy a position of authority, to draw on her technological knowledge and assert her personal agency to utilize data logging equipment. Without reflexively positioning himself as an agent of change, turning Ethan's secret story, ***I continue to struggle to utilize digital technologies for inquiry***, into a sacred story would require a person like Charlotte to guide him toward teaching inquiry *with* and *through* digital technologies.

# Chapter 10: Interpreting a Novice I Teacher's Perceptions of Agency Utilizing Digital Technologies in Science

***Interviewer:*** *What do you believe is the purpose of schooling?*

***Isabelle:*** *To educate.*

***Interviewer:*** *For what purpose?*

***Isabelle:*** *Uh, socially, um, curriculum. Just for knowledge.*

## 10.1 Introduction

Chapter five introduced Isabelle as a junior science, mathematics and senior chemistry teacher who had served at Riverside for 13 years. In 2016, Isabelle was not only a classroom teacher but also assumed the duties of Science Coordinator for the first time. Due to these additional responsibilities and a period of long service leave, Isabelle was unable to participate in this research to the same extent as Charlotte, Rachel and Ethan. She constructed a personal meaning making map (PMMM) and participated in two interviews before and after teaching geoscience. I also recorded memos of my informal interactions with Isabelle while she taught geoscience.

Isabelle's perceptions of her sense of agency to utilize digital technologies in science are explained using the positioning triad (Harré & van Langenhove, 1999), shown in Figure 10.1, and complementary analytical tools. Constructivist grounded theory coding procedures (Charmaz, 2014), pronoun grammar analysis (Mühlhäusler & Harré, 1990; Redman, 2013a; Redman & Fawns, 2010) and Rokeach's (1968) five types of beliefs are utilized to track changes in Isabelle's discursive practices (Harré & van Langenhove, 1999). These changes highlight tensions and shifts between cover, sacred and secret stories (Clandinin & Connelly, 1996) as Isabelle positioned the digital technologies as material objects (Harré, 2002b), herself and her students. As such, they are indicative of the extent to which Isabelle felt empowered (Foucault et al., 1988) to act autonomously or with the guidance of others while teaching with digital technologies.

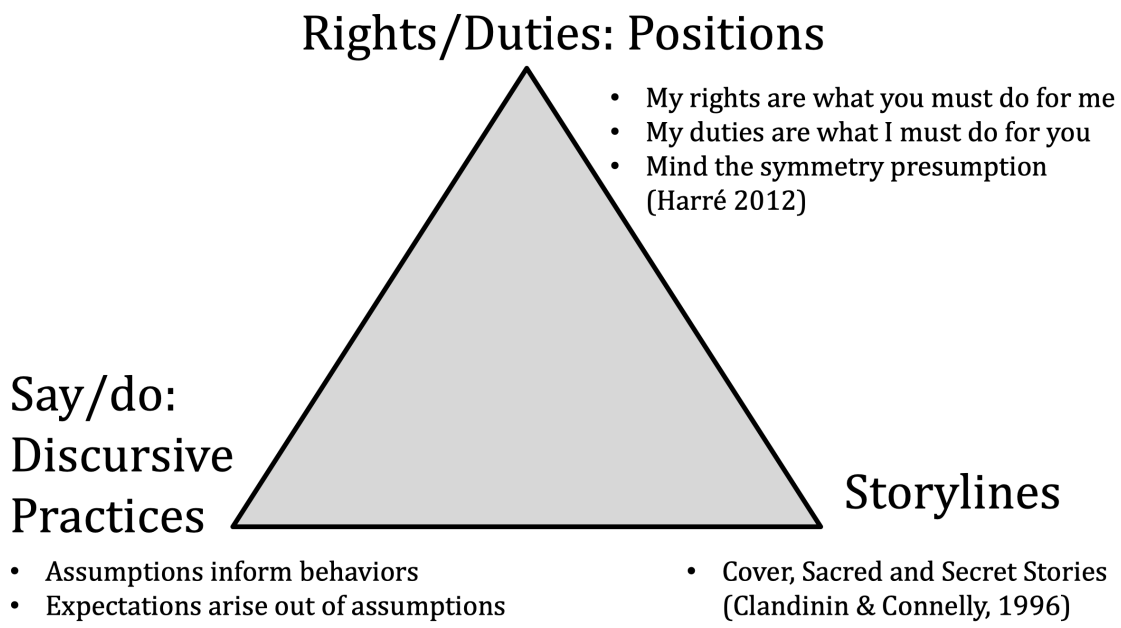



**Figure 10.1: The Positioning Triad Adapted from Harré and van Langenhove (1999)**

Table 10.1 shows the focused codes and theoretical categories (Charmaz, 2014) derived from Isabelle's discursive practices. Prior to teaching geoscience, Isabelle's self-assessments seemed to position (Harré & van Langenhove, 1999) her at the novice I level on the continuum for digital technology use introduced in chapter four. Novice I users assumed the professional duty (Harré & van Langenhove, 1999) to utilize digital technologies to primarily teach science understanding, yet they seemed to be either unaware of the digital skills students were expected to develop and/or appeared to lack the confidence to teach these skills. Isabelle's sense of agency to utilize digital technologies appeared to be strengthened by a personal duty to cater for all learners' understanding and the social signs (Foucault et al., 1988) provided by her colleagues. However, a lack of personal history utilizing digital technologies seemed to compromise the extent to which she was able to accurately assess her students' capacity for digital technology use and attend to a duty to teach digital skills.

Isabelle seemed to apply a pragmatic approach to her classroom teaching, possibly to manage her administrative duties as Science Coordinator. While teaching geoscience, her sense of agency continued to be strengthened by social signs from within the local moral

order (Harré & van Langenhove, 1999), however Isabelle remained guarded throughout the experience. In an attempt to be perceived as a competent teacher Isabelle's negotiation of her professional relationships seemed to prevent her from getting the assistance she required, limiting her sense of personal agency to transform and produce (Foucault et al., 1988) lessons with digital technologies. Finally, Isabelle's strengthened capacity to utilize Google Drive, may have compromised her development of geoscience pedagogical content knowledge as she was able to delete previously unexplored approaches from the lesson plans and resources provided.

**Table 10.1: Overview of the Focused Codes and Theoretical Categories**

| | **Prior to Being Offered Support** | **Being Offered Support** |
|---|---|---|
| **Development of Focused Codes** | **Positioning of Digital Technologies** | |
| | Digital technologies as teacher | Digital technologies as tools |
| | **Positioning of Self** | |
| | Keeping up with colleagues | Keeping up appearances with digital technology use |
| | **Positioning of Students** | |
| | Keeping one step ahead of students | Keeping up appearances while teaching out-of-field |
| **Theoretical Category** | **Struggling to Stay Afloat** | **Displaying the Tip of the Iceberg** |

## 10.2 Before Teaching Year Nine Geoscience: Struggling to Stay Afloat

In July 2016, Isabelle and I were away from the school campus in Melbourne's central business district supervising year nine students as they participated in a program to explore science and society. At this venue Isabelle constructed the PMMM shown in Figure 10.2.

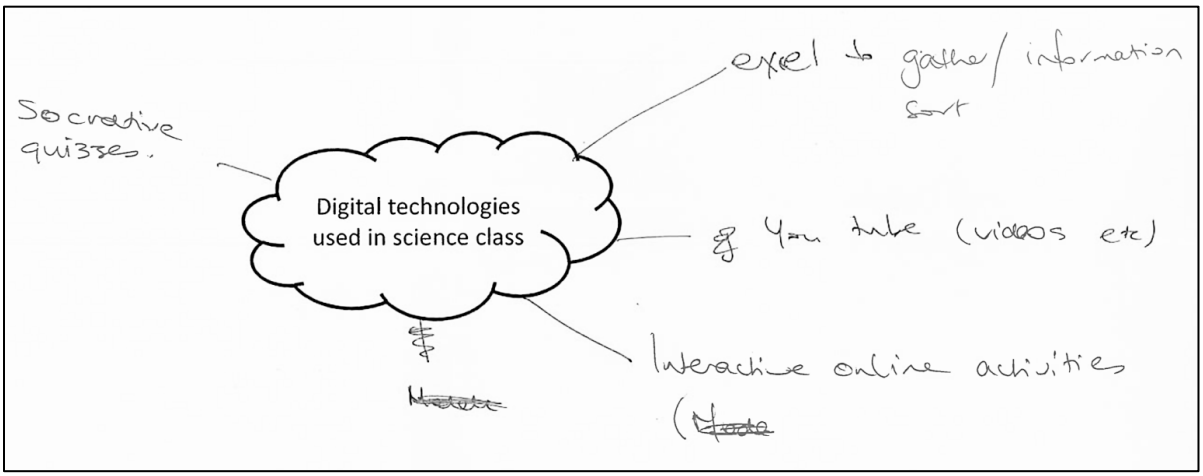



**Figure 10.2: Isabelle's Personal Meaning Making Map from July, 2016**

After a short time, Isabelle handed me her PMMM saying 'sorry' repeatedly. She ended the exchange with: 'I'll just deliver [the unit of work].' Using 'deliver' at the outset, seemed to indicate that Isabelle had relinquished her duty to be part of a group of teachers involved in planning the geoscience unit. Perhaps Isabelle felt that she could better attend to her professional duties as Science Coordinator while others engaged in an already accepted practice to revise unit plans for topics of interest. For Isabelle 'delivering' what was offered may have been a safe place that preserved an acceptable cover story: ***All students at Riverside have similar classroom experiences designed by teachers who are considered experts in their field.*** However, Isabelle's apologetic stance and use of 'deliver' also seemed to indicate an overall guarded narrative that would emerge from her reflections and actions as she negotiated her duties as an out-of-field (OOF) teacher of geoscience and digital technologies.

Isabelle's PMMM indicated that she utilized some of the software her colleagues had integrated into their lessons including Socrative online quizzes, Microsoft Excel, YouTube videos and interactive activities. Apart from 'Excel is used to gather/sort information,' Isabelle did not explain the pedagogies she used with these digital technologies. Moments of hesitation were also present in her writing as she appeared to reconsider ideas. 'Mode' was crossed out twice leaving the intended meaning unclear. Perhaps Isabelle meant that the interactive online activities were intended to model scientific phenomena. Of note is that unlike her colleagues, Isabelle did not reflect on the Cyber-Enabled Earth Exploration

(CE3) curriculum (Almquist et al., 2012; Blank et al., 2016; Blank et al., 2012) shared with Riverside teachers in 2015.

I invited Isabelle to reflect on her PMMM and what drove her to utilize digital technologies in science. She explained:

*Varying my lessons and trying to cater for everyone. [Be]cause it is pretty hard.*

Here, Isabelle identifies a complex professional duty, attending to individual students' rights (Harré & van Langenhove, 1999) to engage with and understand the curriculum. This reflection seems to align with and confirm what Isabelle identified as the purpose of schooling in the opening of this chapter, educating children both socially and in subject-specific content knowledge.

### 10.2.1 Digital Technologies as Teacher

For Rokeach (1968) beliefs are predispositions to action with cognitive, affective and behavioral components. Attitudes arise out of clusters of beliefs advocating action or inaction. To begin to understand how Isabelle positioned digital technologies as material objects, I invited her to reflect on what she felt was the most valuable contribution from digital technologies. She spoke quickly to explain:

> *I guess, um, showing them [students] that-what <u>can</u> happen. Sometimes in class you're limited with what you've got, but if you're showing them an interactive activity, they can get a feel for it and understand. It increases their understanding of something where as-.*

Isabelle's pace, her emphasis on 'can' and use of the personal pronoun 'you' seemed to indicate that she was sharing a well-rehearsed sacred story, a theory-driven view of practice held by teachers, theoreticians and policy makers: ***I'm using digital technologies for students to understand complex scientific phenomena***. For Isabelle, interactive activities, specifically those developed by the publishing company Pearson, enable teachers to overcome the limitations of physical resources to enact a professional duty to 'show' students what happens and facilitate their understanding of subject-specific content

In the final sentence of the turn, Isabelle continued to speak quickly at almost a whisper and the storyline appeared to shift to a secret story: ***I'm unsure how digital technologies actually increase students' understanding***. Isabelle did not articulate what

she meant as students 'get a feel' for and understand the content with their devices indicating that she may be traversing a new language environment as she reflects on the pedagogical importance of digital technologies. A novice user of digital technologies herself, Isabelle seems to require allocated time and space to have professional conversations with colleagues who might provide her with mentorship.

To better understand how Isabelle positioned digital technologies, Table 10.2 exemplifies some of her *reflections*, shows how they were initially coded and classifies her emergent **beliefs**. Analyses accompany Isabelle's reflections which have formed the focused code: Digital technologies as teacher.

## Table 10.2: Digital Technologies as Teacher

| |
|---|
| Socrative feedback enabling revision<br>**Enhancing Belief**<br><br>*I think they're [Socrative quizzes] fantastic for revision. Because number one: They [students] get instant feedback, so they know exactly what they need to focus on.*<br><br>Isabelle explains that Socrative online quizzes offer students feedback about their progress before summative assessment and she seems to position Socrative as a teacher helping her to assume this professional duty. Isabelle also positions her students as self-directed learners assuming they have the metacognitive capacity to incorporate this feedback into their revision practices. As such, she may overclaim for beneficial affordances of Socrative. Socrative is a platform for teachers to design and share quizzes, the teacher chooses when students receive feedback and to what extent, labelling answers in/correct and/or with accompanying explanations. Isabelle's reflection also seems to indicate that, although used in her lessons, she may not have the technological proficiency to produce (Foucault et al., 1988) these quizzes. |
| Video emphasizing points<br>**Enhancing Belief**<br><br>*(Sighs) I guess it [YouTube] emphasizes it, uh, a certain point in a different way for them, visually. Something that maybe I can't show them in class that would be useful to them.*<br><br>Like her colleagues, Isabelle used YouTube videos in her lessons and she seems to position these videos as teacher enabling her to attend to a professional duty to 'emphasize' points in different ways. This reflection is indicative of Isabelle's personal and professional duty to 'cater for everyone,' yet when reflecting on the pedagogical importance of the videos, Isabelle qualifies her reflection with 'I guess,' indicating that she may lack a personal commitment to critically evaluate videos or plan for their meaningful use. Continuing her guarded narrative, Isabelle did not reflect on pedagogical practices to expand or draw out students' understanding by, for example, stopping/starting videos to explain or ask students questions. |
| Google Earth explaining and showing things to students<br>**Enhancing Belief**<br><br>*[Google Earth j]ust explains things and they [students] can see anything.*<br><br>Isabelle is reflecting on the CE3 curriculum as we discuss digital technologies that might be useful in geoscience. The turn begins with the qualifier 'just' suggesting that by simply utilizing Google Earth students were learning about geoscience. Although Google Earth can be utilized to introduce students to different representations of geographical features, including 3D and satellite images, this software does not explain content to students. Again, Isabelle seems to overclaim for the benefits of digital technologies by positioning Google Earth as teacher. In addition, she did not reflect on the human component to the design of these activities. Embedded animations within .kmz files, designed by geoscience educators, provide explanation to aid students' reasoning as they complete inquiry activities. Using 'just' also seems to indicate that Isabelle may relinquish a professional duty to plan for learning with Google Earth, including facilitating technology use, evaluating student understanding and modeling critical thinking. |

Although Isabelle appealed to the sacred story, identifying the teacher as responsible for digital technology use, her reflections indicate that a lack of personal history with digital technologies may compromise her sense of agency such that she may relinquish professional duties to facilitate learning with digital technologies. As such, the codes presented in Table 10.2 and the emergent secret and sacred stories were raised to the focused code: Digital technologies as teachers.

### 10.2.2 Keeping Up with Colleagues

The previous section explained how Isabelle positioned digital technologies as teachers and shed some light on her proficiency to utilize them. This section focuses on Isabelle's reflexive positioning of herself as user *of* and teacher *with* digital technologies. Isabelle explained her overall use of digital technologies in science:

> *Ah, g-ooh, God. Gather information, complete lessons, complete work, um, interactive… Yeah. Interactively-provide interactive lessons? With the kids. So, I don't know if there's anything else, probably but yeah.*

After her initial surprise, Isabelle confidently listed ways she utilized digital technologies in her class. Isabelle shared a sacred story: ***Acceptable teaching practice means that students use their devices to research and interactively engage with content***. In the second half of the turn Isabelle's confidence seemed to waver with an inflection on 'interactive' and admission that she is aware of but unable to identify additional ways to utilize digital technologies. A secret story emerges: ***Not only am I teaching geoscience OOF but also digital technologies***.

Table 10.3 exemplifies how Isabelle's *reflections* were <u>initially coded</u>, her **beliefs** about self and digital technology use identified and how these were analyzed and raised to the focused code: Keeping up with colleagues.

## Table 10.3: Keeping Up with Colleagues

Using online quiz software in different ways
**Enhancing Belief**

*Socrative I'll use a bit different-ah Kahoots I guess I can use as a whole class activity at the end for the last five minutes of class just to review what was taught in the lesson and that's sort-sort of like, um, they have, um, fun with it. Socrative I use just as a revision quiz-type-thing just sort of half way through a topic.*

Perhaps reflecting a sense of oughtness (Linehan & McCarthy, 2000) to engage students in similar ways as her colleagues, Isabelle uses Socrative and Kahoot! online quiz software. She explains that these technologies enable her to attend to a professional duty to help students revise content and appeals to their rights to have fun. Although her use of 'just' implies an ease to using the software, qualifying words, paraverbals and moments of hesitation appear throughout the reflection as Isabelle tries to explain how these different platforms are used. Of note is that she did not draw on specific examples to articulate her pedagogical choices for utilizing these technologies at distinct times in the lesson sequence. A secret story emerges: ***I want to appear like I'm doing similar things as my colleagues, but I'm not sure how to draw on the affordances of the technologies to add value.***

Showing students how to use digital technologies
**Enhancing Belief**

*Well, sometimes I.. sort the information to show them how to use something. For instance, for City Experience for their, uh, data collection, show them how to use Excel. Put in different examples from, um, different websites like BOM [Bureau of Meteorology] data. Show them how to use Excel to, um, summarize their information.*

After an initial pause, perhaps to choose an appropriate example, Isabelle shares an enhancing belief as she reflexively positions (Harré & van Langenhove, 1999) herself as capable user of Microsoft Excel. Isabelle explains how she tries to meet the professional expectations of the science faculty by teaching students digital skills and preparing them to design experiments. These skills include entering and manipulating raw data, performing analyses and graphing results. Of note is that Isabelle suggests that Excel is used to 'summarize' rather than enable students to analyze data. Her repeated use of 'show' seems to position students as passive participants while she displays her skills to manipulate (Foucault et al., 1988) the program.

Feeling unsure about scaffolding students' digital skills
**Deflating Belief**

*It's probably me not explaining it [how to use Excel] properly to them.*

Continuing the turn above, Isabelle shares a deflating belief about self while reflecting on her perceptions of students' proficiency with Excel. By attending to her professional duty to teach these digital skills to the best of her capacity, Isabelle seems to be attending to the sacred story: ***We have a duty to teach digital technologies***. However, when reflecting on the outcome, attributing students' questions about the program to her inability to explain it 'properly' to them, the secret story that emerges is: ***I'm not confident in my ability to teach these skills***.

Isabelle's enhancing beliefs about self tell a sacred story that is also shared by her colleagues: ***Digital technologies are used to enhance teaching and learning of content and science inquiry skills***. These beliefs reflexively positioned her to be affiliated with a group of teachers in this local moral order who attend to their professional duties to incorporate digital technologies into their practice. However, she seemed to struggle keeping up with her colleagues. The triumphs Isabelle made by exploring online quiz software and endeavoring to show students how to use Excel seemed to be in tension with her secret story: ***My limited capacity to utilize digital technologies prevents me from strategically incorporating them into lessons and articulating the pedagogical value of them***.

Although Isabelle spoke the language of the sacred story, her struggle to use and articulate the pedagogical value of the technologies seemed to indicate a disconnect between her practical reason, *phronesis,* and practical action, *praxis* (Burkitt, 2002). Isabelle may be developing her capacity to manipulate digital technologies after attending to social signs from her colleagues, but producing and transforming lessons with them seemed out of reach. As such the codes presented in Table 10.3 and the emergent secret and sacred stories were raised to the focused code: Keeping up with colleagues.

### 10.2.3 Keeping One Step Ahead of Students

In the previous section Isabelle positioned herself as keeping up with colleagues. This section seeks to understand how, with limited confidence and capacity, she positioned her students as they utilized digital technologies. Isabelle expressed only a handful of deflating beliefs (Rokeach, 1968) about students and, like her colleagues, she did not position them as proficient digital technology users. However, like Ethan, a novice II digital technology user introduced in chapter nine, Isabelle seemed to have an underlying expectation that students were familiar with some digital skills taught elsewhere in Riverside's enacted curriculum.

Reflecting on Microsoft Excel, Isabelle explained that year nine students do not have the expected technical proficiency with the software when she said:

*No, because I actually had to show them right before as well*.

Isabelle began this turn confidently and her use of the qualifier 'actually' seemed to reinforce a belief that students do not know how to use digital technologies for science. Using the personal pronoun 'I,' Isabelle positions herself as expert in this instance and endeavors to assume a professional duty to 'show' students how to use Excel. Taken at face value Isabelle's reflection seems to promote the sacred story: ***I'm responsible for developing students' digital skills in the science classroom***.

Table 10.4 exemplifies and explains some of Isabelle's *reflections* of her students' digital technology use and how they were initially coded. Her **beliefs** are identified and analyzed to form the overarching attitude: Students have difficulty using digital technologies for science.

**Table 10.4: Students Have Difficulty Using Digital Technologies for Science**

| |
|---|
| Struggling to create new ideas<br>**Deflating Belief**<br><br>*(Sighs) … [How do students create new ideas] with digital technologies? Hm… mmm.. I guess they can explore different things. Um, that's very hard for them to-using digital technologies for the first time and to create ideas for them. I-I guess, it depends where they're at. I don't know. Sorry.*<br><br>Isabelle speaks quickly to reflect on students using digital technologies to create new ideas. Her use of the qualifier 'I guess,' moments of hesitation and paraverbals seem to indicate that using digital technologies to create new ideas may have been an unfamiliar pedagogical practice. Unlike Ethan who sought clarification about the meaning of 'create new ideas,' Isabelle explained that students struggle to use digital technologies for 'the first time.' She defers to the sacred story, recognizing that students' abilities fall on a developmental continuum, 'it depends where they're at,' but her deflating belief about students' abilities, being first time technology users and having difficulty, seems to conceal a secret story: ***I haven't explored utilizing digital technologies in ways that challenge my students to develop critical thinking skills beyond explicit instruction and revision of subject-based content***. As such, this reflection seems to position Isabelle as a novice user of digital technologies more so than her students. |
| Forgetting how to use digital technologies<br>**Deflating Belief**<br><br>*No, they [students] forget. They forget and they do that in maths as well. They use it in maths so they do forget.*<br><br>Prior to this reflection, Isabelle shared a deflating belief about self: 'It's probably me not explaining it properly [...]' By attributing students' lack of proficiency with Excel to her own explanations, Isabelle seemed unable to meet her professional duty to teach digital skills effectively.<br><br>Here, Isabelle draws on her experience teaching mathematics to elaborate and seems to revert to a sacred story: ***Children are forgetful and need to be taught skills repeatedly over time***. Although she identifies cross-curricular links, the pedagogical practices employed within this local moral order remain unspoken and students seem to be positioned with a duty to remember what they have been taught. This is a reasonable expectation for teachers working toward developing students' skills across explicit and enacted curricula, however Isabelle seems to lack a sense of oughtness to assume a professional duty to assess students' skills prior to introducing Excel in the science classroom. Although she may have the capacity to manipulate Excel, producing and transforming lessons beyond 'showing' and 'explaining' seems, for the moment, out of reach and may leave Isabelle frustrated when students' skills do not carry over. |

The reflections in Table 10.4 are more indicative of Isabelle's capacity to plan for and utilize digital technologies compared to her students' technological capacity. They seem to reflect a sacred story in tension with and distinct from the secret story: ***As trained professionals we're able to assess students' use of digital technologies, but I'm not sure how to do this in my classroom***. For Isabelle, students' digital skills were not fully developed to enable them to be applied to science, therefore she assumed a professional duty to 'show' and 'explain' how to use digital technologies. Being a novice user herself,

however, Isabelle's sense of agency seems to be compromised as she is unable to evaluate and plan for developing students' digital skills. As such, she did not appear to feel a sense of oughtness to produce and transform lessons with digital technologies. The codes presented in Table 10.4 and the emergent secret and sacred stories were raised to the focused code: Keeping one step ahead of students.

### 10.2.4 The Emergence of a Theoretical Category: Struggling to Stay Afloat

Struggling to stay afloat is a theoretical category grounded in Isabelle's positioning of digital technologies, self and her students. Two structural features of beliefs described by Nespor (1987) seem to be recurring in these positions:

1. Episodic storage; and
2. Existential presumptions

Episodic storage is informed by a teacher's experiences and events in which cultural and institutional sources of knowledge are transmitted to them. For Isabelle this aspect of her beliefs seems to be informed by the social signs within the Riverside local moral order and the sacred stories promoted by teachers, theoreticians and policy makers. Isabelle's interpretation of the explicit curriculum and the actions of her colleagues provided social signs that strengthened her sense of agency to utilize digital technologies to the extent that her capacity would enable. As such, she maintained a sense of group affiliation as a competent science teacher, although, with a lack of certainty and personal commitment toward developing students' digital skills.

These aspects of Isabelle's belief system, however, seem to be in tension with existential presumptions, perceptions of student ability, maturity and motivation beyond a teacher's influence. Isabelle's secret stories of classroom practice position both the digital technologies and the students with high expectations for learning and metacognitive capacities beyond her control and seem to enable her to relinquish the professional duties she reflects on in her sacred stories. Isabelle occupied a novice stage of the technology of production (Foucault et al., 1988). She learned how to manipulate some of the digital technologies her colleagues used to enact what she believed to be appropriate pedagogical practice, to 'show' and 'emphasize points.'

Struggling to stay afloat evokes an image of swimming in an unpredictable current or through rough waves. While tiring the swimmer occupies a precarious position between danger and safety where small triumphs are made as short distances are swum. Isabelle's perceptions of her own and her students' digital skills seemed to reflect a limited sense personal agency in this liminal space. Here, Isabelle negotiated her professional identity as Science Coordinator and being part of a team utilizing digital technologies, while at the same time negotiating her identity as OOF teacher of digital technologies. Within this space Isabelle positioned digital technologies as teachers as she endeavored to keep up with her colleagues and stay one step ahead of her students.

## 10.3 During and After Teaching Geoscience: Displaying the Tip of the Iceberg

Apart from interpreting social signs to use digital technologies consistently within the local moral order, the previous section indicated that Isabelle seemed to require support to strengthen her sense of agency toward developing pedagogical practices with the technology of production. This included acquiring the technological knowledge and support to practice utilizing digital technologies in pedagogically distinct ways to possibly improve her technological pedagogical content knowledge (Koehler & Mishra, 2009) and sense of personal and professional agency teaching science content and inquiry skills.

Isabelle's personal and professional duties prevented her from participating in this research to the same extent as Charlotte, Rachel and Ethan. However, as she taught geoscience I was able to offer Isabelle support, observe her online activity through changes she made to the Google Drive and record memos of our interactions. These observations and memos are paired with interview data collected after Isabelle taught year nine geoscience to explain how she positioned the digital technologies, self and her students and to what extent this novice digital technology user may have been supported to teach OOF, if at all.

### 10.3.1 Digital Technologies as Tools

Shortly after the conclusion of the seven-week geoscience unit, I invited Isabelle to reflect on her experiences by revisiting her PMMM, shown in Figure 10.3. Isabelle was the only participant to record changes to her PMMM. These changes have been underlined for

clarity and may be indicative of her personal and professional growth learning to teach at the intersection of two OOF topics, geoscience and digital technologies.

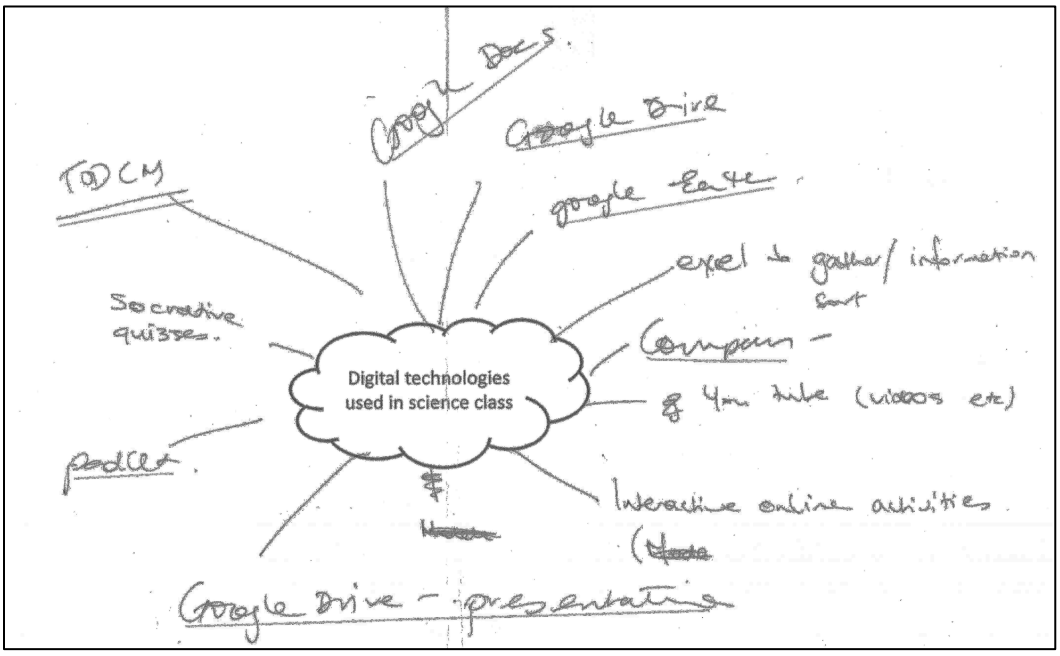



**Figure 10.3: Isabelle's Personal Meaning Making Map from December, 2016**

Prior to teaching geoscience, Isabelle positioned the digital technologies as teachers which seemed to enable her to assume but also relinquish some of her personal and professional duties as a classroom teacher. After the unit, Isabelle expressed very few deflating beliefs about the digital technologies. Table 10.5 exemplifies and explains how Isabelle's *reflections* were initially coded, classified using Rokeach's (1968) types of **belief** and analyzed. The initial codes, sacred and secret stories were raised to the focused code: Digital technologies as tools.

## Table 10.5: Digital Technologies as Tools

PowerPoints enabling guidance of students
**Enhancing Belief**

*[T]he ones [PowerPoints] we had were quite good once again they were instructional r-and telling them [students] what they need to be doing, where they need to be, what they need to be focusing on for the lesson and finding information. [...] [They were distinct] 'cause the information that-all of the information wasn't on there. They actually had to find the information through Google Earth.*

Isabelle reflects on her use of PowerPoint presentations intended to guide students and teachers through both on and offline activities while promoting classroom discussion. She explains how this use of PowerPoint is distinct from her usual practice, evaluating them as 'quite good.' Earlier in the interview, however, Isabelle suggested students were unsettled. Some students reported frustration with the inquiry-based activities and drew on their perceived rights to be provided with summarized science content, 'I haven't been given any information.' Although, Isabelle perceived that using PowerPoint in this way was beneficial, her positioning of students with a duty to 'find the information' and repeated use of 'they' seems to indicate that she does not position herself as facilitator of the learning. Again, there seems to be tension between the sacred and secret stories: ***Students need to take an agentic approach to their learning, but I don't assume the duty to facilitate this learning***.

YouTube videos enabling thinking
**Enhancing Belief**

*The YouTube videos that we had were actually quite good. So, um, some of them did make them [students] think so you've got to be quite selective in what you're choosing.*

Isabelle utilized YouTube videos to 'emphasize certain points.' In geoscience, videos were selected for different purposes within the teaching sequence to inspire curiosity, explain concepts and prompt questioning of alternative conceptions. Isabelle seems to use 'actually' as a qualifier suggesting surprise that 'some' videos could be used to facilitate thinking when teachers assume a duty to be selective. A sacred story emerges: ***Video can be used to facilitate scientific thinking when chosen selectively***. Of note is that all videos were accompanied with suggested prompts to promote small group and whole class discussion, yet Isabelle did not reflect on these possibly suggesting that she continues to require support to produce and transform lessons with video to assume a professional duty to encourage higher-order thinking with these tools.

Google Drive enabling sharing and organization
**Enhancing Belief**

*I thought-I thought it was great just to organize things. And for sharing documents and, um, editing, it was great.*

As a novice digital technology user, Isabelle did not appear to have personally explored cloud computing software and thus took pedagogical risks to do so with students. Drawing on a sense of oughtness, Isabelle assumed a professional duty to offer students consistent experiences across science classes. She confidently lists affordances of Google Drive, enabling organization, sharing and editing of files. These affordances are distinct from Compass, Riverside's attendance and learning management software, enabling the learners to have more control of their digital portfolios. Although Isabelle was more familiar Compass, these affordances may act as sign systems (Foucault et al., 1988) for her to incorporate into her future practice provided she feels empowered to utilize them.

Isabelle's reflections are indicative of the personal and professional risks she took to incorporate both new and unexplored digital technologies into geoscience. She was already familiar with PowerPoint and YouTube, these technologies were included to scaffold novice teachers' technological pedagogical content knowledge by utilizing them in pedagogically distinct ways. However, Isabelle did not reflect on students articulating ideas together and she seemed to relinquish a professional duty to facilitate learning by helping students engage in geoscientific epistemic practices resulting in tension between her sacred and secret stories.

For Isabelle, the most significant use of digital technology seemed to be Google Drive. Speaking as Science Coordinator, frustrated with school-mandated curriculum mapping software, she explained:

> *[I]t doesn't take long to edit that much on Google Drive. [In prior years there] was a little bit [resources] there but not enough to actually empower staff to use it. [...] And in terms of knowledge and everything, everything was just there. So, it just helped. You had to do a little bit of background work, but not as much [as] in previous years.*

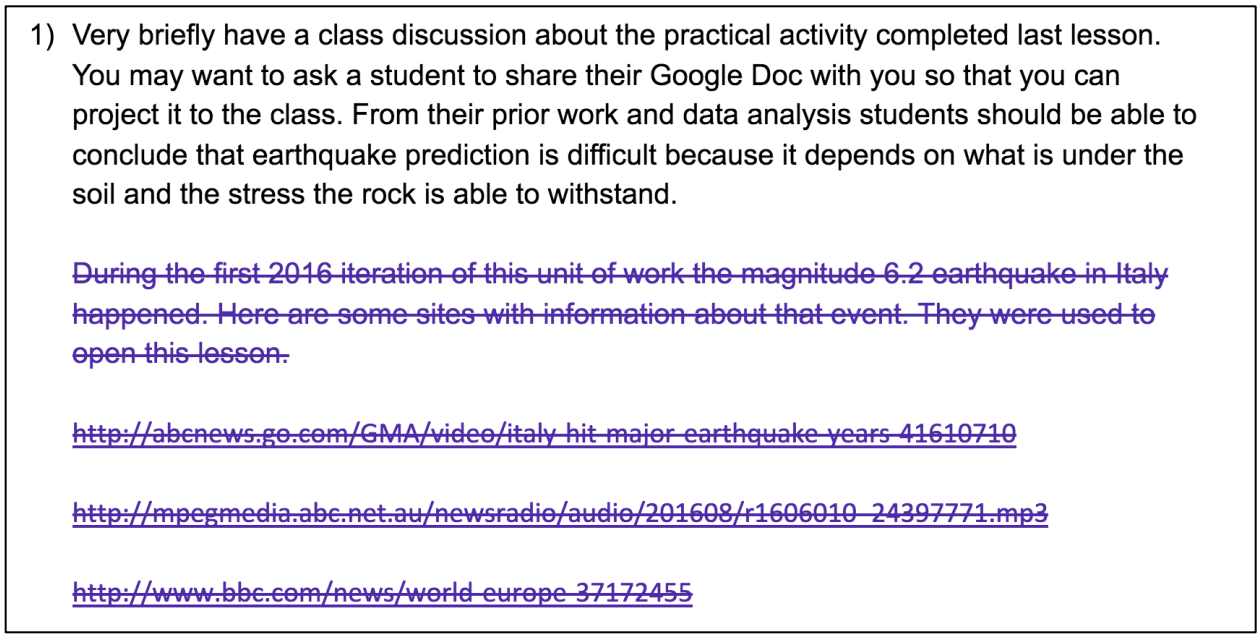
Isabelle spoke on behalf of teachers identifying rights to be empowered to utilize curriculum mapping software and to be provided organized resources that could be accessed efficiently. As such, she reflects on what she perceives to be a disconnect between the intended institutional uses of digital technologies and teachers' needs. Using 'actually' and 'just,' Isabelle seems to indicate a shift in her perception that using Google Drive may have been easier than expected, possibly indicating that utilizing cloud computing in this way may strengthen teachers' capacity to meet both institutional and professional needs.

Before teaching geoscience, Isabelle positioned the digital technologies as teachers that 'emphasize' and 'explain' content to students. After, she identified different affordances of both un/familiar digital technologies. These affordances seemed to strengthen Isabelle's capacity to explore distinct pedagogical practices, attend to her administrative duties and assume her professional duties as Science Coordinator. As such, the initial codes and the secret and sacred stories have been raised to the focused code: Digital technologies as tools.

### 10.3.2 Keeping up Appearances with Digital Technology Use

Isabelle's original PMMM and interview data indicated that she attended to social signs within the local moral order and seemed to feel a sense of oughtness to utilize digital technologies familiar to her colleagues. However, she struggled to explain the affordances of the technologies and their pedagogical value indicating that she had a limited sense of agency to manipulate digital technologies and required support to transform and possibly produce of lessons with them. Google Drive was introduced as a technology Isabelle had not previously explored and is an appropriate starting place to begin to understand how she positioned herself as a user of digital technologies in geoscience.

Isabelle made three changes to the Google Drive, suggesting a degree of empowerment and sense of agency to transform provided lesson plans for her own purposes. Figure 10.4 shows purposeful removal of materials sourced from the professional media to be used in a class discussion connecting the motion of seismic waves to earthquake intensity. Figure 10.5 shows purposeful removal of higher-order thinking questions intended for students to collaboratively reflect on a documentary about continental drift.



1) Very briefly have a class discussion about the practical activity completed last lesson. You may want to ask a student to share their Google Doc with you so that you can project it to the class. From their prior work and data analysis students should be able to conclude that earthquake prediction is difficult because it depends on what is under the soil and the stress the rock is able to withstand.

~~During the first 2016 iteration of this unit of work the magnitude 6.2 earthquake in Italy happened. Here are some sites with information about that event. They were used to open this lesson.~~

~~http://abcnews.go.com/GMA/video/italy-hit-major-earthquake-years-41610710~~

~~http://mpegmedia.abc.net.au/newsradio/audio/201608/r1606010_24397771.mp3~~

~~http://www.bbc.com/news/world-europe-37172455~~

**Figure 10.4: Isabelle's Edits to a Lesson Introducing Seismic Waves**

8) ~~How is new crust being formed at ocean ridges?~~

9) ~~Why do geologists suspect that the volcanic Mariana Islands were being caused by the trench? Use the term *subduction* in your response.~~

10) ~~From the video, what is something that you would like to learn more about? If you'd like a personal response, consider asking your questions here.~~

**Figure 10.5: Isabelle's Edits to a Collaborative Document about Continental Drift**

Removing these activities could indicate that Isabelle was attending to a secret story: ***My students are struggling and I need to save time to get through the material.*** However, this came at the expense of attending to the sacred story: ***The natural world is in predictable flux affecting society, teachers have a duty to help students make these connections.*** Goffman (2002) explains:

> *Often we find that if the principal ideal aims of an organization are to be achieved, then it will be necessary at times to by-pass momentarily other ideals of the organization, while maintaining the impression that these other ideals are still in force (p. 45).*

Although Isabelle could identify benefits of using Google Drive, her sense of agency to manipulate documents highlights tension at the intersection of the secret and sacred stories. Manipulating lesson plans at the expense of her students' learning appeared to be a high price for developing Isabelle's technological knowledge (Koehler & Mishra, 2009).

Table 10.6 exemplifies more of Isabelle's personal *reflections* after teaching geoscience. Initial coding and identification of her types of **beliefs** are presented alongside the analysis. Of note is that Isabelle taught geoscience at the same time as Charlotte, Ethan and Michael. Michael was not a participant in this study, yet he is introduced because Isabelle reflected on her work with him to modify some resources. Isabelle and Michael shared an office and had been colleagues for 13 years. Isabelle's reflections seem to indicate an overarching attitude that teaching OOF with digital technologies and provided resources was smooth sailing. This emergent attitude and the cover, sacred and secret

stories were raised to the focused code: Keeping up appearances with digital technology use.

**Table 10.6: Keeping Up Appearances with Digital Technology Use**

| |
|---|
| Working with a colleague and individually to manipulate materials<br>**Enhancing Belief**<br><br>*Well (sigh) I guess I worked in conjunction with Michael. With Michael, um, he sort of made the details a little bit more specific where necessary and that sort of and then I sort of, when necessary, I modified them again to suit myself. So, the instruction parts-[...]*<br><br>Isabelle shares a personal reflection about working with Michael. She continues a guarded narrative with 'I guess' and 'sort of' indicating uncertainty about how she was able to 'make the unit her own.' She positions Michael as technologically savvy, a colleague she could depend on to specify 'instruction parts' helping her to assume a professional duty to teach students how to use Google Earth. This is telling of Isabelle's technological capacity and also her commitment to trial the activities as a learner herself. A secret story emerges: ***I'm going to use these digital technologies in class, but I'm not capable to do so on my own***. After Michael's modifications, Isabelle made additional changes to 'suit' herself as opposed to her students. Isabelle did not explain these additional modifications, however her use of the personal pronoun 'myself' and the changes she made to the Google Drive may indicate that these modifications helped her to negotiate her administrative and professional duties. |
| Having confidence after going through materials<br>**Enhancing Belief**<br><br>*[...]-and a key part of it also was having to go through it yourself the first time just to make sure that you knew what you were doing. But after you went through it once, you didn't have to go through and fine-tune anything. You were fine. You knew what you were doing, where you were heading.*<br><br>Continuing the turn above, Isabelle draws on the personal pronoun 'you' to possibly distance herself from the experience while at the same time speaking on behalf of her colleagues. She attends to the sacred story identifying a professional duty for teachers to 'go through' the materials. However, the extent to which Isabelle has done this from a learners' perspective is unclear. She explains that by previewing materials teachers are able to position themselves as technologically competent. The previous turn, however, seemed to indicate that Isabelle had difficulty using Google Earth, yet here she reports that doing so once is enough to achieve technological competence. A cover story, ***I'm a capable user of Google Earth***, is in tension with the secret story, ***I may not be as prepared as I should be.*** |

Isabelle did not express any self-deflating beliefs nor was she apologetic about her responses as she was in our first interview. Her reflections in Table 10.6 seem to indicate a strengthening sense of personal agency and confidence teaching with digital technologies and Isabelle expressed satisfaction (Krathwohl, 2002) using phrases such as 'I enjoyed teaching the unit' and 'I enjoyed using the technologies.' In addition, Isabelle's overarching attitude appeared to shift from keeping up with colleagues toward a smooth process of

technology incorporation. Closer analysis of her discursive practices, however, indicates that Isabelle continued her guarded narrative through her articulation of cover and sacred stories.

At times, students seemed unsettled reporting that some teachers did not appear to be technologically competent. During the unit Isabelle was disquieted by this feedback. When I invited her to reflect on her feelings, she explained:

> *(Sighs) Yes, 'cause I felt that it was me not-because I had just had my laptop, my new laptop. My new laptop, I actually got it at recess and it was period two that I was teaching the class. So, things were just all over the place. So, not only did I have my laptop which was going-I also had the Google Earth. And it sort of just made me feel, yeah. But anyway, we got-I got through it. It took a while, but I got through it.*

Teachers in government schools are provided laptops which are regularly replaced as the technology and teachers' needs become more sophisticated. Although Isabelle's new device was able to function with school-mandated software, she explains her frustration when she realized that she had to download and install Google Earth with a lack of personal agency to do so shortly before beginning her class. This reflection is indicative of Isabelle's capacity to utilize digital technologies independently. Making the exchange at recess, Isabelle was unable to access her colleagues' support in the following period. A cover story emerges as Isabelle avoids positioning herself as vulnerable: ***It's the computer, not me!***

Isabelle appeared to experience similar frustrations in the classroom. Apart from her purposeful modifications to lessons, Isabelle's final edit to the Google Drive was a mistake. Her students were preparing to post their findings from a Google Earth practical activity on Padlet, a digital bulletin board. Isabelle accidentally deleted the link. I was nearby when Isabelle deferred to the laboratory technician who reported that she was often called on during lessons to solve Isabelle's technical problems.

Although, as an insider-researcher (Mercer, 2007), I offered Isabelle support before, during and after class, she seemed to take comfort seeking help from others to maintain the cover story: ***I'm a competent user of digital technologies***. Yet, there was a mismatch between Isabelle's discursive practices indicating that although she was, to some extent, empowered to manipulate the digital technologies, she had difficulty doing so independently. Perhaps Isabelle's professional identity as Science Coordinator and negotiation of collegial relationships prevented her from developing a greater sense of

agency to utilize digital technologies. As such, the initial codes exemplified in Table 10.6 and the secret, sacred and cover stories emerging were raised to the focused code: Keeping up appearances with digital technology use.

### 10.3.3 Keeping up Appearances while Teaching OOF

Section 10.2.3 explained how Isabelle positioned her students which seemed to indicate more about her own capacity to utilize digital technologies than her students'. Being a novice digital technology user, Isabelle kept one step ahead of her students. Similarly, Isabelle's positioning of her students during the geoscience unit was indicative of her own capacity to teach with them. Table 10.7 exemplifies the initial coding, types of **belief** and analysis of some of Isabelle's *reflections.* These analyses and the emergent secret, sacred and cover stories were raised to the focused code: Keeping up appearances while teaching OOF.

**Table 10.7: Keeping up Appearances while Teaching OOF**

| |
|---|
| Students not appreciating digital technologies but knowing what to do<br>**Deflating/Enhancing Belief**<br><br>*It [digital technology] made it [geoscience] come alive for them [students]. Even though they didn't appreciate it, they did know what they were doing.*<br><br>Reflecting on the geoscience/digital technologies curricular intersection Isabelle shares conflicting beliefs about her students, positioning them as passive participants playing the game of school. Although capable, she perceived her students to be unappreciative learners with digital technologies. Unfortunately, Isabelle did not elaborate on her meaning of 'appreciate.' I wondered if Isabelle's students did not enjoy the experience. Or were they unaware that digital technologies were used to invite them into the epistemic practices of scientists through collection and analysis of data, modelling natural phenomena and engaging in discussion? Isabelle's reflections analyzed earlier, however, seem to indicate that her own proficiency to utilize digital technologies may prevent her from accurately evaluating her students' capacity. As such, Isabelle may be sharing a cover story that overclaims for students' progress developing their digital skills. |
| Students were thinking but didn't realize it<br>**Enhancing/Deflating Belief**<br><br>*[T]hey were actually thinking and doing the work even though they didn't realize it.*<br><br>Isabelle uses 'actually' to emphasize an enhancing belief about students, indicative of her certainty that they were developing higher-order thinking skills and possibly setting this unit apart from others. In the second half of the turn, she shares a deflating belief about students' metacognitive abilities, 'they didn't realize' they were thinking and completing the work. Here is another contradiction between Isabelle's discursive practices. Reflections analyzed earlier indicate that Isabelle may have relinquished a professional duty to scaffold students' metacognitive skills for self-directed learning. Teachers have a professional duty to ensure that students complete work, but to what extent? Does Isabelle value the product more than the process? If so, were students unaware of what success looked like? Despite maintaining feeling 'comfortable' teaching OOF, these questions seem to indicate that Isabelle was unable to facilitate students' understanding of the learning outcomes. A secret story seems to emerge: ***Students are working, but I'm unable to develop their metacognitive skills***. |

Isabelle's enhancing and deflating beliefs about students in Table 10.7 seem to be in tension with students' reflections. Data from focus groups and questionnaires indicated that, at times, students felt unsettled. One student reflected:

> *I found that the only way to understand geoscience was to memorize facts. Usually in science we don't have to make observations as much as we have in this unit.*

Isabelle responded to this student's reflection by explaining:

> *Ok, in this instance here I guess students had to find the information for themselves. So, that was very, very hard for them. They had to search for the information. We weren't spoon-feeding them any of the information. Which mi-was it-th-they had to think.*

For Isabelle, like her colleagues, the geoscience unit was distinct from others taught within this local moral order because students were not positioned as receivers of

packaged information. At the end of the turn, Isabelle struggled to defer to the sacred story: ***We teach students how to think***. However, her use of 'I guess' and re-positioning learners as finders of information seems to indicate uncertainty about the purpose of the digital technology use and dilutes the pedagogical strength of the inquiry-based activities. As such, Isabelle's cover story, ***I'm able to teach OOF with digital technologies***, seems to erode as the secret story emerges, ***I'm keeping up appearances to teach OOF by endeavoring to engage in similar practices as my colleagues.*** As such the initial codes and Isabelle's secret, sacred and cover stories were raised to the focused code: Keeping up appearances while teaching OOF.

### 10.3.4 The Emergence of a Theoretical Category: Displaying the Tip of the Iceberg

Prior to teaching geoscience Isabelle seemed to be struggling to stay afloat. As an experienced teacher yet novice digital technology user, she interpreted the social signs of the local moral order assuming the professional duty to use digital technologies to emphasize content. To an extent she was able to draw on her limited capacity and assert her agency to show students how to use digital technologies. Displaying the tip of the iceberg is a theoretical category that has emerged from the focused codes grounded in Isabelle's positionings of the digital technology, self and her students during and after teaching the geoscience unit.

In our interviews Isabelle seemed to display the tip of the iceberg, pristine and free-flowing. She took personal and professional risks to incorporate both un/familiar digital technologies into her practice, expressing satisfaction and claiming a sense of personal agency to teach for technology-enabled learning (Brantley-Dias & Ertmer, 2013; Ertmer & Ottenbreit-Leftwich, 2013). Isabelle's reflections seemed to indicate that the lesson plans and resources provided sign systems enabling her to recognize pedagogically distinct ways to utilize familiar technologies. To an extent, she was also able to assert her professional agency and engage in the technology of production by learning basic manipulation skills with the help of her colleagues, reflecting that the most difficult aspect of teaching OOF with digital technologies was 'getting the students to use it [Google Drive].'

Beneath the surface of the iceberg, however, can lie a treacherous environment that must be navigated carefully. Isabelle's awareness of the pedagogical affordances of digital

technologies seemed to improve after teaching geoscience. To what extent these practices would be employed, however, remained uncertain:

*I think I've come…. Um, um, I've made some progress (laughs).*

Isabelle's moments of hesitation and nervous laughter at the end of this reflection seem to indicate that she continues to feel a limited sense of agency to utilize digital technologies and is not yet empowered to produce and transform lessons and explore the pedagogical practices modelled in this unit.

## 10.4 Conclusion: Toward Understanding Accountability for Digital Practices

Although Isabelle was unable to participate in this research to the same extent as her colleagues Charlotte, Rachel and Ethan, performing a fine-grained analysis using positioning theory strengthens the importance of its use to analyze the perceptions of science teachers teaching OOF. Reflecting on Isabelle's role as Science Coordinator, the cover and sacred stories she narrates may suggest a greater sense of personal agency and continued commitment to teach OOF with digital technologies than was actually experienced.

When I asked Isabelle whether she would be willing to use the same digital technologies in the following year, this exchange occurred:

***Isabelle:*** *Hopefully.*

***Interviewer:*** *Why do you say 'hopefully?'*

***Isabelle:*** *Well, if I can remember how to use it. If I practice over the holidays.*

Isabelle began this turn confidently yet when pressed to explain, she spoke at almost a whisper inviting me into a secret story***: I might not have taken away as much as I thought***. Isabelle ended the exchange with a confident sacred story that, when told at the end of the school year, was perhaps more indicative of a cover story: ***I'll practice over the holidays.***

Krathwohl (2002) explains that there are distinct levels of internalization as individuals experience and respond to phenomena affectively. At the lowest levels, individuals are aware of and may be willing to attend to the phenomenon. Although her sense of personal agency seemed to continue to be strengthened by social signs and the

provision of resources, Isabelle told a guarded narrative throughout our exchanges. She seemed to endeavor to maintain face with her colleagues and students in ways that compromised her sense of personal agency to transform and produce lessons with digital technologies. Unfortunately, Isabelle was not allocated year nine science in 2017 and so the growth that she has shown with geoscience-specific digital technologies may be unlikely to carry through without further practice, mentorship and more successful experiences.

# Part IV: The Explicit Personal Pragmatic Approach (EPPA) to Professional Learning

# Chapter 11: Conclusion and Recommendations

## 11.1 Overview

This research investigated the intersection of the science and digital technologies curricula (VCAA, 2016c) that government school teachers were mandated to teach in the Australian state of Victoria in 2017. Over seven months multiple sources of data were collected and analyzed from an inner-city school in Melbourne, Riverside High (pseudonym), and 10 teachers to better understand teachers' perceptions of their personal and professional duties to teach science with digital technologies. Four of these teachers were then offered professional support to utilize digital technologies in their teaching of geoscience. Geoscience is a sub-discipline of science largely taught by non-specialists (Dawson & Moore, 2011; King, 2001, 2008; Lewis & Baker, 2010). As such it is an unfamiliar body of knowledge and language for many general science teachers who teach this topic out-of-field (OOF). Teachers' self-assessments of their digital technology use before, during and after teaching geoscience were gathered and triangulated with 28 year nine students and 22 colleagues who attended the annual Science Teachers' Association of Victoria (STAV) conference.

Positioning theory (Harré & van Langenhove, 1999) was the overarching philosophy and methodology informing the research design. Constructivist grounded theory coding procedures (Charmaz, 2014), pronoun grammar analysis (Mühlhäusler & Harré, 1990; Redman, 2013a; Redman & Fawns, 2010) and the positioning triad (Harré & van Langenhove, 1999) were used to analyze the data. These analytical tools and Foucault's (1988) technologies of the self enabled tracking of any changes in teachers' perceptions of their personal agency to utilize digital technologies and flag areas where support for professional growth *was* and *continued to be* needed.

This chapter responds to the research questions and explains the significance of the findings for implementing professional learning experiences for in-service science teachers. To conclude, the chapter explains additional unique contributions to knowledge the research offers to:

1. Methodological discussions drawing on the use of positioning theory in the context of schooling;

2. The fields of digital technology use in education and the OOF teaching experience; and

3. Understanding the experiences of research scientists transitioning to teaching

Grounded in a more informed understanding of teachers' perceptions of their agency, a three-dimensional model of professional learning is offered, the Explicit Personal Pragmatic Approach (EPPA), illustrating the relationships between the findings. The EPPA may not only be of value to the field of educational technology and teacher development for OOF teaching but also to other occupations where professionals are required to continually refine their knowledge and skills in unfamiliar contexts. In addition, the findings have informed recommendations for implementing effective use of digital technologies across the institutional and subject-specific expectations of teachers and may have international implications, particularly in a time when a variety of stakeholders rely on teachers' digital technology use to help combat global health issues.

## 11.2 Review of Research Questions and Summary of Findings

The seminal research question was:

To what extent do secondary science teachers' perceptions of their agency change as they are supported to teach an out-of-field area of the curriculum with digital technologies?

Three subsidiary questions focused my investigation and research design:

1. How do secondary science teachers self-assess their uses of digital technologies in the classroom?

2. How do secondary science teachers perceive their capacity to teach geoscience with digital technologies?

3. How does participating in the delivery of a unit of work at the intersection of the geoscience and digital technologies curricula change teachers' beliefs about their sense of agency teaching an out-of-field area, if at all?

### 11.2.1 How do secondary science teachers self-assess their uses of digital technologies in the classroom?

Initial teacher education and certification (AITSL, 2015), professional standards (AITSL, 2011; ASTA, 2002), digital education policy (DEEWR, 2008; DEECD, 2014) and

state-mandated curriculum documents (ACARA, n.d.-a; VCAA, 2016d) summarize teachers' roles and the professional expectations of them as skilled members of the profession. The research literature, however, suggests that teachers' use of digital technologies varies considerably and has historically been shown to depend on a number of factors (Ertmer & Ottenbreit-Leftwich, 2013; Inan & Lowther, 2010; Somekh, 2008; Waight et al., 2014; Zhao & Frank, 2003). Ertmer (2016, 2017) and Ertmer and Glazewski (2015) suggest that teachers require support with initial steps toward change if they are to explore pedagogical possibilities with digital technologies and perhaps support for negotiating new roles for themselves and their students. Focus should be on the contextual, cognitive and affective factors shaping teachers' work (Ertmer & Ottenbreit-Leftwich, 2010, 2013; Ertmer et al., 2014; Pareja Roblin et al., 2018).

To understand how secondary science teachers self-assessed their use of digital technologies, 10 teachers were invited to construct personal meaning making maps (PMMMs) and participate in individual interviews. Figure 11.1 shows the continuum of categories of digital technology use grounded in teachers' reflections. These teachers demonstrated varying levels of empowerment (Foucault et al., 1988) to manipulate digital technologies and produce and transform their lessons from *technology integration* toward *technology-enabled learning* (Brantley-Dias & Ertmer, 2013; Ertmer & Ottenbreit-Leftwich, 2013). Respectively these terms are defined as utilizing digital technologies to primarily teach science content, for instance through the use of online quiz software or Microsoft PowerPoint presentations, versus teaching science inquiry skills, for example through the use of real time data collection with data logging equipment. Interestingly, experienced and early-career teachers were found to be placed at all levels of the continuum.

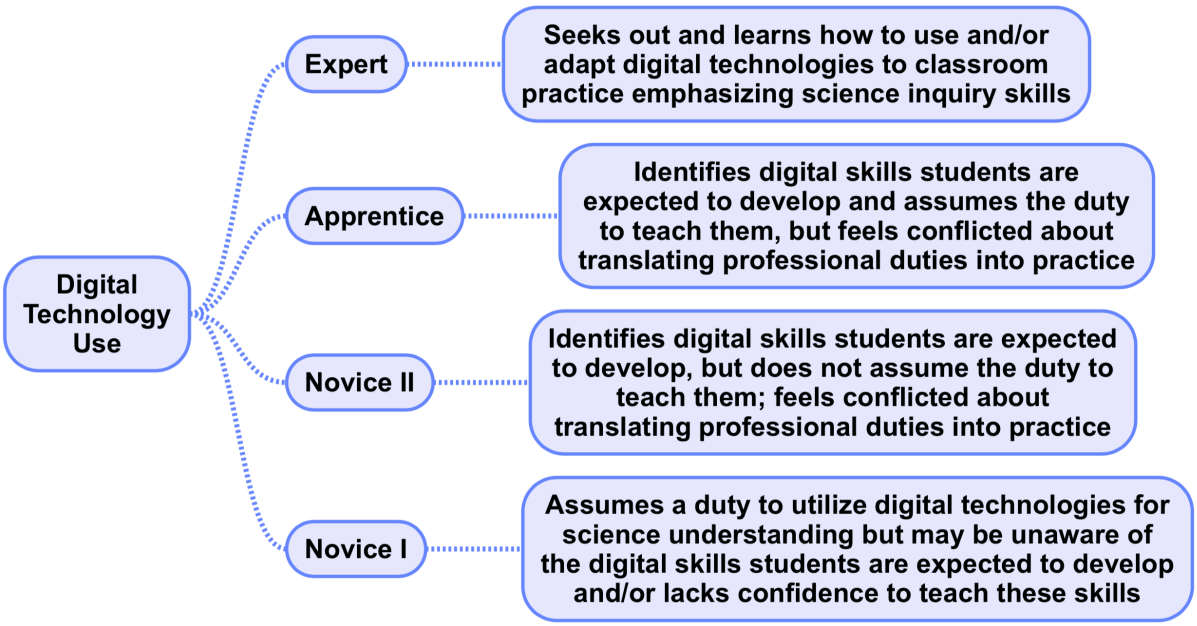



**Figure 11.1: Continuum of Digital Technology Use**

Of significance are the experiences of former research scientists, specifically those in the early stages of their career with less than five years' teaching experience. Rachel, Ethan and Anthony can be described as career-change teachers. Varadharajan, Buchanan, and Schuck (2018) and Varadharajan and Schuck (2017) draw on Eifler and Potthoff (1998) to define career-change teachers as those who:

- Are over 25 years old; and/or
- Were formerly employed in a field other than teaching for at least two years; and/or
- Entered initial teacher education eight years or more after completing formal schooling

Some studies have explained the positive contributions career-change teachers bring to the profession suggesting that these teachers may alleviate current challenges such as the supply and demand for subject specialists. Studying over 500 pre-service, career-change teachers, Varadharajan and Schuck (2017) explain that they bring experience and valuable skills to approach teaching with confidence, maturity and wisdom. Crosswell and Beutel (2017) explored resilience and teacher identity of 31 pre-service, career-change teachers at four stages in their initial teacher education. They found that

teachers responded and adapted to the expectations of classroom teaching by employing self-activated resilience strategies when faced with challenges. In addition, researchers also highlight the role these teachers may play to bridge theory from initial teacher education to practice (Varadharajan, 2014; Varadharajan, Carter, Buchanan, & Schuck, 2016).

Although some former industry professionals' knowledge and experience may align with classroom reforms set out by policy (Antink-Meyer & Brown, 2017), other scholars have found that career-change teachers may have difficulty contributing to the profession in a number of ways (Diezmann & Watters, 2015; Peters-Burton & Burton, 2016; Varadharajan et al., 2018; Watters & Diezmann, 2015). Rowston, Bower and Woodcock (2020) investigated how 19 career-change, pre-service teachers' technological capabilities, teacher-training and placement experience affected their perceptions about technology use and practice. Interview data indicated that prior technological experience influenced teacher confidence, resilience and self-regulation to utilize technologies, however ineffective modeling of digital technology use during initial teacher education, preconceived beliefs and insecurity about content knowledge led pre-service teachers to employ transmission-oriented pedagogies.

The experiences of Rachel, Ethan and Anthony seem to confirm these findings. These early-career teachers could be grouped at both the novice and apprentice levels along the continuum of digital technology use indicating that scientific researchers who train as teachers cannot be assumed to be able to intuitively draw on their transferrable skills to teach for technology-enabled learning. Thus, these teachers warrant targeted professional support to teach this skill set.

### 11.2.2 How do secondary science teachers perceive their capacity to teach geoscience with digital technologies?

According to Shulman (1986b), 'we assume that most teachers begin with some expertise in the content they teach' (p. 8). Despite the historical reality that teachers of broad multi-disciplinary subjects may be highly accomplished in some topic areas but not others (Carlsen, 1992; Kind, 2014; Nixon et al., 2016; Nixon & Luft, 2015; Sanders et al., 1993), this assumption seems to underlie the expectations placed on general science teachers through initial teacher education and certification, professional standards and

state-mandated curriculum. In areas where teachers have had targeted training and experienced discipline-specific epistemic practices, they can be expected to possess specialist pedagogical content knowledge (Shulman, 1986b). However internationally geoscience has been documented as being largely taught by non-specialist general science teachers (King, 2008, 2013, 2015) and so teachers may require additional support to bolster their personal and professional capacity to teach geoscience. This unfamiliar body of knowledge provided the meaning-making space within which this research was conducted.

To understand how secondary science teachers perceived their personal and professional capacity to combine their teaching of an OOF sub-discipline of science with the use of digital technologies curriculum documents from Riverside High and interview data from 10 teachers were analyzed. The extent to which Riverside teachers enacted state-mandated curricular expectations was better understood as a complex, ongoing development and refinement of classroom pedagogies. In addition, the institutional expectations to document the curriculum seemed to be perceived by teachers as disconnected from their classroom duties. Since some teachers did not yet have a professional history teaching geoscience, their perceptions of digital technologies that could be utilized to teach this topic were analyzed and collated into a continuum of awareness for digital technology use.

Figure 11.2 illustrates this continuum which spans from being unaware to having an acting awareness by assuming a duty to seek out digital technologies to produce and/or transform lessons for technology-enabled learning. Of note is that I draw on and extend the term 'technology-enabled learning' to signify its use in this research where both teachers and students utilize digital technologies to collect and analyze real time data in ways that model the work of geoscientists. Notably, apart from three teachers placed at the expert level of digital technology use in Figure 11.1, most Riverside teachers did not seem to be able to readily identify their existing digital practices as transferrable and linked to teaching geoscience.

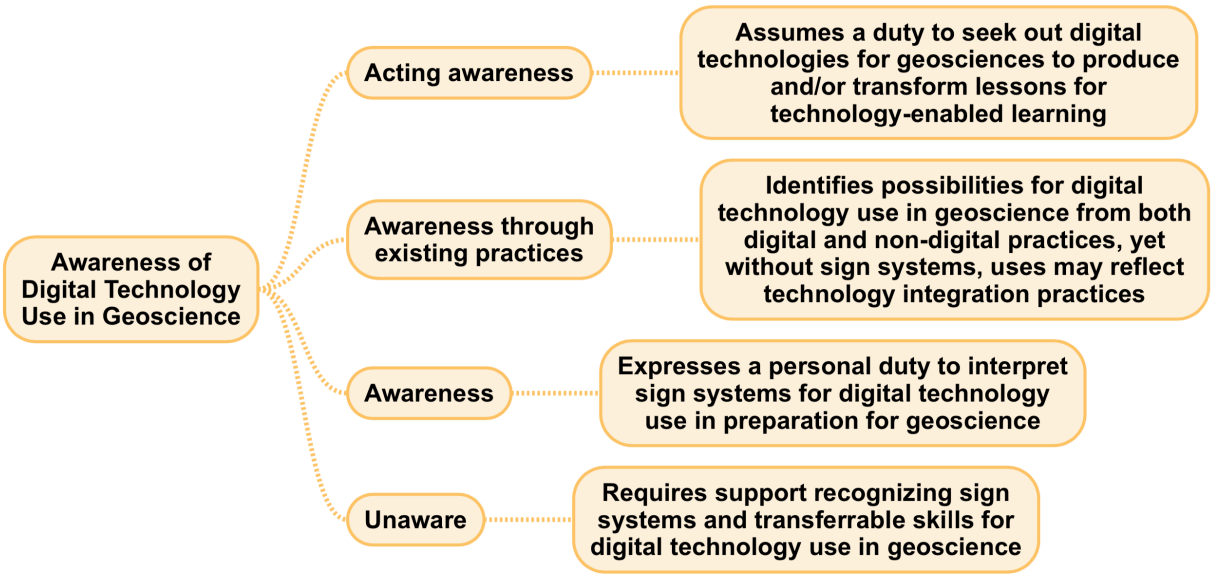



**Figure 11.2: Awareness Continuum of Digital Technology Use in Geoscience**

For experienced teachers who were placed at the expert level of digital technology use, they were able to identify transferrable skills from their specialist areas and were empowered to explore digital technologies enabling them to achieve pedagogical goals to which they positioned themselves as personally accountable. For less experienced, career-change teachers placed at the novice II and apprentice levels of digital technology use, they were found to require further support to incorporate digital technologies in geoscience, a finding similar to Rowston et al.'s (2020) study. These findings seem to support the conclusions of Venkatesh et al. (2003) as they account for individual experience in the Unified Theory of Acceptance and Use of Technology. However, experienced teachers at the novice and apprentice levels of the digital technology use seemed unable to identify and enact transferrable skills from their specialist areas, a finding found to be supported by Sanders et al. (1993) who explain that experienced science teachers approached unfamiliar sub-disciplines in ways that resemble their novice colleagues. As such the OOF teaching space in geoscience seems to be exacerbated by the use of digital technologies, an additional OOF area for these teachers.

### 11.2.3 How does participating in the delivery of a unit of work at the intersection of the geoscience and digital technologies curricula change teachers' beliefs about their sense of agency teaching an out-of-field area, if at all?

When the responses to subsidiary questions one and two were compared two overarching and notable conclusions emerged. Firstly, teachers did not seem to make connections between utilizing digital technologies to document the curriculum, an institutional duty promoting Riverside's cover story (Clandinin & Connelly, 1996), and their subject-specific duties to utilize digital technologies in the classroom, the sacred story to which teachers held themselves personally and professionally accountable. Similar conclusions have been documented in the literature where the administrative uses of digital technologies do not reflect the needs and desires of teachers (e.g. Dede, 2008; Selwyn, 2014; Watters, 2014).

Secondly, in the absence of a formal program of digital experiences for students *and* teachers' varying degrees of personal and professional history utilizing digital technologies secret stories emerged. These secret stories indicated that the necessary sign systems (Foucault et al., 1988) were not yet in place for Riverside teachers to either identify the pedagogical possibilities for digital technology use and/or intuit successful practices from their specialist areas to apply them to the OOF teaching context. This conclusion and teachers' placement along continua of awareness and use of digital technologies support the work scholars who explain that professional learning must be tailored and respond to the needs of individual teachers (e.g., Darling-Hammond, Hylet, & Gardner, 2017; du Plessis, Gillies & Carroll, 2014; Kenny, Hobbs, & Whannell, 2019; Korthagen, 2017; Ríordáin, Paolucci, & O'Dwyer, 2017; Thompson, 2019) .

du Plessis et al. (2019) explain that teachers' enjoyment and confidence teaching OOF improved when:

> [...] they saw their knowledge of curriculum, content, and teaching approaches improving; they sought and received support from colleagues; there were productive relationships with colleagues especially where there were mentors; and there were positive outcomes and relationships with their students' (p. 223).

As such, a year nine geoscience unit was designed to explicitly support teachers to connect the expected institutional practices for digital technology use to subject-specific pedagogical practices. This unit was then offered to four teachers who were novice,

apprentice and expert technology users and had demonstrated distinct levels of awareness for technology use in geoscience.

To varying extents, Charlotte, Rachel, Ethan and Isabelle participated in collaborative interactive discussions (CIDs), focus groups and individual interviews as I recorded observations of my interactions with them. Analyses of these data sets enabled me to respond to the third subsidiary question in terms of the *external* and *internal* factors that both strengthened *and* compromised teachers' evolving sense of personal agency to utilize digital technologies in an OOF area. *External factors* are extrinsic to teachers and include the institutional expectations and accepted practices within the local moral order (Harré & van Langenhove, 1999). *Internal factors* are intrinsic to teachers and include their beliefs about and attitudes toward certain objects and situations.

Tondeur, van Braak, et al. (2017) explain that mismatches between anticipated change and the meanings attached to it by individuals instrumental in change processes often lead to failed technology incorporation. According to Pareja Roblin et al. (2018) teachers' decisions to utilize digital technologies are largely influenced by a practicality ethic (Doyle & Ponder, 1977; Janssen, Westbroek, Doyle, & van Driel, 2013) where they acknowledge feasibility and benefits of use within the constraints of classroom practice. Similar conclusions are made by Scherer and colleagues (2019), teachers are more likely to adopt a technology when they perceive it as relevant to supporting subject specific goals, and Prestridge (2017) calls for deeper understanding of teachers' developmental processes of conceptualizing the relationship between technology and pedagogy. This in-depth analysis of Riverside teachers' experiences sheds light on the social processes at play in this complex environment as teachers are offered a variety of technologies and pedagogies to explore.

Surprisingly, all teachers appeared to benefit from content-based and technical support offered by me and the resources provided. Table 11.1 summarizes specific external and internal factors drawn from these teachers' discursive practices that indicate their strengthening sense of agency to utilize digital technologies in geoscience. Of note are the italicized terms *drive* and *choice*, which were deliberately used to distinguish between distinct levels of internalization (Krathwohl et al., 1980). *Drive* describes beliefs and attitudes that become part of an individual's identity and are held deeply within the belief

system (Rokeach, 1968) such that they consistently manifest as behavior. *Choice* describes behavior that results from beliefs and attitudes peripheral to the belief system which may be in flux depending on how individuals perceive their rights and duties as they interpret different social situations.

**Table 11.1: Factors Strengthening Teachers' Sense of Agency Teaching OOF with Digital Technologies**

| **Participant:** Categorization | **External Factors** | **Internal Factors** |
|---|---|---|
| **Charlotte:** An expert digital technology user with an acting awareness of digital technology use in geoscience | Being permitted to experiment and have 'fun' in the classroom | Having the personal *drive* to experiment and have 'fun' |
| **Rachel:** An apprentice digital technology user aware of digital technology use in geoscience through existing practices | Being offered the time and space for *dialogic planning* | Having the personal *drive* to reflexively position oneself as a learner |
| **Ethan:** A novice II digital technology user unaware of digital technologies for geoscience<br><br>**Isabelle:** A novice I digital technology user unaware of digital technologies for geoscience | Being held professionally accountable to teach subject-specific content and digital skills | Acting on personal *choice* to take pedagogical risks driven by external factors |

Notably expert and apprentice digital technology users seemed to perceive improvements to their practice as they were supported through mentorship and simultaneously afforded the freedom to explore, plan for and skillfully refine their pedagogical practices. Both Charlotte and Rachel's practice appeared to be fueled by a sense of empowerment (Foucault et al., 1988) emanating from job satisfaction and personal learning gains. Novice digital technology users explored distinct pedagogical practices through mentorship and accepted being positioned as part of a group professionals exploring the pedagogical possibilities for digital technology use. However, the extent to which these practices would be sustained seemed to be determined by novice teachers' sense of agency to enact personal choice to utilize some digital technologies over others. Ethan and Isabelle's reflections suggested that their professional growth was

actively being sustained by being held accountable for manipulating digital technologies in similar ways to their colleagues.

For Rachel and Ethan, early-career teachers and former research scientists, both lacked a professional history teaching with digital technologies yet experienced varying extents of change in their personal agency to do so. Rachel was *driven* to take supported risks utilizing digital technologies that she believed students would perceive as unworthy avenues of exploration. Ethan adapted to teaching geoscience with digital technologies, yet he continued to relinquish a duty to teach digital skills when these were not formally assessed.

Diezmann and Watters (2015) draw on Lévi-Strauss (1962) to explain that career-change teachers need to transition from scientist to bricoleur. Rachel and Ethan's experiences seem to be similar to other career-change teachers who experienced internal conflict between their self-perceptions and interaction with the classroom setting (Snyder, Oliveira, & Paska, 2013). Ethan and Rachel's experiences signal the importance of peer-to-peer support to develop a practiced history utilizing digital technologies, recognizing transferrable skills from their research experience and supporting their evolving personal agency to teach for technology-enabled learning. This conclusion supports the work of Price et al. (2019) who call for professional learning, funding and resources to help early career teachers successfully transition from initial teacher education to the classroom.

At the same time, the experiences of Charlotte and Isabelle have shown that this support is also required for experienced in-service teachers who may be teaching OOF not only in science but also across digital technologies. Charlotte was empowered to take risks exploring new pedagogical practices with digital technologies, yet when she did so it became apparent that she required further support to develop students' metacognitive skills as they learned *with* and *through* digital technologies. Isabelle's lack of personal history using digital technologies combined with maintaining an appearance as a competent teacher compromised her sense of oughtness (Linehan & McCarthy, 2000) to draw on external support mechanisms outside trusted collegial relationships. The reflections of these experienced teachers further draw attention to the need for differentiated professional learning experiences.

As important as external and internal strengthening factors are to developing a teachers' sense of self-efficacy (Bandura, 1989), Hobbs and Törner (2019) explain that OOF teachers face challenges that can 'restrict, hinder or work against teacher learning' (pp. 4-5). As an insider-researcher (Mercer, 2007) I aimed to minimize some of these challenges by designing a formal program of digital experiences for students, setting aside time and space for teachers to plan together and offering as-needed technical support. However, Charlotte, Rachel, Ethan and Isabelle's experiences suggested that an unanticipated external factor would be highly likely to compromise their evolving sense of agency to utilize digital technologies in geoscience: disruptive timetabling. Disruptive timetabling occurs when teachers' allotments change from year-to-year preventing them from consistently developing and refining their pedagogical skills by repeatedly teaching year levels or units of work.

The conclusions emerging from investigating teachers' perceptions of participating in a unit of work at the intersection between two areas of the curriculum indicate that perhaps professional learning opportunities may have the most significant impact on both the expert and apprentice digital technology users. Thus, expert and apprentice teachers scaffolded through support mechanisms similar to those offered in this research could possibly be positioned as effective agents of change within their local moral order by re-defining both the subject-specific professional and institutional expectations placed on them to utilize digital technologies.

### 11.3 To what extent do secondary science teachers' perceptions of their agency change as they are supported to teach an out-of-field area of the curriculum with digital technologies?

The rigorous and robust approach to this research has added to the evidence base concerning teachers' professional learning by demonstrating how pedagogical knowledge alongside technological knowledge affects teachers' use of digital technologies in an OOF area. Overall, the extent to which Riverside teachers perceived a change in their sense of agency to teach OOF with digital technologies varied and seemed to be determined by either their personal sense of job satisfaction and/or perceptions of the duties to which they were held professionally accountable. From the outset, science teachers with diverse

technological knowledge were positioned as capable individuals who could continually refine their skills and effectively utilize digital technologies in their classroom practice. Interestingly, these findings draw attention to the needs of both experienced and early-career teachers, in particular those who have entered the teaching profession after careers in scientific research.

Notably, secondary science classroom teachers cannot be grouped as homogeneous users *of* and teachers *with* digital technologies. Teachers' personal and professional capacity and interpretations of their professional rights and duties to utilize digital technologies must be understood for effective, differentiated professional growth to take place. In addition, care needs to be taken to enable and strengthen teachers' capacity to negotiate both subject-specific and institutional expectations for digital technology use. Individuals offering professional learning to teachers must attend to both the external and internal factors that may compromise the extent to which teachers feel a sense of empowerment to carry out their important work. This means avoiding an assumption that capacity across one set of expectations equates to capacity across another set of expectations.

## 11.4 A Model to Scaffold Teacher Agency and Recommendations

There is a wide body of literature offering theories and models to explain and represent teacher change. Chapter two introduced three seminal models of technology adoption including the Theory of Reasoned Action (TRA) (Fishbein & Ajzen, 1975), the Technology Acceptance Model (TAM) (Davis, 1985; Davis et al., 1989) and the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003). The limitations of these models were explored when applied to the context of teaching and learning.

Tondeur, van Braak, et al. (2017) explain that failed attempts of technology incorporation are often due to mismatches between anticipated change and the meanings attached to change by individuals instrumental in change processes. Teachers' decisions to utilize digital technologies are largely influenced by a practicality ethic (Doyle & Ponder, 1977; Janssen et al., 2013) where they acknowledge feasibility and benefits of use within the constraints of classroom practice (Pareja Roblin et al., 2018). Similar conclusions are

also made by Scherer and colleagues (2019) who explain that teachers are more likely to adopt a technology when they perceive it as relevant to supporting subject specific goals. Here, I unpack two models of teacher change drawing on similar constructs as the technology adoption models explored in chapter two, beliefs, attitudes and behavior. Guskey's Model of Teacher Change (1986) and Clarke and Hollingsworth's (2002) Interconnected Model of Professional Growth have been widely cited in the literature and are utilized to reflect on the research findings.

Early models of professional learning propose that changes in knowledge and beliefs lead to changes in classroom practice and finally to change in student learning outcomes. Like earlier models, Guskey's (1986) Model of Teacher Change, presented in Figure 11.3, is linear. However, earlier models that assume change in knowledge and beliefs come first do not lead to strong commitment from teachers because they have not yet experienced changes to student outcomes. Guskey explains that '[t]he crucial point is that it is not the professional [learning] *per se*, but the experience of successful implementation that changes teachers' attitudes and beliefs' (p. 383). This model, however, makes two crucial assumptions that practicing teachers would draw attention to:

1. Teachers experience the professional learning homogeneously and meet the learning outcomes to the same extent; and

2. The institutional setting within which the professional learning is offered has organizational practices and infrastructure in place to support sustained development

Findings from this research indicate that these assumptions cannot be overlooked. Prestridge (2017) calls for deeper understanding of teachers' developmental processes of conceptualizing the relationship between technology and pedagogy. This in-depth analysis of Riverside teachers' experiences sheds light on the social and organizational developmental processes at play as teachers are offered a variety of technologies and pedagogies to explore.

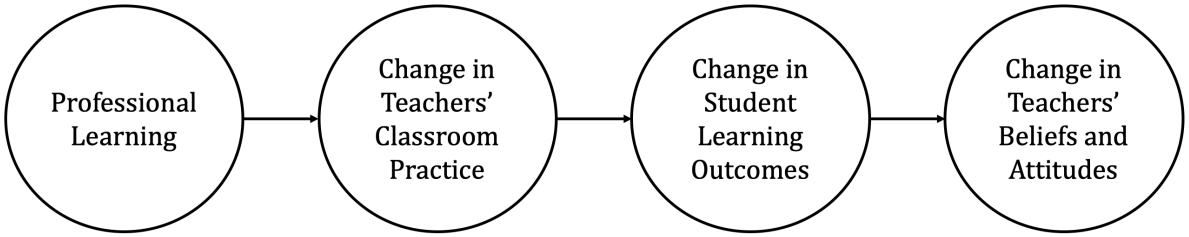



**Figure 11.3: Model for Teacher Change, adapted from Guskey (1986)**

Clarke and Hollingsworth (2002) offer a cyclic model that presents four domains of the teaching landscape and illustrates change as occurring through mediating processes of reflection and enactment. The Interconnected Model of Professional Growth is shown in Figure 11.4. The model acknowledges teachers distinct professional learning experiences and that learning is an iterative process. However, the arrows indicating reflection and enactment from the external domain seem to assume that the source of information or stimulus is not only reflected upon but also enacted. This is problematic when considering professional learning offered from distinct stakeholders. For instance, professional learning 'offered' to teachers in the use of an institutionally mandated digital technology may not be as readily reflected upon and enacted as professional learning for the use of a subject-specific technology that can be used in the classroom. Riverside teachers' reflections on the use of curriculum mapping software and Microsoft OneNote versus Google Earth and Google Drive exemplify these varied responses.

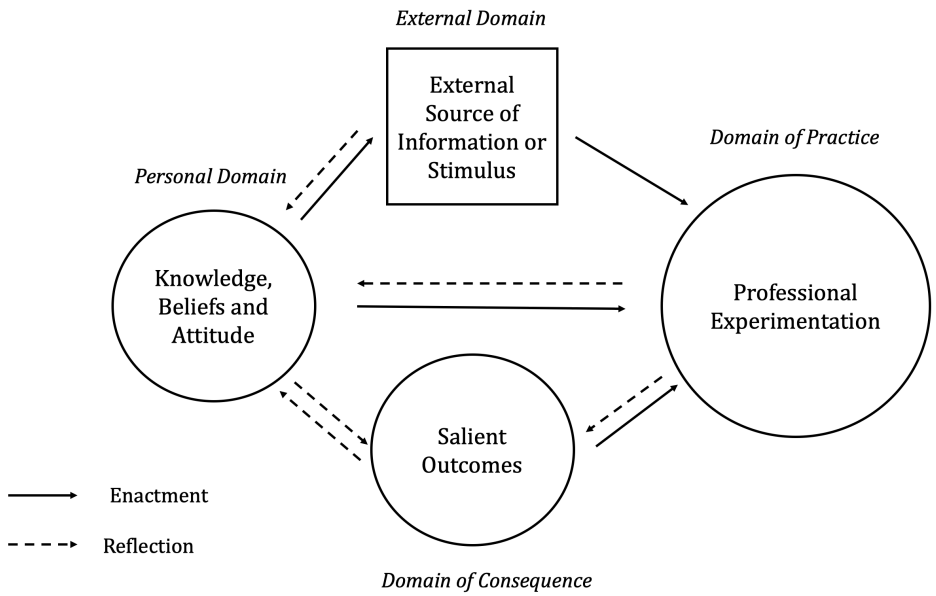



**Figure 11.4: The Interconnected Model of Professional Growth, adapted from Clarke and Hollingsworth (2002)**

Responding to the need for a more nuanced understanding of physical, social and knowledge structures that enable or disable teacher agency (Rivera Maulucci, Brotman, & Fain, 2015), Martin (2020) explains that positioning theory offers theoretical resources to understand teacher professional learning and agency through the analysis of their discursive practices. Here, a rigorous and robust research process has exemplified the fine-grained analytical procedures utilized to better understand the 'relationships that a teacher has to outside influences that come from the broader institutional setting' (Redman & Coyle, 2013, p. 271). Figure 11.5 presents The Explicit Personal Pragmatic Approach (EPPA) to professional learning. This three-dimensional model places teachers at the center of their work as they negotiate the cover, sacred and secret stories (Clandinin & Connelly, 1996) and are supported to understand and reflect on what they are professionally held accountable for and personally able to do.

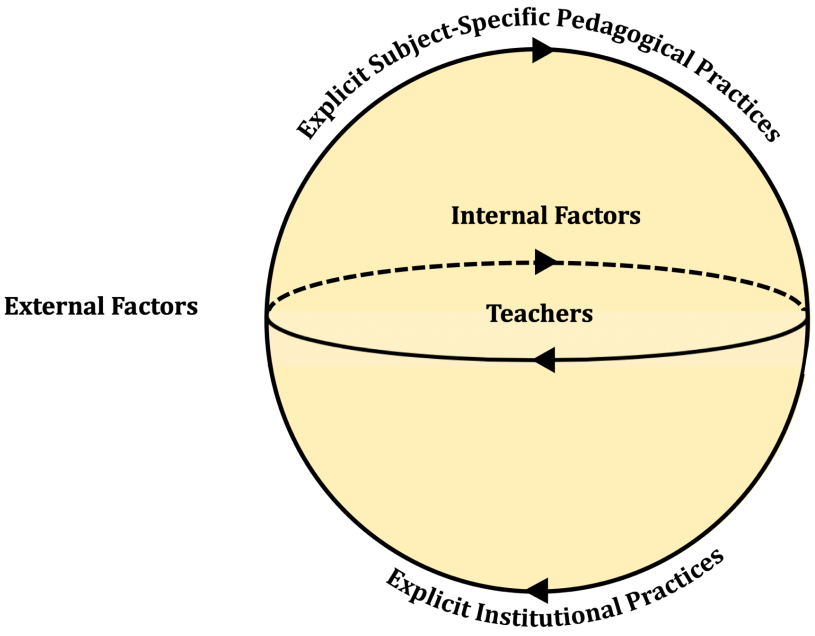



**Figure 11.5: The Explicit Personal Pragmatic Approach to Professional Learning**

The EPPA to professional learning illustrates the types of significant relationships and the need for explicit connections between institutional expectations, the cover story, and subject-specific pedagogical practices, the sacred story, for digital technology use. Of note is that the term 'explicit,' as opposed to visible, has been deliberately chosen. Making practices explicit means providing and offering sign systems to not only scaffold awareness of and connection between institutional and subject-specific pedagogical practices, but also to respect and invest in teachers' capacity as professionals by clearly and actively signaling possibilities for teachers to make professionally informed choices to act. In this way teachers can be afforded distinct opportunities to re-position themselves as increasingly agentic digital technology users.

This means teachers understanding what they are held professionally accountable for in terms of their institutional duties and how attending to them can possibly strengthen their practice. This is a pragmatic approach that could begin with understanding teachers' personal capacities to use digital technologies and demonstrate connection to practice by offering them ongoing training and support. For example, when teachers are expected to utilize a technology for an institutional practice, such as using Microsoft OneNote for

curriculum documentation, teachers could also be supported to make links to how this software could also be utilized in the classroom through the use of Class Notebooks. As they are continuously supported, through organizational practices like dialogic planning, teachers can refine their digital skill sets while attending to the sacred and cover stories.

Of note is that teachers' personal and professional growth across these storylines is an ongoing and dynamic process. Both external and internal factors can, to varying extents, strengthen and/or compromise teachers' sense of agency. They are spatially and temporally located within the context of the social situation and there is an interplay between them as an individual teacher's beliefs and attitudes about her/his rights and duties meet the beliefs and attitudes of administrators, theoreticians, policy makers, students, parents and other teachers. This interplay within the local moral order offers teachers opportunities to fully/partially assume or outright reject the professional duties assigned to them through moment-to-moment re-/positioning of self and others.

Linehan and McCarthy (2000) draw on Lave and Wenger's (1991) legitimate peripheral participation (LPP) to explain the importance of interactive engagement in the community of practice. They argue that as individuals assume distinct positions the moment-to-moment oughtness in prosaic acts can enable understanding of how a participant's 'selfhood emerges and is enacted in particular moments' (Linehan & McCarthy, 2000, p. 452). For these reasons, arrowheads have been added to the diagram to help illustrate the significance of the dynamic space within which teachers work and negotiate their professional identities.

The EPPA offers an original approach to professional learning for the use of digital technologies in an educational context by connecting the cover, sacred and secret stories and highlighting a need for pragmatic approaches to be in place to support teachers to attend to their professional duties. As an insider-researcher (Mercer, 2007), I am aware of an accepted secret story within the teaching profession: ***It's another decree from the ivory tower!*** Without specific strategies explaining how it might be implemented, the EPPA only serves a theoretical purpose. Teaching OOF has been shown to have implications for teacher knowledge and practice (Carlsen, 1992; Crisan & Hobbs, 2019; Kind, 2014; Nixon et al., 2016; Nixon & Luft, 2015; Ríordáin et al., 2019; Sanders et al., 1993), identity formation (Hobbs, 2012, 2013b, 2014; Olitsky, 2007), student outcomes (Porsch & Whannell, 2019),

policy (Productivity Commission, 2017; Vale & Drake, 2019), leadership practices (du Plessis, 2015, 2017; du Plessis et al., 2015; du Plessis et al., 2014; du Plessis et al., 2019), the quality of initial teacher education programs (Coral Campbell et al., 2019; Hobbs & Campbell, 2014) and teacher professional development (du Plessis et al., 2014; Faulkner et al., 2019; Kenny et al., 2019). Thus, the recommendations cited here are relevant to a number of stakeholders beginning at the school wide level:

1. School leadership, including information technology support and those responsible for finance, must work toward offering and sustaining formal programs of digital experiences for students that are informed by subject-specialists;

2. School leadership, theoreticians and policy makers must work toward developing programs what offer teachers sign systems to assess, develop and enact their personal and professional capacity to facilitate these experiences with students;

3. Teachers must be afforded the time and space to meaningfully plan for and enact these experiences together *and* with subject-specialists through support from policy and leadership such that new technologies are implemented in stages;

4. Programs of digital experiences for students should be included as part of teachers' assessment practices and stipulated within school policy;

5. Theoreticians and school leadership should develop and provide differentiated professional learning opportunities for teachers which take into account not only their teaching experience but also their pre-existing skill sets for targeted professional growth; and

6. For these programs to be sustained supportive timetabling practices must be in place for teachers to consistently develop and refine their pedagogical practices

## 11.5 Implications and Future Research Opportunities

This research has utilized positioning theory as a methodology to explore and better understand science teachers' perceptions of their experiences teaching an OOF area of the curriculum alongside digital technologies. The research design and findings offer unique contributions to knowledge in the following areas:

- Research methodology;
- Digital technology use in education and the OOF teaching experience; and
- Understanding the experiences of research scientists transitioning to teaching

### 11.5.1 Contribution to Research Methodology

Positioning theory has been utilized in a variety of education research endeavors to better understand participants' interpretations of the local moral order through fine-grained analysis of discursive practices. For instance, Blannin (2017) studied primary teachers' choices to use digital technologies in the classroom to better understand their inconsistent use despite being available for more than two decades. In mathematics education teachers' positioning of self and students has been found to influence learning more so than classroom resources (Tait-McCutcheon & Loveridge, 2016) and positioning students as *kinds* influences how classroom participation is viewed and valued (Anderson, 2009). In science education positioning theory has been used to examine gender, status and power as students construct circuits (Ritchie, 2002), to better understand metacognitive behaviors as children use digital technologies (Redman & Jones, 2007), to make sense of children's meaning making of Earth and space (Redman, 2004) and molecules (Jakab, 2013). Positioning theory has also been employed to better understand the experiences of educators, including beginning teachers' socialization processes to improve early career experiences (Tan, 2015), the experience of dyslexic tertiary educators' professional identities (Burns & Bell, 2011) and teaching assistants' assertion of their professionalism (Watson, Bayliss, & Pratchett, 2013).

The work cited here is not extensive, yet serves to exemplify the contribution positioning theory has made to education research. At the same time, however, conducting research in education can also contribute to methodological discussions. In chapter three, section 3.8.1, I drew on the work of Herbel-Eisenmann et al. (2015) who call attention to conceptual ambiguities between the terms 'positions/positioning' and 'storylines' highlighting a need for explanation and operationalization of these terms. As such, they have introduced Lemke's (2000) timescales to positioning theory to understand how multiple storylines and positions may influence interactions. Although positioning theorists do not claim that discursive practices are divorced from the history of interactions, the work of these researchers signals the potential for positioning theory to evolve as it is used and adapted for specific contexts.

To better understand the storylines emerging as teachers experience curriculum change this research incorporated Clandinin and Connelly's (1996) cover, sacred and

secret stories to track changes in the storylines unfolding within and beyond the classroom. To my knowledge, utilizing cover, sacred and secret stories as a framework within the positioning triad is a unique contribution to this methodological conversation. Here, this framework offered explanatory power to the analysis of teachers' perceptions of their lived experience as they negotiated their professional duties and personal agency to teach OOF with digital technologies.

### 11.5.2 Contribution to Digital Technology Use and the Out-of-Field Teaching Experience

Ingersoll (2019) explains that although not all instances of teaching OOF are of equal magnitude, understanding them is essential to assessing the 'quality and performance of schools, teachers and students' (p. 27). This research draws attention to the importance of understanding the complex knowledge landscape that teachers navigate. Surprisingly, some teachers were found to be teaching OOF in both geoscience and digital technologies. It demonstrates how the positioning of teachers by the wider community and themselves can affect the ways in which they develop their practice. The findings were used to craft the EPPA, a unique approach to professional learning that contributes to the literature about the use of digital technologies in education and the OOF teaching experience.

The EPPA has potential to contribute to the work of other scholars who have drawn attention to the OOF teaching experience in broad multi-disciplinary subjects (Crisan & Hobbs, 2019; Hobbs, 2015; Hobbs & Törner, 2019; Ingersoll, 1998). Research about teacher knowledge in mathematics, for example, has much in common with the context of science education (Ríordáin et al., 2019) and often literature seems to be directed at both audiences (e.g., Bartos et al., 2014; Hobbs, 2013b; Ingersoll & May, 2012; Mavhunga & Rollnick, 2013; Nixon, Toerien, & Luft, 2019; Tytler, Symington, Darby, Malcolm, & Kirkwood, 2011; Zhou, 2014). As such the EPPA could be applied to other subject areas or professions where workplace professionals are required to continually refine their knowledge and skills in unfamiliar contexts. Future research endeavors might apply the EPPA to similar contexts and/or evaluate the model.

### 11.5.3 Contribution to Understanding the Experiences of Career-Change Teachers

In Australia, theoreticians and policy-makers have drawn attention to the supply of and demand for subject specialists (Masters, 2015; Productivity Commission, 2017; Weldon, 2015; 2016). Recruiting industry professionals to teacher training programs may offer a solution to attend to this need. In his study of six Hong Kong teachers at early stages in their careers, Trent (2018) found that career-change teachers were resourced with valuable competencies from their professional histories, yet they perceived the knowledge and skills specific to education to be acquired only through classroom experience. Of 500 career-change, pre-service teachers, Varadharajan et al. (2018) reported that 65 percent expressed tension between wanting to contribute to the teaching profession and requiring assistance to effectively do so.

Diezmann and Watters (2015) explain that there has been 'limited research on highly qualified professional scientists pursuing a teaching career and how they apply their advanced subject matter knowledge' (p. 1518). Drawing on data from a three-year longitudinal study they present the case of a research scientist entering teaching. This teacher's expertise was found to be 'contextualized to a professional science laboratory and not the realities of a school environment' (p. 1531). Drawing on data from the same study, the experiences of 14 teachers indicated that when challenges faced by this cohort are overlooked, teachers bracket their former professional identities to assume new teacher identities (Watters & Diezmann, 2015). In addition, these teachers may experience feelings of marginalization due to the high expectations placed on them to apply their subject matter knowledge in the classroom (Diezmann & Watters, 2015). Snyder et al. (2013) analyzed multiple sources of qualitative data from four female science, technology, engineering and mathematics (STEM) professionals over three years concluding that successful transitions occur when teachers experience 'science teaching as social rebirth rather than social death' (p. 634).

Unexpectedly five of 10 Riverside teacher participants reported having professional experience in scientific research prior to entering the teaching profession. As such, this research may contribute to the growing body of literature to understand career-change science teachers' transitions to teaching. The findings challenge an assumption that scientific researchers are able to identify and enact duties to intuitively draw on their

transferrable skills from the laboratory and apply them to the classroom, confirming findings from studies of career-change teachers in fields other than science (Diezmann & Watters, 2015; Rowston et al., 2020; Trent, 2018; Varadharajan et al., 2018; Watters & Diezmann, 2015). These findings also point to a need for targeted support to be offered to this unique cohort of teachers specifically at the intersection between the institutional and subject-specific uses of digital technologies.

Support for career-change teachers might begin by exploring teachers' classroom experiences. Rachel and Ethan, for example, were placed at distinct levels along a continuum of digital technology use. These teachers could then be paired with mentors to develop specific pedagogical skillsets. For Rachel, she might be mentored by a more experienced colleague, Charlotte. Together they could engage in dialogic planning and possibly foster a synergy of personal drive to explore and incorporate digital technologies into the classroom with purpose. For Ethan, a novice, he could work as part of a team mentored by leadership to enact professional duties through development of assessment strategies targeted at digital technology use. Future research endeavors into both in- and OOF teaching could work toward identifying further support structures bridging the institutional and subject-specific expectations faced by career-change teachers to re-position them as agentic teachers *of* and *with* digital technologies.

## 11.6 Conclusion

This chapter summarized the research questions and findings which informed the development of the EPPA to professional learning. This model aims to illustrate the dynamic relationships between the internal and external factors affecting teachers' sense of agency to enact the institutional and subject-specific expectations for digital technology use at the intersection of the cover, sacred and secret stories. Grounded in teachers' reflections, recommendations were offered to inform school-wide implementation of digital technology use. This model may not only be of value to the field of educational technology and teacher development for OOF teaching but also to other occupations where professionals are required to continually refine their knowledge and skills in unfamiliar contexts. Other unique contributions to research methodology and understanding the

experiences of career-change teachers were explained. Finally, it is worth noting that the recommendations of this research are especially timely with a rise in the necessity for utilizing digital technologies for learning during a global pandemic. The research offers depth to understanding the complexity of teachers' professional knowledge and has brought into focus the need for teachers to have digital competencies to be able to manage learning at a distance.

*~ The End ~*

# Appendix A: Student Questionnaires I-IV



## Student Questionnaire I

The purpose of this questionnaire is to gather information about how students perceive learning with digital technologies. The questionnaire will take place in class and last no longer than 15 minutes.

* Required

1. **Over the past few lessons, you have explored geoscience concepts in different ways. This questionnaire asks you to reflect on your experiences. Please read the questions carefully. There are no right or wrong answers. Your responses will help researchers understand your experiences and provide advice to teachers. If there are some questions you choose not to answer that's fine.** *

*Check all that apply.*

- [ ] I understand and choose to proceed to the questions.

2. **List 3 surprising things you learned this week in science?** *

3. **How did you learn them?** *

4. **The classroom environment in science generally allowed me to get on with my work.** *
*Mark only one oval.*

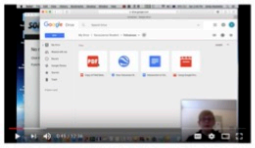
| | 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|
| Strongly disagree | ◯ | ◯ | ◯ | ◯ | Strongly agree |

5. **I believe that it is more important to remember facts about the Earth than to analyse data to understand geological processes.**
*Mark only one oval.*

| | 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|
| Strongly disagree | ◯ | ◯ | ◯ | ◯ | Strongly agree |

## These were the digital technologies you may have been using over the past few lessons.

- Videos including
  - TED talks
  - Instructional videos made by a teacher
- Socrative quiz
- Google Drive
- Google Docs
- Web browsers
- PowerPoint
  - Used by the teacher
  - In the Geoscience Student folder
- Podcast from the Smithsonian



6. **The digital technologies I used helped me to understand geoscience.** *
*Mark only one oval.*

| | 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|
| Strongly disagree | ◯ | ◯ | ◯ | ◯ | Strongly agree |

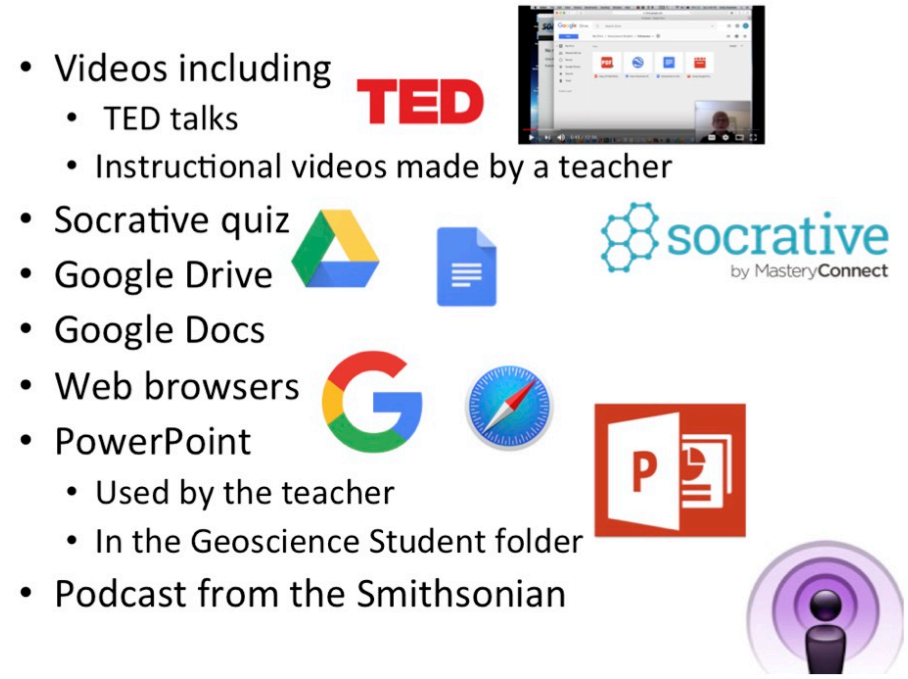
7. **Would you like to explain why?**

8. **Please rank the following in order of most (4) to least (1) helpful in your learning of geoscience this week:** *
*Mark only one oval per row.*

| | 4 | 3 | 2 | 1 |
|---|---|---|---|---|
| Teacher | ◯ | ◯ | ◯ | ◯ |
| Friends | ◯ | ◯ | ◯ | ◯ |
| Textbook | ◯ | ◯ | ◯ | ◯ |
| Digital Technologies | ◯ | ◯ | ◯ | ◯ |

9. **Can you explain how you came to the conclusion above or tell us about something that helped you but was not mentioned in the list?**

**These were the digital technologies you may have been using over the past few lessons.**




10. **Which of the above technologies helped you the most to remember and understand facts about geoscience and geological time?** *

11. **Which of the above technologies helped you the most to analyse and explain ideas about geological time?** *

12. **Which of the above technologies helped you the most to predict or judge the effects of geological time?** *

13. **Which of the above technologies helped you to challenge your assumptions or discuss ideas about geological time?** *

14. **Which of the above technologies helped you to hypothesise about geological time?** *

15. **If you like, you can explain your responses here.**

16. **If there was a technology that was not mentioned and you believe helped your thinking, could tell us about it?**

17. **Which technologies, if any, were similar to others you've used but allowed you to do something new? For example: I used Microsoft word to write a prac report. I could've written it in my notebook, but I was glad to have spell check!**

18. **Were there any technologies that you didn't really need to use because, for example, you could have done the same thing with a pen and paper?**

19. **From your experience, could you suggest any digital technologies you would like to see brought into geoscience? Why?**

20. **I _____ using digital technologies in science class. Tick the response that best describes you.** *

*Mark only one oval.*

- ◯ am becoming more open to
- ◯ have no opinion about
- ◯ am becoming less open to

21. **Would you like to make an additional comment?**

**That's the end of the questionnaire! Thank you for being part of the research!**

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# Appendix B: STAV Conference Attendee Questionnaire



## Experienced Teachers: Questionnaire

Plain Language Statement: Experienced Teacher at the STAV Conference

"Empowering women in Geology: Student and teacher perspectives on the use of interactive digital technologies in the Science classroom"

Dear Teacher,

You are invited to participate in the above research project being conducted by Dr. Christine Redman (supervisor), Dr. Paul Chandler (supervisor) and Ms. Emily Rochette (PhD student) from the Melbourne Graduate School of Education at The University of Melbourne. You have been selected to participate in this stage of the research due to your experience teaching secondary school Science. The Human Research Ethics Committee and the Department of Education and Training have approved this project.

This study aims to unpack and theorize female secondary students' experiences and understand how they are satisfying task demands using digital technologies in Earth Science. Should you agree to participate, you would be asked to contribute by completing an online questionnaire regarding your experience with digital technologies in Earth Science. This will take no longer than five minutes. This data will give the researchers a picture of some current practices in place in Earth Science classrooms and inform the second part of the study.

We intend to protect your anonymity and the confidentiality of your responses to the fullest possible extent, within the limits of the law. You do not need to submit your name or contact details and thus it is unlikely anyone will be able to identify you based on your responses. Any references to personal information that might allow someone to infer your identity will be removed.

Data collected for this research will be kept on a password-protected computer and all hard copies will be locked at The Melbourne Graduate School of Education. This data may be presented at conferences, in journal articles and books and will be kept for at least five years or until it is no longer generating academic discussion. At which time, it will be destroyed under supervision.

Please be advised that your participation in this study is voluntary. However since this questionnaire is completed online with no record being kept of participant details, withdrawing data is not an option.

The risk of participating, inconvenience due to time sought to respond to this survey, is minor and offset by the benefits of this research. If you would like to participate, please indicate you have read and understood this information by continuing with this survey. By continuing with the survey, it is assumed you have given consent.

If you have any concerns or require further information about this study, please do not hesitate to contact any of the researchers using the information given below. If you have any concerns about the conduct of the project you are welcome to contact the Executive Officer, Human Research Ethics, The University of Melbourne by phone: 8344 2073 or fax: 9347 6739.

Sincerely,

Dr. Christine Redman (Supervisor)
Phone: (03) 834 8555
email: redmanc@unimelb.edu.au

Emily Rochette (PhD Student)
Phone: 0420598272
email: rochette@student.unimelb.edu.au

Dr. Paul Chandler (Supervisor)
Phone: (03) 9953 3271
email: paul.chandler@acu.edu.au

* Required

1. **I identify as:** *
   *Mark only one oval.*
   - ◯ Male
   - ◯ Female
   - ◯ Other

2. **I have been teaching for _____ years.** *

3. **The majority of my career has been spent teaching in government schools.** *
   *Mark only one oval.*
   - ◯ True
   - ◯ False

4. **The majority of my career has been spent teaching in _____ .** *
*Mark only one oval.*

- ◯ coeducational schools
- ◯ single sex female schools
- ◯ single sex male schools

5. **The main reason I am attending the STAV conference is...** *
*Check all that apply.*

- ☐ To learn more about pedagogical practices in science
- ☐ To learn more about science content in a particular area
- ☐ To deliver a workshop
- ☐ Because I was asked to attend
- ☐ Other: _____

6. **An area of science I would like to receive more professional development in is:** *

_____

_____

_____

_____

_____

7. **I use digital technologies to teach science content.** *
*Mark only one oval.*

- ◯ Every day
- ◯ A few times a week
- ◯ A few times a month
- ◯ Rarely

8. **Would you like to share an example of this?**

_____

_____

_____

_____

_____

14. **When teaching geoscience concepts, what are some practices that have worked for you and your students?** *

15. **I believe geoscience is important for all students to learn.** *
*Mark only one oval.*

| | 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|
| Strongly Disagree | ◯ | ◯ | ◯ | ◯ | Strongly Agree |

16. **If you would like to comment, please do so here:**

17. **It's important for students to be able to remember facts about the Earth.** *
*Mark only one oval.*

| | 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|
| Strongly Disagree | ◯ | ◯ | ◯ | ◯ | Strongly Agree |

18. **It's important for students to be able to apply knowledge of geological processes.** *
*Mark only one oval.*

| | 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|
| Strongly Disagree | ◯ | ◯ | ◯ | ◯ | Strongly Agree |

19. **Digital technologies are necessary for teaching geoscience.** *
*Mark only one oval.*

| | 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|
| Strongly Disagree | ◯ | ◯ | ◯ | ◯ | Strongly Agree |

9. **I use digital technologies to teach science skills.** *
*Mark only one oval.*

- ◯ Every day
- ◯ A few times a week
- ◯ A few times a month
- ◯ Rarely

10. **Would you like to share an example of this?**

_____

_____

_____

_____

_____

11. **In my science class(es), digital technologies are mostly used to:** *
*Check all that apply.*

- ☐ Replace another technology with no improvement in mind
- ☐ Substitute another technology with some improvement in mind
- ☐ To help students redesign ideas
- ☐ To help students create new ideas

12. **I have studied geoscience at the following levels (choose all that apply):** *
*Check all that apply.*

- ☐ Year 7-10 Science
- ☐ VCE or equivalent
- ☐ Undergraduate
- ☐ Graduate
- ☐ Postgraduate
- ☐ Never
- ☐ Other: _____

13. **My school offers topics in geoscience at the following year levels:** *
*Check all that apply.*

- ☐ Earth's resources at Year 7
- ☐ Rocks, minerals, timescales at Year 8
- ☐ Plate tectonics, global patterns of geological activity at Year 9
- ☐ Global systems (biosphere/lithosphere/hydrosphere/atmosphere) at Year 10
- ☐ We do not offer Geology topics
- ☐ Other: _____

20. **If you would like to comment, please do so here:**

21. **Digital technologies are necessary for learning geoscience.** *
*Mark only one oval.*

| | 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|
| Strongly Disagree | ◯ | ◯ | ◯ | ◯ | Strongly Agree |

22. **If you would like to comment, please do so here:**

**Thank you for completing this survey. Have a nice day.**

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# Appendix C: Ethics Approval Letters

**From:** <themisPROD-noreply@unimelb.edu.au>
**Date:** 27 April 2016 at 1:00:50 PM AEST
**To:** <emily.rochette@mgc.vic.edu.au>
**Subject: Ethics Application 1543885**

Dear Dr Redman

I am pleased to advise that the Humanities and Applied Sciences Human Ethics Sub-Committee has approved the following Project:

Project Title: Empowering women in Geology: Student and teacher perspectives on the use of interactive web-based technologies in the science classroom
Researchers: Dr C Redman, Dr. P Chandler, E Rochette
Ethics ID: 1543885

The Project has been approved for the period: 27-Apr-2016 to 31-Dec-2016

A signed letter confirming this approval will be forwarded to you shortly.

It is your responsibility to ensure that all people associated with the Project are made aware of what has actually been approved.

Research projects are normally approved to 31 December of the year of approval. Projects may be renewed yearly for up to a total of five years upon receipt of a satisfactory annual report. If a project is to continue beyond five years a new application will normally need to be submitted.

Please note that the following conditions apply to your approval. Failure to abide by these conditions may result in suspension or discontinuation of approval and/or disciplinary action.

(a) Limit of Approval: Approval is limited strictly to the research as submitted in your Project application.

(b) Variation to Project: Any subsequent variations or modifications you might wish to make to the Project must be notified formally to the Human Ethics Sub-Committee for further consideration and approval. If the Sub-Committee considers that the proposed changes are significant, you may be required to submit a new application for approval of the revised Project.

(c) Incidents or adverse effects: Researchers must report immediately to the Sub-Committee anything which might affect the ethical acceptance of the protocol including adverse effects on participants or unforeseen events that might affect continued ethical acceptability of the Project. Failure to do so may result in suspension or cancellation of approval.

(d) Monitoring: All projects are subject to monitoring at any time by the Human Research Ethics Committee.

(e) Annual Report: Please be aware that the Human Research Ethics Committee requires that researchers submit an annual report on each of their projects at the end of the year, or at the conclusion of a project if it continues for less than this time. Failure to submit an annual report will mean that ethics approval will lapse.

(f) Auditing: All projects may be subject to audit by members of the Sub-Committee.

If you have any queries on these matters, or require additional information, please contact me using the details below.

Please quote the ethics ID number and the title of the Project in any future correspondence.

On behalf of the Sub-Committee I wish you well in your research.

Ms Jennifer Hassell
Secretary, Humanities and Applied Sciences HESC
Phone: 90353341, Email: hassell@unimelb.edu.au

Department of
Education & Training
Strategy & Review Group

2 Treasury Place
East Melbourne Victoria 3002
Telephone: 03 9637 2000
DX210083

2015_002855

Emily Rochette
Melbourne Graduate School of Education
The University of Melbourne
12/7 Manningham Street
PARKVILLE 3052

Dear Miss Rochette

Thank you for your application of 31 August 2015 in which you request permission to conduct research in Victorian government schools titled *Empowering women in Geology: Student perspectives on the use of interactive web-based technologies in the Science classroom.*

I am pleased to advise that on the basis of the information you have provided your research proposal is approved in principle subject to the conditions detailed below.

1. The research is conducted in accordance with the final documentation you provided to the Department of Education and Training.

2. Separate approval for the research needs to be sought from school principals. This is to be supported by the Department of Education and Training approved documentation and, if applicable, the letter of approval from a relevant and formally constituted Human Research Ethics Committee.

3. The project is commenced within 12 months of this approval letter and any extensions or variations to your study, including those requested by an ethics committee must be submitted to the Department of Education and Training for its consideration before you proceed.

4. As a matter of courtesy, you advise the relevant Regional Director of the schools or governing body of the early childhood settings that you intend to approach. An outline of your research and a copy of this letter should be provided to the Regional Director or governing body.

5. You acknowledge the support of the Department of Education Training in any publications arising from the research.

6. The Research Agreement conditions, which include the reporting requirements at the conclusion of your study, are upheld. A reminder will be sent for reports not submitted by the study's indicative completion date.

Your details will be dealt with in accordance with the *Public Records Act 1973* and the *Privacy and Data Protection Act 2014*. Should you have any queries or wish to gain access to your personal information held by this department please contact our Privacy Officer at the above address.

VICTORIA
State Government

I wish you well with your research. Should you have further questions on this matter, please contact Youla Michaels, Project Support Officer, Insights and Evidence Branch, by telephone on (03) 9637 2707 or by email at michaels.youla.y@edumail.vic.gov.au.

Yours sincerely

Megan Kerr
Manager
Strategic Evaluation and Evidence

5/10/2015

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State Government

# Appendix D: Examples of Plain Language Statement and Consent Form

University Logo

**Plain Language Statement: Class Participation Teacher**

**"Empowering women in Geology: Student and teacher perspectives on the use of interactive digital technologies in the Science classroom"**

Dear Teacher,

You have already participated in the above research project and we thank you for your contribution. The next phase of this research is being conducted by the same researchers from The Melbourne Graduate School of Education at The University of Melbourne: Dr. Christine Redman (supervisor), Dr. Paul Chandler (supervisor) and Ms. Emily Rochette (PhD student). The Human Research Ethics Committee and the Department of Education and Training have approved this project.

This study aims generate a theory from female secondary students' experiences and understand how they are satisfying task demands using digital technologies in Earth Science. At this stage, the study aims to understand students' and teachers' assessments and perceptions of learning activities utilising digital technologies. Should you agree to participate, you would be asked to contribute in the following ways:

- To collaborate with Emily Rochette during your faculty's regularly scheduled planning time to integrate activities utilising technologies to address the AusVels standards of Earth Science at the level suitable to your class. If required, you will receive professional learning in the agreed upon technologies. These may include Google Earth, the educational social networking site Edmodo, search engines and simulations.
- To volunteer your Year 9 class to undertake these activities during your Earth Science Unit. Emily Rochette will observe the class and offer any technical support while the activities are running. For example, some students will be audio-visually recorded using a computer provided by the researcher.
- To participate in at most five interviews over the course of the unit of work. These will be audio recorded, completed at the school and are estimated to take 30 minutes each.
- To verify any interview transcripts. This may take place during following interviews or via email and are anticipated to take no more than an additional 30 minutes.

Your total time commitment for this stage of the study would be at most three hours outside of class.

We intend to protect your anonymity and the confidentiality of your responses to the fullest possible extent, within the limits of the law. Your name and contact details will be kept in a password-protected computer file separate from any data you supply. Your details will only be linked to your responses by the researchers, for example, to know where to send interview transcripts for verification. Any audio-visual recordings taken within your classroom will not be used publically; they will be destroyed after five years. In the final report you will be referred to by a pseudonym and any references to personal information that might allow someone to infer your identity will be removed. We are seeking approximately two teachers to participate in this phase



**Melbourne Graduate School of Education**
The University of Melbourne Victoria 3010 Australia
**T:** +61 3 8344 8285 **F:** +61 3 8344 8529 **W:** www.edfac.unimelb.edu.au

of the research and since the sample size is small, it may be possible that someone may still be able to identify you.

Data collected for this research will be kept on a password-protected computer and all hard copies will be locked at The Melbourne Graduate School of Education. This data will be kept for at least five years or until it is no longer generating academic discussion. At which time, it will be destroyed under supervision.

When the thesis arising from this research is completed, a brief summary of the key findings can be made available to you. Furthermore, data from this study may be presented at conferences, in journal articles and books.

Please be advised that your participation in this study is voluntary. Should you wish to withdraw at any stage or withdraw any unprocessed data you have supplied, you are free to do so without explanation or prejudice.

The risks of participating are minor and offset by the benefits of this research. They include potential discomfort due to audio-visually recording or prior relationships between the student researcher and inconveniences due to time commitment. Protocols have been outlined to minimize these risks. If you would like to participate, please indicate you have read and understood this information by signing the accompanying consent form and returning it to Emily Rochette. The researchers will then contact you to arrange a mutually convenient time for the planning and professional learning session.

If you have any concerns or require further information about this study, please do not hesitate to contact any of the researchers using the information given below. If you have any concerns about the conduct of the project you are welcome to contact the Executive Officer, Human Research Ethics, The University of Melbourne by phone: 8344 2073 or fax: 9347 6739.

Sincerely,

**Dr. Christine Redman (Supervisor)**
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**Consent Form: Class Participation Teacher**

University Logo

**Project Title: Empowering women in Geology: Student and teacher perspectives on the use of interactive digital technologies in the Science classroom**

**Name of participant (please print in block letters): _____**

**Name of researcher(s): Emily Rochette, Dr. Christine Redman, Dr. Paul Chandler**

1. I consent to participate in the project named above. I have read and understood the *Plain Language Statement: Class Participation Teacher*. My role in working with the researcher to integrate digital technologies into the Earth Science Unit and professional learning surrounding this have been explained to me. My participation in the delivery of these activities, including audio-visual recording of participating students and follow up audio-recorded interviews has also been explained to my satisfaction. A written copy of the information has been given to me to keep.

2. I understand this project is for research purposes and has been approved by the Human Research Ethics Committee and the Department of Education and Training. I authorise the researcher to use the audio recordings of interviews and audio-visual recordings made during class referred to above for this purpose.

3. I acknowledge that:

    a. The possible effects of participating in planning and delivery of Earth Science concepts using digital technologies, professional learning and audio-recorded interviews have been explained to my satisfaction
    b. I have been informed that I am free to withdraw from the project at any time without explanation or prejudice and to withdraw any unprocessed data previously supplied
    c. The project is for the purpose of research
    d. I have been informed that the confidentiality of the information I provide will be safeguarded subject to any legal requirements
    e. Due to the small sample size, there is a possibility that I may be identified
    f. Data will be will be stored on a password-protected computer and all hard copies locked at The Melbourne Graduate School of Education
    g. Data will be retained for at least five years or until it is no longer generating academic discussion after which it will be destroyed under supervision
    h. Knowledge generated from this data will be published as a PhD thesis and may be presented in journals, books and at conferences
    i. Once signed and returned this Consent Form will be retained by Emily Rochette (PhD student)

**Signature (participant): _____ Date: _____**

**HREC:** 1543885.1; **Date:** 2/05/16; **Version:** 1.1

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# Appendix E: Two Examples of Lesson Plans Offered to Teachers

## Lesson 4: Introduction to Volcanos and Catch Up

Learning Intentions:
- To develop observation skills which enable geoscientists to understand how the present tells the story of the past.

Success Criteria:
- To articulate observations about 2 volcanos in Victoria using Google Earth tools
- To articulate how observations can help geoscientists understand volcanic activity

1) Begin the lesson with some homework catchup. The files with the answers to homework activities are in this lesson plan's folder. You might want to start with the activity from Lesson 1: Introduction to Geoscience. You could project the answers on the board and ask students to correct their work, alt + v will give them a √. For Lesson 2-3 homework, the podcast or the TED Talk, you could ask some students to share their answers orally, with others writing their peers' thoughts on the whiteboard. You could project the correct responses on the board and draw students' attention to areas of success/improvement. I suggest spending no longer than 25 minutes on this activity.

2) Before students move on to the Introduction to Volcanos activity, it will be necessary to stress that geoscientists often rely on observation. Geoscience is distinct from other sciences like chemistry and physics because it is difficult if not impossible to perform controlled experiments when studying processes that take millions, if not billions, of years to occur.

   Today students will start developing their geoscientific observation skills and take some measurements in Google Earth. In the following lessons, they will develop their Google Earth skills further.

   Here are some things to consider before teaching the lesson:

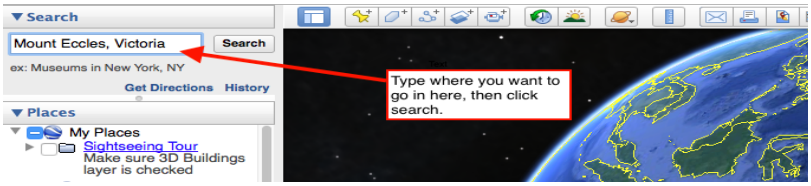
   1. Students will need to copy the file *Introduction to Volcanos and Observation* from the *Geoscience Student* folder. They will be working from this and editing it.

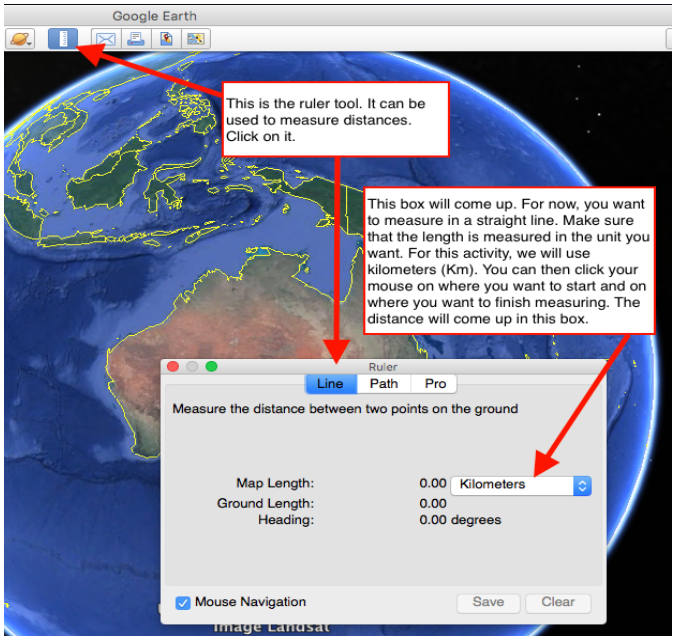
   2. You will need to have Google Earth downloaded to your device before the lesson, students should also have this completed. Here is the link for the download: https://www.google.com/earth/download/ge/agree.html

3. You will need to make sure students have some skills to utilize Google Earth, here are a list with pictures if necessary:

   a. Taking a screenshot:
      - **Mac users:** shift + command + 4, take the shot and it will appear on the desktop, you can drag it into the file you are using
      - **PC users:** in Start search for *snipping tool*, take a snip and save to the desktop, you can then drag it into the file you are using

   b. Using Google Earth: Use these tools to change the orientation, zoom in/out.




You may want to project these instructions onto the board for students to refer to while they are working.

You could take up the answers as students work through the activity or next class. The answers are in the folder for this lesson plan.

3) Homework: Students complete the activity

## Lesson 7: Introduction to Earthquakes

Learning Intentions:
- To revise and understand earthquake hazards through discussion and observation

Success Criteria:
- To use subject-specific language to describe earthquake hazards including hypocenter (focus), epicenter, magnitude and intensity
- To be able to make claims, gather evidence and state your reasoning about where the safest place to be is and/or what happens in an earthquake either in San Francisco, Shanxi or the Indian Ocean

1) Begin with this hook: https://www.youtube.com/watch?v=dPEpSX08K_Q

   What does this video show? How do volume and pitch convey the magnitude and depth of earthquakes?

2) Use the PowerPoint presentation called *Introduction to Earthquakes*. This presentation is intended to help you understand what students already know about earthquakes. It also offers information that will extend their knowledge and be of use to help them make conclusions about earthquake prone areas of the Earth.

   The first slide should be used for classroom discussion. Try to get everyone to share something about their knowledge/experience with earthquakes. You might want to preview the slide first to have a strategy in place for how you will encourage students who tend to participate less during class.

   Next, let's look at some of the effects that earthquakes have on land. Use the TEDEd link: http://ed.ted.com/on/xf6DdXrh. Watch the video, there are some questions about the video on the next few slides of the PowerPoint.

   Continue with the PowerPoint. Students should write definitions for the hypocenter (focus), epicenter, magnitude and intensity in their notes. They could take screenshots of the board or include pictures from their own drawings or Internet searches to complement their notes.

3) Students will spend the rest of the lesson completing **1 folder** from the Earthquake Hazard Google Earth curriculum. Students will explore: Folder 2: Shaanxi, China or Folder 3: San Francisco, California or Folder 4: East Indian Ocean. Groups of students will learn about some of the hazards of earthquakes by collecting data and making conclusions based on this data.

Students should download the *Earthquake Hazards* file in the *Geoscience Student* folder. You may want to direct them to the Google Earth video tutorials I have made.

Please photocopy the Student Worksheets in this lesson plan. Each student should only receive only the pages for 1 of the folders. There will not be enough time for more. Students may work with their own computer or in pairs but must have their own set of observations.

The solutions can be found in the Teacher Field Notebook file. This is password protected. The password is: **********

Students can scan their worksheets on the photocopier as they did in the last lesson.

4) After completing their folder, students share what they've learned on a Padlet link. The Padlet addresses for each class follow. I suggest putting this into your Compass lesson plan for the students to access. Please ensure that your class has the link assigned to you.

5) Homework: If time does not permit students to complete the Padlet exercise, they can do this as homework. Students should understand that earthquake hazards vary based on the amount of energy released, the rock beneath the ground and the geography of the surrounding area.

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