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Consolidating concepts of technology education

From rhetoric towards a potential reality

ANDREW DOYLE

KTH ROYAL INSTITUTE OF TECHNOLOGY
SCHOOL OF INDUSTRIAL ENGINEERING AND MANAGEMENT

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From rhetoric towards a potential reality

Andrew Doyle

Doctoral thesis
Department of Learning in Engineering Sciences
School of Industrial Engineering and Management
KTH Royal Institute of Technology
Stockholm, Sweden

Completed under the supervision of
Dr Lena Gumaelius, KTH Royal Institute of Technology
Dr Niall Seery, Athlone Institute of Technology
Dr Donal Canty, University of Limerick
Dr Eva Hartell, KTH Royal Institute of Technology

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Abstract

The thesis focuses on the relationship between international rhetoric and classroom realities in technology education. For some time there has been widespread recognition that the intended goals for learning in the subject area have failed to manifest in enacted practices as envisioned. As the intermediary between rhetoric and reality, the technology teachers and ways of understanding their enacted practices are the focus of this work.

The thesis is based on four research articles which adopt theoretical and empirical approaches to investigating the technology teacher as mediator of enacted practice. In Article I, technology education in the Irish national context is investigated through technology teachers' reflections on enacted practice. In response to a variety of situational- and systemic- factors which impede classroom practice being identified, Article II and III theorise approaches to investigating enacted practice in technology. In acknowledging the epistemological basis of technology as depicted in the extant literature, a reconceptualisation of how to utilise pedagogical content knowledge research in explaining enacted practice is put forward. Article IV returns to the technology teacher in a transnational context, whereby teachers from the Republic of Ireland, Sweden and New Zealand are interviewed in constructing a grounded theory of teachers' purposes for teaching technology.

The contributions of the research are twofold. Firstly, following the identification of evidence to support the existence of rhetoric-reality tensions in technology education, an ecologically situated framework of enacted practice is put forward. The framework acknowledges how subject matter is treated in technology education in striving for more comprehensive ways of investigating enacted practice. Secondly, in taking a preliminary step toward understanding enacted practices, a grounded theory of teachers' purposes for teaching technology is put forward. This grounded theory offers a unified model for articulating the purposes of teaching technology that prevail in classroom realities today.

Keywords: Technology education; enacted practice; Pedagogical Content Knowledge (PCK); teacher conceptions; and; Nature of Technology.

Sammfattning

Den här avhandlingen handlar om hur diskursen iteknikundervisning förhåller sig till den undervisning som bedrivs i klassrummet i en internationell kontext. Det är känt sedan tidigare att de mål som återfinns i styrdokument för teknikundervisning till stor del inte uppfylls genom rådande klassrumspraktik. I syfte att förstå bakgrunden till denna diskrepans fokuserar det här arbetet på lärarens roll i teknikundervisningen. Läraren betraktas här som den mellanhand som omvandlar retoriken till undervisningspraktik.

Avhandlingen bygger på fyra forskningsartiklar som använder både teoretiska och empiriska angreppsätt för att undersöka teknikläraren roll som förmedlare av kunskap i teknikämnet. Artikel I undersöker teknikundervisning i en irländsk kontext genom att analysera teknikläraranas reflektioner över sin praktik i klassrummet. Studien identifierar flera faktorer som påverkar klassrumspraktiken. Artikel II och III bygger vidare på det resultat som framkom i studie I genom att teoretiskt resonera kring lämpliga metoder för att undersöka teknikämnets klassrumspraktik.

Genom att använda den epistemologiska utgångspunkt för teknikundervisning som speglas i litteraturen, så utformades ett nytt sätt för att använda PCK (Pedagogical Content Knowledge, ett etablerat ramverk som beskriver lärarens kompetens) som förklaringsmodell för att beskriva klassrumspraktik. Artikel IV återvänder i en empirisk studie till teknikläraranas roll men denna gång med ett transnationellt perspektiv i syfte att arbeta fram en grundläggande teori om lärares mål och syften med teknikundervisning. Studien bygger på intervjuer med lärare från Irland, Sverige och Nya Zealand

Resultatet i denna avhandling bidrar med kunskap på två sätt
För det första, efter att ha identifierat faktorer som stärker tidigare belägg att det finns spänningar mellan målen beskrivna i styrdokumenten och klassrumspraktiken, så togs det fram ett teoretiskt ramverk för forskningsstudier om teknikundervisning. Ramverket utgör en modell som på ett nytt sätt beskriver förhållandet mellan de faktorer som påverkar klassrumsundervisningen. Modellen ger möjligheter att på ett mer omfattande sätt än tidigare studera och förstå klassrumsundervisningen utifrån lärarens perspektiv. För det andra, som ett första steg mot att förstå den rådande undervisningspraktiken presenteras en grundläggande teori kring lärares syften med undervisning i teknik. Denna grundläggande teori erbjuder en sammanhållen modell för att formulera, lyfta fram och tydliggöra syften med att undervisa teknik i den verklighet som råder i klassrummen idag.

List of contributions

This thesis is based on the following articles*:

I. Doyle, A., Seery, N., Canty, D., & Buckley, J. (2019). Agendas, influences, and capability: Perspectives on practice in design and technology education. *International Journal of Technology and Design Education, 29*(1), 143–159. https://doi.org/10.1007/s10798-017-9433-0

II. Doyle, A., Seery, N., Gumaelius, L., Canty, D., & Hartell, E. (2019). Reconceptualising PCK research in D&T education: proposing a methodological framework to investigate enacted practice. *International Journal of Technology and Design Education, 29*(3), 473–491. https://doi.org/10.1007/s10798-018-9456-1

III. Doyle, A., Seery, N., & Gumaelius, L. (2019). Operationalising pedagogical content knowledge research in technology education: Considerations for methodological approaches to exploring enacted practice. *British Educational Research Journal, 45*(4), 755-769. https://doi.org/10.1002/berj.3524

IV. Doyle, A., Seery, N., Gumaelius, L., Canty, D., & Hartell, E. Subject(s) matter: A grounded theory of technology teachers' conceptions of the purpose of teaching technology (submitted manuscript)

*Articles are not included in the electronic version of this thesis.

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Andrew Doyle
15th April 2020, Stockholm

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List of abbreviations

CM	Consensus Model (of PCK, Gess-Newsome and Carlson 2013)
CoRe	Content Representation
GT	Grounded Theory
PCK	Pedagogical Content Knowledge
PCKg	Pedagogical Content Knowing
PCK&S	Pedagogical Content Knowledge and Skill
STEM	Science, Technology Engineering, and Mathematics
STS	Science and Technology Studies
TCoRes	Technology Education Content Representation
TPKB	Teacher Professional Knowledge Base
TSPK	Topic Specific Professional Knowledge

1. INTRODUCTION

1.1. Context and research questions

Technology education is a relative newcomer to second-level education curricula internationally. Since its inception in the late 1970s and early 1980s, the subject is recognised as having held a somewhat precarious position in schools. A lack of congruence in understanding what technology education is (Dakers, 2018), and how to articulate goals for learning in the subject area appear central to its 'fragile position' in curricula (Jones et al., 2013, p. 203). This thesis seeks to explore the relationship between enacted practices, as represented by the technology teacher, and the rhetoric regarding goals for technology, as described by the international research community. Often considered as a disparity between rhetoric and reality (Banks & Barlex, 1999; Kimbell, 2006; Spendlove, 2012), closing this gap appears to be a perennial challenge for the subject area. As the mediators between goals for learning and enacted practices, understanding the role of the technology teacher, and ways of investigating teachers' practices, are the focal points of this thesis.

The difficulties with articulating goals for learning in technology education are evidenced by the multitude of philosophical and empirical investigations to this end. In the place of consensually agreed goals, a number of broad conceptual terms have come to the fore that are commonly used to describe intentions for learning. Constructs such as technological capability, technological literacy, technological competence, technological perspective and technacy, to name but a few, are commonly referenced within the literature and policy documents. These terms are often held up as the panacea for engagement with technology education. Although this approach to conceptualising a subject may appear unintuitive, it is often celebrated as a unique advantage of technology education. In affording the technology teacher the autonomy to take ownership of curricular materials, they can subsequently direct learning to areas that are of interest to their cultural or historical context (McLain et al., 2019), or to their students' interests (Spendlove, 2012). An important point of note is that the level of variance in technology education practice is thus increased, as the role of the individual teacher is amplified through the increased levels of autonomy in the interpretation and contextualisation of these higher constructs.

Despite efforts towards the articulation of goals for technology education, the subject area has struggled to hold and maintain a consistent place in many curricula (Wright et al., 2018). With the associated variability of technology education practices brought about through conceptually oriented goals, investigating enacted practices becomes more complicated. Thus, this thesis explores ways of moving towards a more coherent theory of practice, through investigating the technology teacher as mediator of enacted practice, and theorising different approaches to investigating enacted practice in technology education. Specifically, this research set out to answer the following questions:

1. How do technology teachers describe their enacted practices relative to the more general aims of technology education?
2. How can teachers' enactment of technology education be investigated?
3. How do technology teachers represent the purpose of teaching technology through reflection on their enacted practices?

1.2. Document outline

Based on the stated context and research questions, this document seeks to briefly describe and synthesise the work presented in the four appended articles. Including this **introduction,** there are six chapters. The **theoretical foundations** chapter outlines technology education as a context for educational research and elaborates upon the challenges within the subject area that this research sought to investigate. The primary theory, namely Pedagogical Content Knowledge (PCK), is also introduced here. Developments of the construct over the past 30 or so years are detailed and some previous investigations of PCK research in technology education are presented. The **methodological approach** chapter briefly details the theoretical and methodological points of departure. Some of the strengths and limitations associated with interpretivism as an ontological position are problematised, and the associated epistemological assumptions are then unpacked. As a result of the chronological order in which research questions were developed and studies carried out, the specific methodological decisions and approaches taken to answering research questions are presented in tandem with emergent findings. In this chapter, entitled the **research journey**, the stated research questions are used as a framework to present the primary findings and contributions of the work. Following this, the **discussion** chapter consolidates the overview of contributions and reflects on implications for imagining a consolidated technology education, investigating practices in the subject, and realising teacher potential are drawn. This chapter also draws implications for practice in technology education, and speculates as to future directions for this research agenda. Finally, the **conclusion** chapter briefly reflects on how the thesis addressed the research questions.

2. THEORETICAL FOUNDATIONS

In this chapter, the theoretical foundations for the thesis are outlined. Beginning with technology education as a context for educational research, the contentions associated with technology education noted in the introductory chapter are elaborated upon. Following this, the nature of technological knowledge is considered, and representations of technological knowledge within the technology education discourse are presented. Given the research questions this thesis intends to address, the focus here is predominantly in how the goals for technology education are described, and what this means for teaching technology. The second part of this chapter outlines Pedagogical Content Knowledge (PCK) as an educational construct, providing a context for the methodological approach taken. After a brief introduction to PCK research and some of the different ways in which the construct has been studied, the model, which informed this research project is illustrated. The chapter then concludes with an overview of previous PCK research in technology education.

2.1. Technology education as a context for study

There is little congruence in the articulation of goals for learning in technology education internationally. Evidenced through the multitude of philosophical (Dakers, 2014b, 2014a; Gagel, 2004; Gibson, 2008; Ingerman & Collier-Reed, 2011; Kelly et al., 1987; Kimbell & Stables, 2007; Petrina, 2000; Williams, 2009) and empirical (Burghardt et al., 2010; Ritz, 2009; Rossouw et al., 2011) efforts towards consolidating an articulation of the goals of the subject area, the variety of conceptualisations that exist within the literature mirror the diverse nature of provision in different educational contexts. One of the reasons for the different organisations of technology education may lie in the contrasting origins of the subject, which is often cited as a critical influence on prevailing practices (Dakers, 2005). In most cases, technology education evolved from technical or vocational education in the late 1970s and early 1980s through recognition of the limitations of such an approach. The difference between technical and technological education is often used as a defining characteristic of technology education, where describing what technology education is not, often comes easier than describing the nature of technology (Dakers, 2014b). The case of the English and Welsh national curricula exemplify these differences, where the shifting curricular emphasis is often described as a change towards a more design centric subject philosophy (Kimbell, 2017). In other national contexts, the relationship between technology education and technical education is more complicated. For example, technology education in Sweden replaced the vocational subject 'technology' (Hultén, 2013), and today, technology education exists in tandem with *slöjd*, loosely translated as craft (Hallström, 2018). Differences can also be drawn when technology education is considered relative to other subjects in school curriculum. For example, in the early 1990s, technology education was often considered a component of science curricula when Science and Technology Studies (STS) was a prevalent theme. More recently, with the rise of the Science, Technology, Engineering, and Mathematics (STEM) agenda internationally the place of technology education relative to science and mathematics has come into question (McGarr & Lynch, 2017). Similar to this is the presence of multiple technology education subjects within the same national context, as is the case in the Republic of Ireland where four subjects at lower secondary education, collectively known as the technologies, are offered in the curriculum.

The point here is not to provide an in-depth depiction of the origins and nature of technology education internationally, as such depictions already exist within the literature (e.g. Banks & Williams, 2013; Black, 1998; Wright et al., 2018). The point is that multiple technology educations do exist. Whether there is a need for commonality in philosophical orientation, technical context, pedagogical approach, or relationship between the subject and other subjects in school curricula, the existence of multiple forms of technology education begs the question of what precisely is (or are) the defining characteristic(s) of the subject. And ultimately, what does this mean for studying teaching and learning within the subject area. As a result of this, with the aim of furthering our understanding of technology education, the representation of technological knowledge is important as it affects what is to be learned and should inform how to evidence learning. The following section provides an overview of the representation of technological knowledge from the philosophy of technology field and how this has manifested in the technology education discourse.

2.2. The nature of technological knowledge

In considering the epistemic emancipation of technological knowledge, Houkes depicts a 'double demarcation problem' (2009, p. 327). With regard to articulating a taxonomy of technological knowledge, Houkes noted that one must first define the context in which the taxonomy is to be defined, before knowledge can be categorised. However, making both of these definitions results in an idiosyncratic taxonomy, that is, a taxonomy which cannot be translated to alternative contexts is developed. In essence, nullifying the initial objective. A useful way of conceiving this is to consider technological knowledge independent of a specific context, and ask the question; what now differentiates this knowledge from other disciplines of knowledge? Herschbach (1995) notes that the remaining knowledge can be more appropriately termed scientific knowledge, amongst others, as it becomes an expression of the physical world and its phenomenon. The epistemological differentiation put forward by Morrison-Love (2016) is useful in further elaborating the nature of technological knowledge. Morrison-Love proposes 'transformation' as the epistemological basis for technology, in a similar way to 'proof' within mathematics and 'interpretation' within science. From these perspectives, the importance of context, and, the centrality of action in defining technological knowledge becomes apparent.

In exploring the philosophy of technology through its relationship with engineering, Mitcham (1994) proposed a fourfold classification of technology. In developing perspectives on the interdependence between knowledge and activity, technological volition, through interactions with knowledge in informing activity, and technological objects or artefacts as the result of technological activity was put forward (Figure 1). The level of abstraction here is important in contextualising technology education as a school subject. Keirl (2017) considers 'anything the species has created or made' (p. 22) as a form of technology, be that physical, political, sociological or economical among countless others.

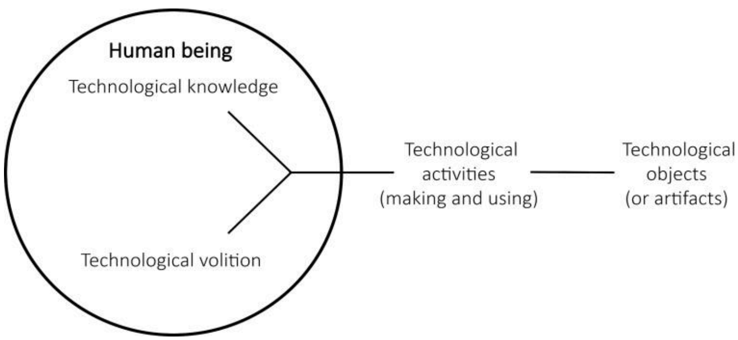

Figure 1. Modes of the manifestation of technology from Mitcham (1994, p. 160)

Building upon philosophical investigations of technological knowledge, there have been efforts towards the articulation of an epistemological basis for technology education. Notably here is the broad acceptance that the classical philosophical notion of knowledge as justified true belief does not necessarily apply to technological knowledge (de Vries, 2016). Norström (2014) suggests that the main reason for this stems from technological knowledge's inherent action orientation, as technologists are less concerned with whether knowledge is true or not, and are instead focused on whether the knowledge is successful in guiding actions towards certain goals. This epistemological fluidity, as articulated by Norman (2013), results in an educational context where 'the domain of knowledge as a separate entity is irrelevant; the relevance of knowledge is determined by its application to the technological issue at hand. So the skill does not lie in the recall and application of knowledge, but in the decisions about, and sourcing of, what knowledge is relevant' (Williams, 2009, pp. 248–249). Therefore, in many ways, the higher constructs such as technological capability, literacy, etc. alluded to in the introduction chapter may be an appropriate proxy for the depiction of an epistemic framework for technology education. Despite multiple perspectives on what constitutes each, Williams (2009) noted that each identified that educational goals are not exclusively knowledge based, and that there are a variety of problem-solving aptitudes, value-oriented perspectives, as well as manipulative skills that are necessary to be considered technologically capable or literate.

It is important here to remain grounded, as assertions of a subject area bereft of what could be termed a 'conventional' knowledge base results in quite a significant ambition for the purpose of a school subject. Here, the differentiation between technical knowledge (epistemic) and technological knowledge (epistemological) drawn by Barlex (2007) in describing technological activity is adopted. Whereas technological knowledge is the knowledge used within technological activity, at the level of abstraction of anything that the species has created or made (from Keirl, 2017), technical knowledge is the associated knowledge adopted within this particular context for activity. Technical knowledge here can thus be taken as the technical norms associated with a context (de Vries, 2014) or the procedural skills for operating within a context (Reinsfield & Williams, 2018). It is important to note that the perspective on technological knowledge and activity presented does not ostracise technical knowledge or question its importance of knowledge within technology education. Instead, the perspective taken is that the acquiring of technical knowledge and skills cannot fully constitute an authentically technological education. Technical knowledge, in its various forms, is utilised in technological activity, however, its application is transdisciplinary in nature and highly context-specific. For example, knowledge from science, agriculture, construction, and mathematics amongst countless others can be described as technological knowledge, depending on its utility in a particular context (McCormick, 2004). It is only by association with activity in a specific context that the knowledge can be appropriately ascribed the label 'technological'. As a result of the apparent interdependence between technological knowledge and activity depicted, questions may be raised as to whether or not it is possible to predetermine technological knowledge for the purposes of writing a technology curriculum specification. Likewise, assertions of the need to support the development of technological knowledge, or students acquiring technological knowledge, are therefore problematic as they misconstrue this perspective on what constitutes technological knowledge.

2.3. Teaching technology

Kimbell (1994) articulated the traditional progression of tasks in technology education, identifying an inverse relationship between learner autonomy and a framework of constraints which govern activities. In theory, as learners progressed through technology education, the framework of constraints governing their work would become increasingly looser. Over a period of time, learner procedural autonomy is facilitated as a result of developing the capabilities to operate in a context, by the development of foundational knowledge and skills within that specific context. In technical education, this context was most often a specific material, such as wood, metal, food, or in some cases, textiles. However, whereas technical education focused on the development of specific knowledge and skills associated with the context of learning, technology education shares a more complicated relationship with contexts for practice. If goals for technology education are not concerned with specific content knowledge but rather a higher understanding of how to use (unspecified) knowledge and skills to identify and resolve (unknown) problems, a context for technology education, although necessary, is only useful in so far as to support learners in acquiring the variety of problem-solving aptitudes, value-oriented perspectives, as well as manipulative skills discussed by Williams (2009).

Williams et al. (2016) noted that a significant implication of describing the teaching of technology in such a way is that teachers no longer have an agreed upon epistemology, without which, continuity in the organisation of topics of inquiry becomes problematic. There are two perspectives to this, in one sense the additional autonomy may be interpreted as a unique advantage of the subject area, as teachers may draw on their, and their students' interests in planning for teaching (Spendlove, 2012). On the other hand, as the epistemic autonomy of teachers (and learners) is greatly amplified through epistemically fluid content boundaries, then there is a greater potential for divergences in practices in technology education than other subject areas. In instances where teachers' fail to share a common understanding of the subject area (Barlex, 2012) this becomes a significant problem as the potential and likelihood for practices to diverge from curricular intentions increases.

An example of how this may negatively manifest was identified in the English and Welsh national contexts (Mittell & Penny, 1997). Here it was identified that teachers' conceptions of the purpose of (design and) technology education was restrictive relative to the goals of emergent policy, as the emphasis placed on technical outputs outweighed the divergent thinking advocated in the curriculum at that time. A similar pattern was identified in the New Zealand context. Similarity of context between technical and technological education was theorised to play a significant part in teacher's apparent subversion of emerging conceptions of capability regarding the nature of technology (Compton & Harwood, 2008). In essence, the technical knowledge associated with the context for technological activity remained the focus of teaching and learning. From these findings, understanding the relationship between conceptually oriented curricular goals and individual teachers' pedagogical aspirations for teaching and learning in technology education are of critical importance in bridging the gap to understanding the reality of classroom practices in technology education.

2.4. Pedagogical Content Knowledge

In a shift from the behaviourist view of teacher knowledge which dominated educational research throughout the 20th century, cognitivist and constructivist perspectives on teaching and learning recognise that teacher knowledge is more personal. Central among these personal perspectives was Shulman's (1986) identification of a blind spot concerning teacher's treatment of specific subject matter. Termed Pedagogical Content Knowledge (PCK), the new type of teacher knowledge sought to represent the 'blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners and presented for instruction' (Shulman, 1987, p. 8). Identified as one of at least seven categories of teacher knowledge including, content knowledge; general pedagogical knowledge; curriculum knowledge; knowledge of learners and their characteristics; knowledge of educational contexts; and, knowledge of educational ends, purposes and values (Shulman, 1987), PCK has come to somewhat dominate teacher knowledge research, particularly in science and mathematics.

Despite attracting significant attention within the educational research community, there was initially very little continuity in how PCK was conceptualised or studied (Abell, 2008). Key to this lack of continuity appeared to be the interconnections that PCK shares with other areas of teacher knowledge, such as general pedagogical knowledge and subject matter knowledge. In the absence of a widely accepted conception and the emergence of contradictory approaches to conceptualising PCK, debate arose as to the nature of the construct (Gess-Newsome & Lederman, 1999). In an effort to consolidate the different approaches to studying PCK within the science education research community, Gess-Newsome (1999) highlighted a tendency for researchers to view the construct as an integrative or transformative knowledge category (Figure 2). An integrative stance does not treat PCK as a distinct category of knowledge, instead it is considered as an amalgamation of different knowledge categories (e.g. general pedagogical knowledge and content knowledge). On the other hand, the transformative stance towards conceptualising PCK treats the construct as a distinct category of knowledge. Here, the initial knowledge bases are 'inextricably combined into a new form of knowledge' (Gess-Newsome, 1999, p. 11), with the implication that PCK must have its own unique identifiers beyond the initial knowledge bases.

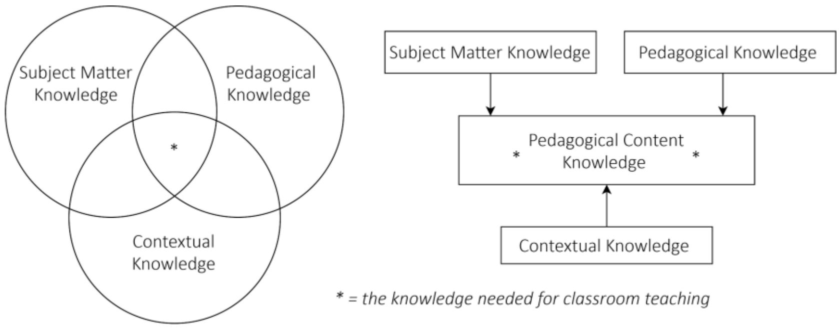

Figure 2. Two models of teacher knowledge (Gess-Newsome, 1999, p. 12)

Further to the different approaches to conceptualising PCK, the level of application has been widely contested. Commonly referred to as the 'grain size' of PCK under investigation, Veal and MaKinster (1999) first introduced the differentiation of general-, domain- and topic-specific PCK in the context of developing a taxonomy for teacher professional development. Since this, the level of concept-specific PCK has been introduced and used within the literature. Although the intention here was to further research in professional development through recognising changes in PCK as a teacher progressed in their education, empirically differentiating between different 'grain sizes' of PCK has proven difficult. It is also unclear how general PCK, sometimes referred to as canonical PCK, is differentiated from 'general' pedagogical knowledge.

Another point of note with PCK research is its apparent distancing from the reality of classroom practices. As Shulman's (1986) initial definition of PCK encompassed comprehension, pedagogical reasoning, transformation and practice, it suggests that it comprises both teacher understanding and their enactment (Barendsen & Henze, 2019). Though critiques of early PCK research largely neglected the reciprocal relationship between knowledge and behaviour, calls for more explanative models of PCK, and methods of conducting PCK research that is more explanative of practices have been made (Abell, 2008), it should be noted that there were efforts towards this end. For example, Magnusson et al. (1999) introduced the concept 'Orientation to science teaching'. Commonly referred to as teachers' 'orientations towards teaching' (Friedrichsen et al., 2010), this concept was introduced in the recognition that a teachers' beliefs serve as a 'conceptual map' that guides instructional decisions about issues such as daily objectives, the content of student assignments, the use of textbooks and other curricular materials, and the evaluation of student learning (Borko & Putnam, 1996). A similar rationale can be given to perspectives on defining the 'K' in PCK as knowing, with the introduction of PCKg (Cochran et al., 1993). Irrespective of such efforts, a dominance in static conceptions of teacher knowledge and PCK as 'what is known' prevailed within the literature.

Between contentions in how PCK is conceptualised, researched and applied to explain or predict practice within the classroom (among other purposes), and the research conducted throughout the 25 years since its inception, criticisms and limitations began to emerge from the education research community. Initially in recognition of the disparity between PCK research and enacted practices through calls for more explanative models (Abell, 2007), but later towards the canonical nature of PCK in that although the general ideas and principles of PCK made sense, research often failed to fulfil this promise (Settlage, 2013). Despite its apparent potential to move understandings of teacher enactment forward, the diverse interpretations of PCK prevalent within the research community was theorised to limit the constructs utility in research, teacher education, and policy (Settlage, 2013).

2.5. Recent trends in PCK research

In an effort to synthesise understandings of the concept of PCK and address the emerging contentions presented above, a PCK summit was held in 2012 (BSCS, 2012). Designed as a working conference, the intent was to push participants beyond their individual research agendas to better understand the issues and concerns of PCK research and its impact and value to science teaching and learning. The outcome of this conference was the development of the 'consensus model of teacher professional knowledge and skill' (Gess-

Newsome & Carlson, 2013) presented in Figure 3. The consensus model (CM) as it is referred to, made a number of important distinctions between different forms of teacher knowledge.

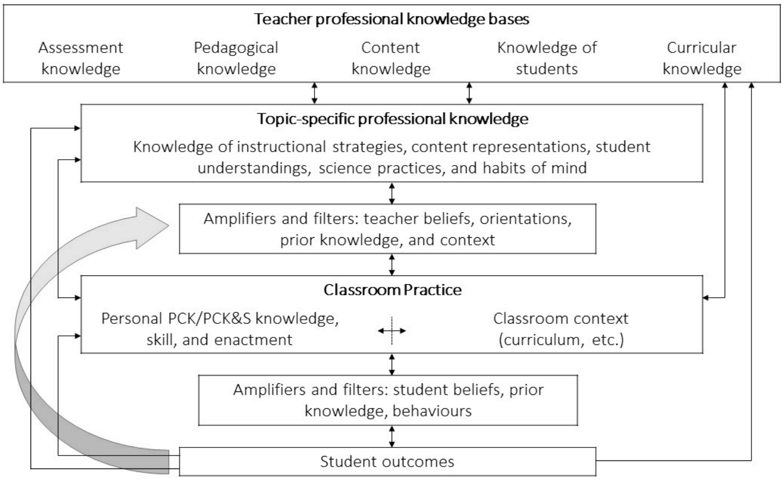

Figure 3. Model of teacher professional knowledge and skill including PCK (Gess-Newsome & Carlson, 2013, p. 16)

The CM distinguished three different types of teacher knowledge; teacher professional knowledge bases (TPKB), topic-specific professional knowledge (TSPK), and PCK. TPKB are defined as general (not content specific) knowledge bases for teaching, such as knowledge of assessment or general pedagogical knowledge. As foundational knowledge bases, these are considered normative and can thus be used to construct assessments to quantify what teachers know. TSPK, on the other hand, is knowledge that has been codified by experts in a discipline as being important to student learning; a public understanding held by a teaching community. Gess-Newsome (2015) asserts that an example of this type of knowledge would be the knowledge articulated within a Content Representation (CoRe) instrument (Loughran et al., 2004) as a CoRe represents the knowledge a community of teachers hold with regard to teaching a particular topic at a particular grade level.

In contrast to TPKB and TSPK, which are both considered canonical in nature and held in the profession itself, PCK is recognised as being a personal form of knowledge specific to individual teachers. Through defining PCK as ‘the knowledge of, reasoning behind, and planning for teaching a particular topic in a particular way for a particular purpose to particular students for enhanced student outcomes' (Gess-Newsome, 2015, p. 36) the CM decouples professional knowledge from personal knowledge and clarifies concepts which were previously conflated in attempts to describe, capture, articulate or measure PCK (Kind, 2009, 2015). It is important to note that the CM goes beyond this however, as PCK is situated in classroom practice, within a teacher's experiences. The decision to situate PCK in practice is supported by the consensus that PCK and associated classroom instruction varies by topic, particularly across topics with different levels of content knowledge (Carlsen, 1993) and for topics within and outside areas of content expertise (Hashweh, 1987, 2005). In introducing the CM, Gess-Newsome (2015) noted that PCK can be found in the instructional plans that teachers create and in the reasons behind their instructional decisions. In other words, PCK is also the knowledge that teachers bring forward to design and reflect on teaching.

From this, the relationship between teacher PCK and practice is theorised to be inherently complex as the interplay involves both knowledge-on-action and knowledge in-action (Park & Oliver, 2008). Although knowledge-on-action is relatively easy to explicate as it can be elicited directly from teachers, knowledge-in-action is both enacted and developed during teaching by reflection-in-action (Schön, 1983). To accommodate this differentiation, a new construct was introduced. Pedagogical Content Knowledge and Skill (PCK&S) seeks to acknowledge that what a teacher does in the classroom, although based on their PCK, is influenced by in-the-moment decisions. The introduction of skill here acknowledges deficiencies in a teacher's ability to implement pedagogical approaches, despite an intention to do so. Related to this is the amplifiers and filter component of the CM. Placed in the intermediary between the professional knowledge bases and personal knowledge bases, this component built on previous attempts to recognise the differences between what a teacher knows, and what they decide to do (Magnusson et al., 1999). Supported by inconclusive findings between teacher PCK, enacted practice and student achievement (Baumert et al., 2010; Gess-Newsome et al., 2019).

2.6. PCK research in technology education

In considering the application of Shulman's initial construct of PCK to technology education, an obvious contention emerges. As outlined previously, content is not represented in the same way in technology education as with many other subjects. However, with attendees at the PCK summit refining the definition of PCK as a personal form of knowledge situated in a specific teacher's experiences, the potential to provide explanatory power of enacted practice in technology education emerges. There have been a number of previous investigations of PCK in a technology education context which provide a foundation for applying the CM (Gess-Newsome, 2015), these are outlined in this section.

Through reflection on the provision of teacher education and classroom research in technology education, Jones and Moreland (2003a) presented a model of PCK for technology education which consisted of seven constructs:

- Nature of the subject and its characteristics;
- Conceptual, procedural and technical aspects of the subject;
- Knowledge of the curriculum;
- Knowledge of student learning in the subject;
- Specific teaching and assessment practices of the subject;
- Understanding the role and place of context;
- Classroom environment and management in relation to the subject.

This perspective on PCK can be considered as integrative in the sense that it sought to represent the different forms of knowledge that a teacher should be introduced to (Jones & Moreland, 2003b, 2004). From the discussion surrounding the introduction of the model, it is unclear how the identified components relates to teacher practice, other than the theorised association between the seven constructs and enhanced teaching and in turn, enhanced student performance in technology. A significant contribution of the model lies in the emphasis placed on technology education, in that not solely the nature of the subject, but also established practices within a classroom environment unique to technology were presented. Although not explicitly concerning PCK, the DEPTH project (Banks et al., 2004) in their investigation of technology teacher education students 'personal subject construct' identified significant variance in how participants conceived the role of teaching the same technology curriculum. Central to this study was the transformative nature of a personal subject construct, as it was identified to constitute more than the sum of its constituent knowledge bases; school knowledge, subject knowledge, and pedagogical knowledge.

A similar conclusion was drawn by Williams et al. (2012) in an investigation of technology teachers' PCK using the CoRe instrument (Loughran et al., 2004). This study compared a partnership between researchers, practitioners and content experts in science education with a technology education partnership of the same composition. The authors noted that in formulating a CoRe, the technology team encountered difficulties in achieving consensus as to the core concepts (referred to as 'big ideas' on the CoRe instrument) within their planning for teaching. The authors theorised that the additional negotiation and justification of concepts in technology stemmed from the fact that there was no schema of knowledge that was common to participants in the study. This was held in comparison to the well-established epistemology of science education which was theorised to lead to a commonly agreed organisation of knowledge. From this, the authors noted the commonly accepted topics of enquiry, facilitating common teacher interpretations and representations of content, concepts and ultimately, pedagogical approaches (Williams & Lockley, 2012). Importantly, these findings suggest that a difference in the epistemological basis of a subject raises questions as to whether or not methods used to study PCK can be transferred between different subjects (de Miranda, 2018). In a follow-up study, Williams et al. (2016) recommended changes to the CoRe instrument based on the challenges associated with applying it a technology education context. The Technology Education Content Representation (TCoRes) was presented as a way to articulate technology teachers' PCK while better representing the organisation of learning within the subject. It is organised under a single project as opposed to a series of 'big ideas'. Subheadings of 'focus' and within this, ability/understanding sought to encompass the variety of technological concepts embedded within a typical technology education activity were proposed.

Within the context of primary technology education, Rohaan et al. (2009) developed a multiple-choice test to measure technology teachers' PCK. Presented with a scenario for teaching, four possible answers were designed by a team of experts to represent 'high PCK', 'low PCK', 'pedagogical knowledge', or 'content knowledge'. Although the test requires teachers to provide a response to a teaching problem, the rationale for teaching and the context in which the teaching is to be considered are not accommodated for. As a result of this, it is unclear whether or not it is possible to differentiate between pedagogical knowledge, content knowledge, or levels of PCK, as the four responses are ultimately pedagogical decisions. Consequently, it was later concluded that the instrument was not ready-to-use for evaluative or diagnostic purposes (Rohaan, 2009).

The variety of different conceptions and approaches to studying PCK presented here mirror PCK research more generally. As a result of this, many of the critiques that culminated in the PCK summit are relevant, notably, how different interpretations of PCK are used to suit particular research agendas (Mulholland & Wallace, 2005). For example, a clear distinction can be drawn between the conception of PCK adopted by Jones and Moreland (2003a) and that adopted by Rohaan et al. (2009). Jones and Moreland developed a model of PCK based on experiences of investigating teaching, which serves to depict the variety of knowledge categories which a technology teacher draws upon in their teaching. On the other hand, the approach to investigating PCK taken by Rohaan et al. is rooted in the assertion that the construct is measurable, suggesting it aligns with the earlier PCK research that held PCK as 'what is known'. The intent of measuring PCK, or using the concept of PCK to represent what is important for initial teacher education students to develop are both relevant education agendas, however, neither serve to appropriately represent teachers' pedagogical decisions and enactment of practices within the technology classroom. A common thread between all studies however was the nature of technology and implications for considering the content within the subject. This appears to go beyond the obvious content demarcation that is a foundational principle to the idea of PCK, to a space where thinking about the subject in different ways was acknowledged as a defining feature of technology education (Banks et al., 2004; Williams et al., 2016).

A final point of note regarding PCK research in technology education concerns the use of the term more generally. A multitude of calls have been made for PCK research within technology education (de Vries, 2003, 2015; Engelbrecht & Ankiewicz, 2016; Fahrman et al., 2020; Jones et al., 2013; Mioduser, 2015; Ritz & Martin, 2012) suggesting a broad recognition of its potential as a useful construct. The question of how the construct may be useful is the point of contention however. The fact that PCK is conceptualised in so many different ways, its potential to be represented as all things pedagogical and concerned with student learning in any educational setting could ultimately result in it meaning very little. Although a lack of continuity in conceptualising the construct mirrors that of other subject areas (Settlage, 2013), the disparity of conceptions represented in a difficult to define technology subject only serve to further complicate the association between policy, teacher knowledge, and enacted practices in the subject area.

3. METHODOLOGICAL APPROACH

The previous chapter sought to outline the epistemological basis of technology education as represented in the extant literature, and how different approaches to conceptualising Pedagogical Content Knowledge (PCK) have been used to study the subject area. This chapter provides an overview of the methodological approach taken to investigating the stated research questions. As such, it begins by elaborating upon the theoretical position taken within this thesis. Then, the ontological and associated epistemological assumptions are outlined before considerations for quality assurance of the included works are considered. This chapter is concluded with some of the broader ethical considerations associated with this thesis.

3.1. Theoretical position

Technical education had, and in the instances where it prevails still has, a very clear subject philosophy. Predicated on the preparation of learners for the world of work, learning outcomes were readily identifiable, and a pedagogical approach, based on the master apprentice model of the medieval guild (Banks & Barlex, 1999), was commonly understood. Challenges associated with articulating clear subject goals for technology education are evidenced through the numerous attempts in the literature towards consolidating perspectives internationally (Ritz, 2009; Rossouw et al., 2011). In place of commonly agreed goals, constructs such as technological capability and technological literacy have been put forward as representations of what technology education strives to achieve. In place of a defined epistemic boundary for the subject area, efforts towards an epistemological framework have noted the importance of activity in defining technology education. With this, the associated knowledge is treated as 'provisional' (Kimbell, 2011, p. 7) only considered relevant through its association with utility in a specific context (Williams, 2009). In place of a defined epistemic boundary for technology education, the higher constructs discussed previously have outlined a series of problem-solving aptitudes, value-oriented perspectives, and technical skills that are considered essential for achieving these broad conceptual goals. The position taken in this thesis is to accept this international rhetoric provisionally, but to explore how technology teachers interpret and enact their practices relative to this rhetoric in schools today.

3.2. Ontological position and epistemological assumptions

The definition of PCK presented with the Consensus Model (CM) shifted the construct from a more generic knowledge base for teaching to a specific teacher or indeed a specific instance of teaching. Defining PCK to a level of topic and context specificity, essentially situating it in the moment of teaching or planning for teaching, raises significant challenges to investigating the construct in a systematic way. Garritz reflected on the implications for researching PCK as a result of defining the construct in this way; '… it means that PCK must be reconstructed specifically each time by a given teacher, within set objectives, has to present a certain topic to a specific set of students with a distinctive background and learning characteristics …' (2014, p. 733). Although it may appear peculiar to present the implications for adopting part of the theoretical framework in the methodological approach chapter of this document, this sentiment is useful in clarifying the ontological position held throughout this thesis. Holding that PCK resides in teachers' planning of, enactment of, or reflection on teaching, reflects a relativist ontological position. Relativism is defined through the view that as one interprets a phenomena through their personal lens, relative to time, place, society, culture, historical epoch, conceptual scheme or framework, or to personal training or conviction, etc., this is their interpretation of reality (Siegel, 2010). Chalmers (2009) notes that the foundational assumption of a relativist ontological position thus lies in the multiple realities which may be perceived, and that these realities can be explored and made sense of through reconstruction of interactions between the researcher and the participants of research. As a result of this, one must accept that others with alternative perspectives may have a different interpretation. Thus, in keeping with the perspective on PCK previously outlined, the use of the construct in this thesis does not extend beyond its utility in providing an explanation for enacted practice. PCK as an educational construct in itself is not measured or assessed, and in a sense is not the focus of the thesis, but rather a mechanism used to investigate the relationship between rhetoric and reality in technology education. There are epistemological implications which arise from the position taken that are important to consider in the design and selection of research methods.

As the perspective taken on PCK as having evolved beyond an exclusively knowledge based construct, it is used in this thesis in a very specific way. As a result of this, and for fear of becoming too metaphysical, Topic Specific Professional Knowledge (TSPK) as introduced in the previous chapter serves as a more concrete example. Gess-Newsome (2015) described these knowledge bases as a relatively static form of teacher knowledge, equated to the notion of knowledge for practice (Cochran-Smith & Lytle, 1999). This knowledge can be identified by the education community and in a sense, be used to describe what it is that a teacher knows. With regard to studying this knowledge however, the relativist ontological stance adopted means that despite this knowledge being described as static, one's observation of that knowledge is subjective, an interpretation. Through interactions with participants, an interpretivist epistemology requires the researcher to make meaning of the data through their own thinking and cognitive processing. There is the understanding that the researcher constructs knowledge socially as a result of their personal experiences of these interactions, within the context of investigation (Kivunja & Kuyini, 2017; Punch, 2005). Brinkmann and Kvale (2015) use a miner and a traveller metaphor to explain this conception of knowledge in the context of conducting interviews. Whereas a miner assumes a singular truth or reality, waiting to uncover this knowledge from an interviewee, a traveller passes through a context which leads to a tale of this knowledge, one that has been interpreted, and to a degree, co-constructed with the interviewee. Likewise, whereas the miner metaphor regards interviews as a site for data collection, distinct from the latter stage of analysis, the traveller metaphor leads to interviewing and analysis as 'intertwined phases of knowledge construction' (Brinkmann & Kvale, 2015, p. 58). Returning to TSKB from earlier, an interpretivist epistemological perspective thus moves beyond the identification and description of this knowledge, towards the identification of relationships between the phenomena under investigation. As such, with this thesis oriented towards co-constructing knowledge with practicing teachers and interviewees, objectively measuring a teacher's knowledge is thus not possible, but importantly from this perspective, nor is it the agenda.

3.3. Considerations for quality assurance and limitations

A major implication of working within a relativist ontology and subsequently adopting an interpretivist epistemology lies in the contentions of how to ensure the quality of research conducted and presented. For some time the limitations of research criteria from other research paradigms has been recognised in terms of their inability to represent quality research (Bochner, 2000). In this thesis, the criteria for assessing the trustworthiness and authenticity of naturalistic inquiry introduced by Guba (1981) are adopted, namely; credibility, transferability, dependability, and confirmability. The consideration and application of these criteria are outlined for the empirical works included in this thesis briefly in the following paragraphs. Specific methodological decisions are then outlined in chapter 4.

The use of interviews as a data collection instrument raises questions as to the trustworthiness of the data, as data is self-reported by interviewees and not necessarily an exact representation of reality. Within this thesis a number of different data triangulation procedures, both within interviews (Article I) and between interviewees (Article I and IV) were used to ensure the credibility of data. These procedures sought to ensure that teachers' reported practices and reflections upon practices aligned with classroom realities. Generalisability of findings is not cited as a goal for qualitative research, instead Guba (1981) proposed transferability as a concept to consider the applicability of research from qualitative studies. An example of how this thesis sought to ensure more transferable results was the decision to elevate 'technology education' to a conceptual space in Article IV. The transferability of the research in this study (and the thesis more generally) is enhanced through increasing the variation within the sample, through recruiting participants from different educational contexts. In tandem with efforts to ensure the transferability of research findings comes the notion of dependability. Dependability refers to the consistency of data collection and analysis procedures used within qualitative research. Similar to ensuring the credibility of findings through rich descriptions of the data (Tracy, 2010), dependability of research can be ensured through providing accurate representations of the methodological and analytical decisions undertaken in the research. For example, as with any research method, consideration must be given to the identification and sourcing of participants in this research. In both empirical works conducted in this thesis, the authors' professional networks were used to source participants. The decisions surrounding why this approach is appropriate and the associated limitations should also be considered. The final criteria for trustworthiness of data outlined by Guba is confirmability. Confirmability refers to the level of confidence in the findings presented and how the researcher accounts for their biases in the data collection, analysis and presentation of findings. The introduction to this chapter outlines the positions adopted within the thesis as a way of acknowledging the theoretical point of departure. Through the research, reflexivity between this position and the emerging findings through analysis was undertaken. Furthermore, efforts towards ensuring confirmability were made through involving multiple researchers at different stages of data analysis. This approach facilitated discussions between different perspectives on data to ensure it is represented accurately.

An important point of note here is the methodological approach adopted within Article IV. Constructivist Grounded Theory (GT) as a methodology has evolved with its own set of criteria over the past number of decades. The approaches towards trustworthiness outlined in this section provide an overview of the approaches adopted within each of the articles in this thesis generally. The specific methodological approach and decisions made within Article IV will be outlined in chapter 4.

3.4. Ethical considerations

Both empirical studies conducted as part of this thesis adhered to international ethical guidelines for the interviewing of human subjects (NESH, 2016). In advance of each interview, participants were provided with an information sheet which described the intentions of the research, the nature of the data to be collected, and the intended uses of the data. Prior to conducting each interview, a volunteer informed consent form was signed by interviewees. This included information regarding participants' right to confidentiality, access to the data, and the intentions to publish the findings of the research. Participants were also made aware should they wish to stop the interview or discontinue participation in the study at any stage, that this was their prerogative. Each participant was also informed of their right to access the transcription of the interview, although nobody availed of this. Due to the sensitive nature of data collected about participants actions within a school, careful consideration was given to the treatment of data. All data was anonymised during transcription or immediately after transcription in the cases where a transcription service was used. The anonymisation involved the cleaning of data of all personal identification of participants, or participants' schools information. Coding systems were used to facilitate this anonymisation. The audio files and verbatim transcriptions collected as part of this research have been used exclusively for the analysis and publication of the appended research articles (Article I and Article IV). Participants were made aware of the intended research outputs at the time of data collection.

4.RESEARCH JOURNEY: OVERVIEW OF CONTRIBUTIONS

As this thesis project developed, a number of methodological shifts were made in following the research aim to better understand the relationship between rhetoric and reality in technology education. Based on the chronology of research questions and how emergent findings influenced subsequent methodological decisions, the specific methodological approaches taken in individual studies are outlined here. Guided by the three research questions, the methodological approaches and primary findings presented in the four appended articles (Figure 4) are summarised in this chapter.

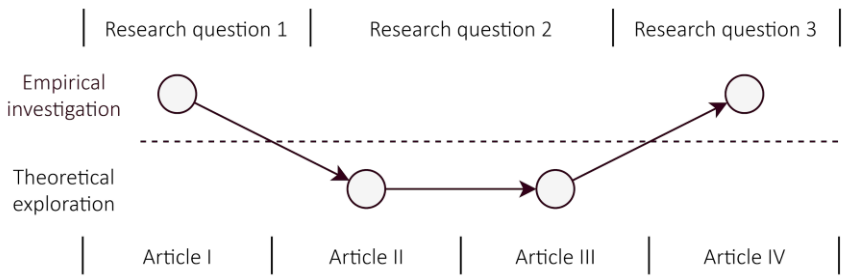

Figure 4. Overview of research questions and relationship to research articles

Building upon an initial empirical understanding that identified gaps in how investigations of enacted practices are framed, this research turned towards theoretical understandings of enactment in the subject. This culminated in the theorisation and publication of a model that applied contemporary understandings of Pedagogical Content Knowledge (PCK) in the context of technology education. Following this theoretical phase of the research, it became apparent that the beliefs component of the model needed further empirical investigation and grounding. These methodological shifts are important to explain. These shifts can be summarised as the synthesising of empirical investigation with theoretical exploration, signified in Figure 4 by the dotted line. The line is broken so that it represents that empirical investigation and theoretical exploration were not mutually exclusive. As will be outlined in the following sections, as knowledge of the enactment of technology education was developed, evidence was sought empirically and from the pertinent theory which sought to move the research forward, all the time guided by the research questions. The synthesis of these approaches ultimately culminated in the development and presentation of an empirically grounded theory informed by the pertinent theories from the technology education discourse. The decisions to shift approaches are outlined in the following overview of contributions, presented under each research question. Each section is followed by a reference to the specific research article(s) which addressed the question, inclusive of publication status.

4.1. Teachers' perspectives on enacted practice

In addressing the first research question, *how do technology teachers describe their enacted practices relative to the more general aims of technology education?*, a study was designed to empirically investigate this relationship. The decision was made to gather empirical evidence as despite frequent speculation of rhetoric-reality disparities in the literature (Banks & Barlex, 1999; Kimbell, 2006; Spendlove, 2012), few studies have investigated this relationship empirically. As the intermediary between rhetoric, as reflected in policy, and the enactment of technology education, practicing teachers were identified as the focus of investigation in this study.

Semi-structured interviews were employed as they facilitate complex representations of data, something which was anticipated given the multifaceted articulations of goals for learning in technology education. To ensure the dependability of data, an interview protocol was designed around three broad themes; the focus of learning activities, the intended learning outcomes prescribed by teachers, and ultimately, the qualities teachers sought to instil or develop in students. A total of 15 interviews were carried out across the four technology education subjects in Irish second-level education. Participants were selected in order to encompass a diverse variation of geographical and socioeconomic regions. The inclusion criterion required participants to be qualified technology teachers, teaching any of the technology education subjects at both lower- and higher-secondary education at the time the study was conducted. The study was designed to ensure credibility of data by two means. Firstly, the interviews were designed around the learning activities that teachers were actively using in their teaching. Based on the assumption that teachers had the autonomy to design or select activities on their own volition, this situated approach sought to unpack interviewees specific rationale for engagement with these activities. Secondly, a cross-sectional approach spanning the technology subjects across each year of schooling in Irish second-level education was decided upon. In this sense, the dependability of data was ensured through the analysis of learning activities in each of the five years of schooling studied.

Analysis of interviewees description of their enacted practices and their representations of what was of importance to student learning in the subject area resulted in the presentation of three themes: (1) a prominence of activities focused on the development of technical knowledge and skills, (2) the pressures of meeting the requirements of summative assessment, and, (3) teachers' professional views on capability.

In contrast to Kimbell's (1994) representation of the procedural progression of learning activities in technology education, the analysis of teacher representations suggested that the development of technical knowledge and skills remained the dominant focus of learning throughout each year of schooling. Although student autonomy through independent design thinking (Kimbell & Stables, 2007) increased as students progressed through their education, the extent of the increase was relatively minor. This hesitancy or reluctance to engage students with design activity is best exemplified through examples of where engagement with design is mandated through the assessment of a design portfolio. In such instances, it was identified that teachers adopted methodological and formulaic approaches to design in many cases, often utilising the assessment rubric as a guide to their practices.

The second theme that emerged from this analysis identified the pressures of meeting the requirements of summative assessment as having a significant influence on teachers' reported practices. Evidenced through narrow engagement with designing previously discussed, this theme was also supported by conscious decisions to truncate syllabi in the circumnavigation of prescribed goals for learning. The influences that summative examinations have on practice in Irish education have been well documented (Hennessy et al., 2011; MacAogáin, 2005). Unsurprisingly, one of the most often cited points of causation is the high stakes nature of second-level education assessment, as results govern matriculation into third-level education (Hyland, 2011). Similar findings were identified in this study, where interviewees cited their schools as 'high achieving' and detailed the resulting cultural expectations placed upon them, ultimately abetting a teaching towards the exam epistemology. An interesting exception to this pattern was identified with the graphics based subjects (Technical Graphics (NCCA, 1991) and Design and Communication Graphics (NCCA, 2007)). Although summative examinations were cited as a core influence on teachers' practices, the unpredictable nature of examinations in these subjects negated a rote-learning approach as inefficient in preparing students for terminal examinations.

The third theme which was identified in the data analysis suggested a misalignment between what teachers held to be of importance to student learning, and the actuality of their classroom practices. Termed 'professional views on capability', this theme consisted of two distinct factors, namely teachers' questioning of the organisation and content of technology curricula, and, the nature of the assessment system. The contentions between what teachers personally held to be of importance to student learning and the questioning of both curricula and assessment systems ultimately resulted in their construct of capability not being implemented as they envisioned. Teachers' awareness of these tensions should also be noted as an important outcome from this study, as it influenced future research decisions.

Two significant contributions emerged from this study. First, the identified tensions between international rhetoric and realities of teachers' reported practices suggest that much of the theoretical questioning of such a disparity has empirical grounding. Perhaps more significantly, the identification of the theme surrounding teachers' personal construct of capability as a point of contention in the manifestation of curricular intentions highlighted that teachers are aware of the potential disparity. With this came a critical misconception implicit to the methodology that informed future research. Teachers were making decisions of how to enact technology education which did not necessarily align with their conception of capability. Thus, concerned with the different conceptions of goals for technology education, and how manifest conceptions influence enacted practices, this study concluded by framing a research agenda to understand the process of enacting technology education.

Doyle, A., Seery, N., Canty, D., & Buckley, J. (2019). Agendas, influences, and capability: Perspectives on practice in design and technology education. *International Journal of Technology and Design Education, 29*(1), 143–159.

4.2. Facilitating the investigation of enacted practice

With the findings from Article I identifying that teacher's conception of what is of importance to student learning did not necessarily align with their representation of enacted practice, the second research question, *how can teachers' enactment of technology education be investigated?*, was formulated. This question was framed in such a way so that individual teacher's practices could be considered, influenced by the variability of practice in technology education endorsed within the literature. In addressing this research question, this study began with a review of the literature which investigates the theoretical basis of teacher enactment in different subjects.

As the knowledge that teachers use in their teaching (Shulman, 1986), PCK was identified as a useful mechanism for explaining enacted practices. This decision was taken amid the myriad calls for the potential utility of PCK research in technology education (de Vries, 2003, 2015; Engelbrecht & Ankiewicz, 2016; Fahrman et al., 2020; Jones et al., 2013; Mioduser, 2015; Ritz & Martin, 2012). A clarification of the perspective on PCK adopted in the thesis is important as conceptions of the construct have evolved significantly over the past 30 years. The Consensus Model (CM) of PCK was adopted here for its potential explanatory power in explaining enacted practices. Despite the previous investigations of PCK in technology education, with the emergence of the CM, there was recognition that the construct needed to move beyond descriptions of teacher knowledge, towards identifying the relationship between teacher knowledge and classroom practices. Thus, a focused review of the literature regarding PCK, and subsequently, PCK in technology education was undertaken to explore the application of the construct to this educational context. This culminated in the presentation of a framework the theorised the application of contemporary perspectives of PCK to technology education.

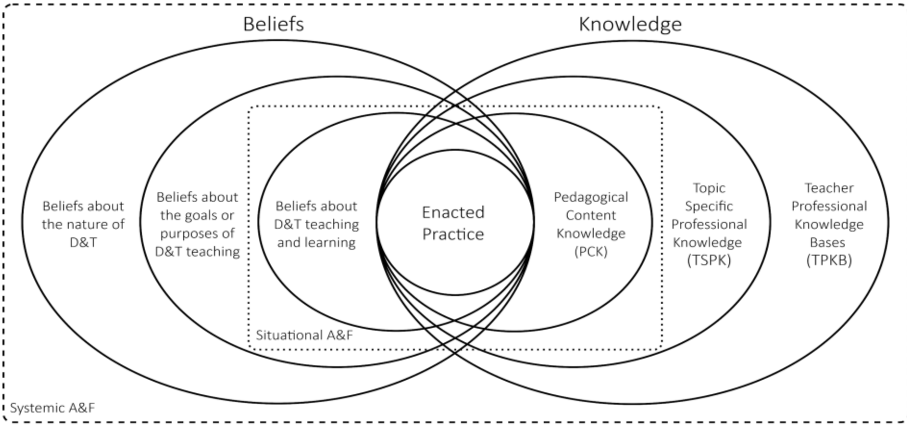

Figure 5. Ecologically situated model of enacted practice, teacher beliefs and knowledge (Article II)

Throughout this review, the alternative approach to conceptualising technology education as a subject area, when compared to other areas on the school curriculum became apparent. A useful way of explaining this is the higher constructs discussed earlier (technological capability, literacy etc.) and the grain size of PCK for investigation. PCK as initially conceptualised was presented at the level of knowledge for teaching, a discipline level understanding of the knowledge that was useful for understanding how 'particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learning, and presented for instruction' (Shulman, 1987, p. 8). However, as research in the area has progressed, different 'grain sizes' of PCK have been identified, such as general-, domain- and topic-specific PCK (from Veal and McKinister, 1999) discussed previously. Given that appropriate knowledge for technology education only emerges through engagement with tasks and activities (Williams, 2009), the application of contemporary PCK frameworks to technology education was theorised to be somewhat premature, as they do not account for the additional negotiation and justification of concepts and principles to be taught (Williams et al., 2016). In other words, identifying the specific grain sizes of PCK for investigation is problematic given the holistic view of the subject. As a result of this, a theoretical methodological framework accounting for the interactions between teachers' knowledge and beliefs about technology was put forward in the model.

The proposed framework, hereafter referred to as the ecologically situated model, synthesises research on teachers' orientations towards teaching (Friedrichsen et al., 2010) with contemporary PCK research and the epistemological basis of technology education. The ecologically situated model builds upon much of the literature surrounding the necessarily dynamic nature of activity in technology education (Atkinson, 2017; Banks et al., 2004; Spendlove, 2012). Perspectives on enhanced teacher autonomy in technology education (Atkinson, 2017; Spendlove, 2012), and research evidence identifying conflicting conceptions of what technology teachers hold to be of importance to student learning in the subject (Barlex, 2015, 2012; Mittell & Penny, 1997; Norström, 2014), led to the greater emphasis being placed on individual teachers' beliefs in influencing enacted practice.

Furthermore, in a pragmatic shift from a descriptive approach to conceptualising PCK to a model which has the potential to be more explanative of enacted practices, the model in turn situates enacted practice as the focal point. Building upon the 'amplifiers and filters' component of the CM (Gess-Newsome, 2015), the ecologically situated model distinguishes between situational and systemic amplifiers and filters of practice. Situational amplifiers and filters are considered to be everyday factors such as availability of resources or student demographics. On the other hand, systemic amplifiers and filters are viewed as factors which affect practices more broadly in the enactment of a subject. For example, the examination system as identified in the previous study (Article I) would be considered a systemic filter of practice.

The variances associated with technology education as a subject area that does not adhere to conventional disciplinary dogma, in having a defined epistemic boundary, are theorised to increase the need to consider the role of teachers' beliefs in influencing enacted practices. With the intent of furthering understandings of the relationship between rhetoric and reality in technology education that this thesis is more broadly concerned, the ecologically situated model presented (Article II), represents a common frame of reference for the investigation of teachers' beliefs as a potential mediator between teacher knowledge and actions in the classroom. The proposed model also captured current understandings of PCK as a potential mediator of enacted practice, moving beyond descriptive conceptions of PCK as an entity. Furthermore, with the preponderance of exploratory research facilitated through the broad conceptual terms used to define the subject area (Jones et al., 2013), more systematic approaches to investigating enacted practices, and the multitude of confounding factors identified in this framework were advocated (Article III).

Throughout this literature review and the different stages of refining the ecologically situated model, the epistemological basis of technology education re-emerged as a point of contention. Thus, following the presentation of the model, attention turned to the different ways in which enacted practice, teacher knowledge and teacher beliefs may be investigated in technology education. In alignment with the underpinning rationale for the model, the limitations of applying research approaches from subject areas with defined epistemological basis to technology education were critiqued. With its basis in advocating an ecologically situated approach to exploring practice and PCK within technology education, the need to develop approaches that consider the relationships between teacher actions, beliefs, and knowledge in technology education were put forward (Article III). Much like the autonomy afforded to the technology teacher in defining activity discussed throughout this thesis, the autonomy afforded to the technology education researcher in defining a specific research agenda comes to the fore. Through opening a discourse on the variables which may have more influence on practices in technology education, this ecologically situated model (Article II) and the subsequent problematising of its application (Article III), sought to take a step towards methodological coherence in the study of enacted practice in technology education.

Doyle, A., Seery, N., Gumaelius, L., Canty, D., & Hartell, E. (2019). Reconceptualising PCK research in D&T education: proposing a methodological framework to investigate enacted practice. *International Journal of Technology and Design Education, 29*(3), 473–491.

Doyle, A., Seery, N., & Gumaelius, L. (2019). Operationalising pedagogical content knowledge research in technology education: Considerations for methodological approaches to exploring enacted practice. *British Educational Research Journal, 45*(4), 755-769.

4.3. The purpose of teaching technology

Following the presentation of the ecologically situated model (Article II) and problematising of the intricacies of operationalising approaches to investigating enacted practice in technology education (Article III), specific attention was given to the beliefs components of the proposed model. The following research question was developed: *how do technology teachers represent the purpose of teaching technology through reflection on their enacted practices?* The decision to focus on teachers' beliefs was largely influenced by the previous finding of a contention between teachers' personal conception of capability and their reported practices (Article I). As this finding suggested that teachers' beliefs govern their actions, although the mediatory effects of systemic amplifiers and filters should also be noted, an empirical study was designed to investigate the three beliefs components of the proposed model (Figure 5).

A significant decision to be made in the initial stages of this investigation was the national context(s) in which technology education was to be investigated. In recent times, the place of technology education in school curricula has been somewhat turbulent (Jones et al., 2013). Thus, national contexts in which technology education holds a sustained place in curricula (Seery et al., 2019; Wright et al., 2018) were identified as sites of interest. In this study, teachers from the Republic of Ireland, Sweden and New Zealand were identified. Importantly though, the different sites were not outlined as different educational contexts through which comparisons were to be made, but rather they served as exemplars of technology education. In a sense, this study elevates 'technology education' to a conceptual space beyond regional curricular specifications to include different manifestations of the subject internationally. Consequently, although different 'sites' were identified, this study was designed to investigate a singular dataset. Thus, with the intent of investigating and ensuring the transferability of findings between education contexts, this study is framed in a transnational sense.

In addressing the stated research question, a constructivist Grounded Theory (GT) approach was employed. Constructivist GT was decided as an appropriate method primarily through its capacity to explain complex social interactions, through mediating existing theoretical understandings with data emerging from the field (Charmaz, 2006). Rooted in relativism (Mills et al., 2006), constructivist GT acknowledged the preconceptions associated with the researcher, and considers how they may affect the study. Resultantly, data and theories are not described as something which is discovered, but constructed by the researcher(s) as a result of interactions with the field and interviewees (Charmaz, 2009;

Thornberg & Charmaz, 2011, 2014). With this in mind, an initial interview guide was developed using the three components of beliefs identified in the ecologically situated model as relevant avenues for exploration; (1) the goals of teaching technology, (2) teaching and learning in technology, and (3) the nature of technology education. The duration of this study can be described as a constant reflexivity between data and existing theoretical understandings. This was facilitated through a memoing system whereby extant knowledge associations were noted to assist in refining the development of codes, categories, and theoretical relationships. Importantly, the constant reflexivity involved using the literature as 'lenses' based on its capacity to provide explanations of the data, and to focus attention on certain phenomena, in line with the logic of abduction (Thornberg, 2012).

The grounded theory which emerged from this analysis shifted from an initial focus on the goals of teaching technology, towards teachers' rationale for the purpose of teaching. Identified through the association between teachers' organisation of teaching and learning across the years of schooling discussed, and the goals for activities in each year, three different conceptions of the purpose of the subject were identified (Figure 6).

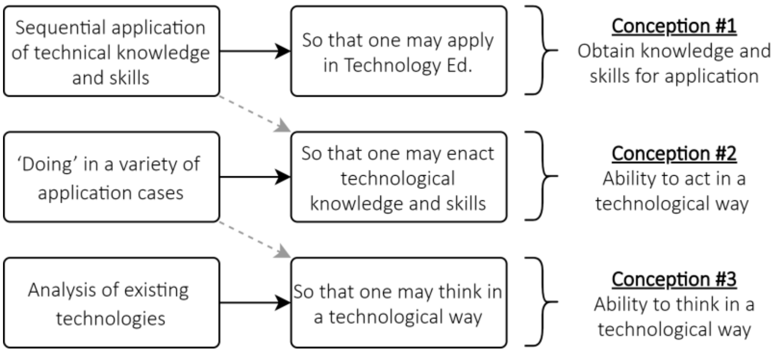

Figure 6. Grounded theory of the purposes of teaching technology (Article IV)

The first conception resulting from the analysis situates the obtainment of knowledge and skills for application as the goal of the subject. Termed 'obtain knowledge and skills for application', this conception was organised sequentially within a singular application case for technology. The technical knowledge and skills associated with the application case was viewed as foundational to progression in the subject area. It is here that an important distinction is drawn. Although an progression between conceptions was observed in some instances, for example, where the technical knowledge and skills were viewed as a prerequisite to acting in a technological way (Conception #2), some participants held that the obtaining of technical knowledge and skills remained the primary focus of teaching and learning throughout the three years of schooling investigated.

With the previous conception, technical knowledge and skill development was held as the purpose of teaching technology, this is also held by interviewees as an appropriate way of framing technology education for another purpose, 'the ability to act in a technological way'. Here, students developed relevant technical knowledge and skills to have, so that they may apply this knowledge in future tasks. In an alternative approach observed within this conception, interviewees situated the act of 'doing' technology in a variety of application cases as both the goal, and organisation for teaching and learning throughout lower-secondary education. With this approach, variability of application case was an intent of the teacher as the remaining commonality, the ability to negotiate novel problem situations was identified as the object of learning.

The third conception identified as a result of this analysis foregrounded students ability to critically think about various technologies, without necessitating engagement with a physical action. Termed 'ability to think in a technological way', this conception is founded on interviewee's assertions of 'technological thinking' and 'technological mind-set' as the ultimate goals for teaching the subject. Rationalised through an evolving technological world, with an exponential rise in the technologies around us, and our dependence upon such technologies, this conception outlines the importance of being able to 'critically engage with new technological innovations'. Again, two approaches to organising teaching and learning were observed within this conception. The first approach adopted the variability of application case approach, whereby students act in a technological way in a number of different cases, but the emphasis is placed on the ability to think in a technological way. The second approach negated the need to act in any instance, instead focusing student activity on deconstructing existing technological artefacts or systems analytically. Students are encouraged to apply a series of 'theoretical lenses' through which to analyse the various technologies under consideration. An apparently sporadic selection of technologies for consideration was noted here. In either the reflective or active engagement with technology approach, the purpose behind engagement with technology education was removed from a specific application case. The purpose instead resided in students developing a broad understanding of 'what technology is and how it affects their lives' and the ability to 'think in a technological way'.

The three conceptions identified in this grounded theory are useful as they open up a discourse surrounding the purpose of technology education, which goes beyond representations of technological activity, or goals for such activities. Although it may not appear intuitive to go beyond the types of activity described by the international community, the observed commonality in rhetoric regarding activity, and the variances concerning articulations of purpose suggest the need for a common framework to inform thinking about why one should engage with technology education. The transnational nature of this study highlights the potentially far-reaching implications of such findings, as the grounded theory may serve as a provisional unified way of framing technology education.

An important point of note is the relationship between conceptions, as an initial glance may presuppose that there is a hierarchical relationship. Although this was observed in instances (i.e. conception #1 as a prerequisite to conception #2) the opposite was also observed. For example, where interviewees outline the importance of understanding how to think in a technological way, before one may engage in technological activity. A final note, which will be discussed in the following chapter, was the utility of the theoretical lens of 'subject matter knowledge in technology education' in formulating this grounded theory. Engaging with a discussion surrounding content (subject matter) appeared to be a significant challenge for interviewees. This may appear peculiar given that interviewees have just outlined their goals of teaching technology for three years of schooling, and thus, is something that warrants further consideration.

Doyle, A., Seery, N., Gumaelius, L., Canty, D., & Hartell, E. Subject(s) matter: A grounded theory of technology teachers' conceptions of the purpose of teaching technology. (Manuscript submitted)

5.DISCUSSION

This thesis was contextualised through the apparently perennial tensions between the rhetoric and reality of technology education (Banks & Barlex, 1999; Kimbell, 2006; Spendlove, 2012). The difficulties associated with articulating the intended learning outcomes of the subject area in a more specific way than the higher constructs of technological capability, technological literacy, technacy, technological competence and technological perspective was broadly mirrored by teachers' descriptions of learning activities in both of the empirical works conducted. However, findings outlining teacher's awareness of contentions between their intentions for student learning, and the actuality of their day-to-day practices, highlighted the importance of understanding the role of the individual technology teacher. Specifically, the research turned towards more foundational approaches towards conceptualising technology education, and what this means for the investigation of practices in the subject area. In the following sections, implications for (1) imagining a consolidated technology education, (2) advocating for the investigation of technology education, and (3) unrealised teacher potential within the subject area will be illustrated.

5.1. Imagining a consolidated technology education

The grounded theory study showed that despite commonality in how teacher's represented learning activities in technology education, there is considerable variance concerning articulations of purpose for engagement with such activities (Article IV). Although such a finding may be in part symptomatic of the activity focused rhetoric of technology education (Jones et al., 2013), the resulting effects on the nature of student learning warrant discussion on how the subject area is currently framed. As previously noted, multiple perspectives on what constitutes technology education exist within the literature, not only in the sense of different cultural or historical perspectives, but as to the nature of technology which manifests as technology education. There are a couple of useful ways of thinking about this.

With the intricate association between technological knowledge and technological activity, whether or not it is possible to explicate technological knowledge for teaching, or if this knowledge would then be better represented as technical (as discussed previously, e.g. Barlex, 2007), raises significant questions about explicitly teaching technological knowledge. The implications of separating technological activity and technological knowledge has previously been discussed within the literature. Notably, Kimbell's (1994) assertion that activity devoid of purpose beyond teaching a skill or internalising a piece of knowledge would more appropriately be termed craft, science or history, dependant on the knowledge or skill involved. Ensuring that the focus of learning remains technological in nature then turns to the association between knowledge and activity. In particular, is it necessitated that students engage with the act of doing technology, or is reflection upon previous technological solutions or innovations appropriate. Building upon this perspective, the theoretical lens of 'subject matter knowledge in technology education' used in developing the grounded theory can be useful in delineating the epistemic basis of the subject. Regarding the treatment of knowledge, considerations of technological knowledge as 'provisional' and determined by its utility in a specific application case reflects the 'ability to act in a technological way' conception. Norman (2013) describes this as a form of epistemological fluidity. This approach contrasts with the somewhat sporadic identification and selection of technical knowledge held within the third conception, the 'ability to think in a technological way'. The treatment of knowledge associated with technical application cases here may be represented as a form of epistemological fluency, as the ways of using technical knowledge, and understanding how technological knowledge is developed, is held above learning explicit technical knowledge. In other words, the explicit technical knowledge is subservient to ways of thinking about how such knowledge is used. In developing this further, with the centrality of explicit technical knowledge (and skills) within the first conception, to 'obtain knowledge and skills for application', the goal for teaching and learning may be described as a form of epistemic fluency. An understanding of, and the capacity to apply specific technical knowledge is the focus of teaching and learning within this conception.

With the differences in conceptions of the purpose of teaching grounded in the realities of practicing teachers, one must consider the different ways in which technology education is currently framed. In applying the grounded theory developed herein, questions arise as to the purpose of technological activities, namely, is the role of technology education to develop (1) technical knowledge and skills for application, (2) the ability to engage in technological activity, or (3) the ability to speculate about the consequences of technological activities. The perspective put forward here is that an authentic technology education resides at the unison of these perspectives. In borrowing the terminology from Mitcham's fourfold classification, perhaps the most authentic technology education would consist of engagement with doing (activity) or reflection on previous technological solutions and innovations (artefacts) so that one develops an understanding (knowledge) of what motivates (volition) technological change and the consequences of this change. Although this should be treated as provisional, the amalgam of the three conceptions serve as a useful mechanism for the technology education community to envision a consolidated view of technology education.

5.2. Approach to investigating technology education

Framing a school subject through the ways in which knowledge is treated, rather than outlining specific knowledge for attainment, affords significant autonomy to the technology teacher in planning for and enacting their subject (Atkinson, 2017; Spendlove, 2012). The identified contentions between teacher's personal construct of capability and their reported enacted practices (Article I) suggest that the role of the technology teacher needs to be better understood. Although the conceptions identified in this thesis serve as a useful point of departure for considering the purpose of teaching technology that goes beyond representations of activity, the technology teacher must still make decisions about how to enact the subject. There are two important contributions from this thesis that facilitate the investigation of how technology education is enacted, the ecologically situated model (Figure 5) and the theoretical lenses utilised in the development of the grounded theory (Figure 7).

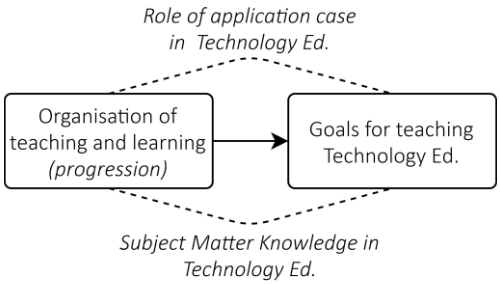

Figure 7. Theoretical lenses for analysis (Article IV)

Firstly, the ecologically situated model was designed in such a way so that the idiosyncratic nature of activity in technology education (Stables, 1997) was placed as the focal point of investigation. In essence, the model affords a perspective on enacted practice whereby teacher knowledge and teacher beliefs may be used to explain enacted practice, but are not the focus of investigation. Although this perspective raises questions as to traditional approaches to investigating PCK as an entity (i.e. something which is measured), the rejection of this approach is becoming increasingly common in other subject areas (Chan & Hume, 2019). Furthermore, meso-level subject-defined or region defined investigation of the concept of amplifiers and filters affords a distinction between factors which are unique to an individual teacher, those that are imposed within a specific teaching episode (situational amplifiers and filters), or within an educational system more broadly (systemic amplifiers and filters). Predicated on identified misalignment between teachers' pedagogical aspirations and reflections on enacted practices (Article I), the identification of these factors at a situational or systemic level is of importance to realigning rhetoric and reality. Factors identified by these means may be used in the development of interventions which facilitate the (re)alignment of practices with policy. The distinction between these situational and systemic amplifiers and filters is of importance to consider in how enacted practice is studied. Situational amplifiers and filters would be a concern for teachers and school leaders. Stemming from Kennedy's (2010) identification of widespread attributional error in the education research community, situational amplifiers and filters are everyday factors which affect teaching and learning. As such, they are essentially of concern in the management of the teaching environment and resources. Empirical evidence of the variety and impact of these factors would contribute to understanding the rhetoric–reality relationship in technology education. In particular, the role that the individual teacher, or the role that the teaching context, has in influencing enacted practice (Article III). In contrast, and perhaps more pertinently, a misalignment between beliefs and enacted practices may be due to a systemic level impediment to the actualisation of curricular objectives. The identification of systemic amplifiers or filters of enacted practice is perhaps more advantageous, given the widely accepted difficulties in shifting pedagogical paradigms in technology education (Dakers, 2005). The identification of factors of this nature would highlight issues beyond the remit of individual teachers, instead concerning policymakers and school and district authorities.

Secondly, in taking the macro-level grounded theory approach (Article IV), the three beliefs components of the proposed model were used to frame an investigation into the role that teachers' beliefs play in influencing enacted practices. The study resulted in a refining of the theorised relationships presented in the ecologically situated model, through the distinction between goals for activities in technology and purposes of teaching the subject. This was facilitated through the identification of the theoretical lenses used in formulating the conceptions presented in this study (Figure 7). The interplay between technological activity and technological knowledge has been a consistent thread throughout this thesis. During the grounded theory study, a conceptual jump was made to move beyond representations of activity, and questions were formulated to specifically address the subject matter knowledge in technology education. The difficulties teachers exhibited in articulating the subject matter of technology in a more specific way than the nature of activity, as technical knowledge associated with a specific application case, highlights the need for a more coherent theory of practice. The lack of clarity here, as evidenced by the three conceptions identified only serves to further perpetuate rhetoric-reality tensions in technology education. Ultimately, this highlights the need to move beyond depictions of activity and conceptually oriented goals for learning (higher constructs) towards a more coherent theory of practice. In moving towards this theory, clarity surrounding what constitutes subject matter in technology education, and thus what constitutes technology education as a school subject is of importance to consider.

5.3. Unrealised teacher potential

As noted in the previous section, during the grounded theory study, a conceptual jump was made to move beyond representations of activity, towards articulating different conceptions of the purpose of teaching technology. Central to this shift in focus was the identification of the theoretical lenses of 'subject matter knowledge in technology education' and the 'role of application case in technology education'. For the majority of interviewees, articulating the specific subject matter appeared to be a challenge, but two approaches emerged through further exploration and probing. Subject matter in technology education was described as either technical knowledge and skills, or a broader understanding of what technology is and how to engage with it. These depictions, like the associations between knowledge and activity, were not mutually exclusive. However, they can be differentiated through how they are defined. Notably, is the subject matter of the technology education defined by the technical context or specific application case? Or, does the subject matter stand independent of technical context or application case? The different conceptions identified indicate that both of these perspectives prevail in current discourse. In particular, the evidence presented suggests a difficulty in bridging to acting in a technological way (conception #2) from technical expertise (conception #1), and conflating technology with science when a more conceptual approach to the subject was taken (discussed in detail in Article IV). Similar to this, teacher's intentional circumnavigation of curricular materials in meeting assessment criteria (from Article I) would indicate that the technical contextual knowledge appears to govern decision making within the classroom, at the expense of achieving the conceptual goals for learning central to the higher constructs discussed previously.

The grounded theory (Figure 6) developed as part of this thesis utilised conceptions of the purpose of teaching as it allowed individual teachers to hold their purpose for teaching technology in a conceptual space, but also articulate more specifically what it is that students are to learn. Through this macro-level approach, the variability of practices which emerged from the literature review as a defining characteristic of technology education was facilitated. The decision to strive for a more unified way of framing technology education was taken after the development of the ecologically situated model, and now that this theory is in place, although provisional, attention may be turned specifically to investigating enactment at a micro-level. The ecologically situated model presented seeks to facilitate this investigation, through framing a more systematic approach to studying enacted practice. In opening a methodological dialogue (Article III) regarding the design and selection of research methods which facilitate the investigation of the factors identified in the ecologically situated model, this thesis seeks to provoke thought on how to use such research to better understand enacted practices in technology education.

5.4. Implications for practice

The findings of this thesis as presented make a significant contribution to technology education as it applies to researchers, teacher educators, and policy-makers. Furthermore, the implications of this research, as it is grounded in the reality of teachers' experiences, should have a direct translation to practices in the technology education classroom. By association, the ultimate implication for this research in developing understandings of rhetoric-reality tensions lies in the enhancement of student learning.

Firstly, from the perspective of conducting research in technology education, the previously discussed ecologically situated model (Figure 5) and theoretical lenses used in the development of the grounded theory (Figure 7) provide a basis for framing research into enacted practice in the subject area. However, consideration should also be given to the grounded theory itself. The approach here may be to design an experimental study, whereby specific subject matter is engaged with via the different conceptions to identify the efficacy of each conception in the learning of specific subject matter. Alternatively, the tensions identified between different application cases and the development of case-independent constructs may also be considered here. Further to this, the utility of the grounded theory in further exploring the purposes behind teaching technology should also be emphasised. Specifically, in some national education contexts technology education was introduced to replace previous technical or vocationally oriented subjects. There are notable exceptions whereby technical or craft subjects coexist with technology education on curricula. Investigating the association between the different conceptions identified and the different manifestations of technology education internationally may serve useful in understanding the different statuses held by the technology education subjects.

From the provision of technology education perspective (e.g. policymakers, initial teacher education, technology teachers), the grounded theory presented may be of particular use. As this theory is grounded within reflections on technology education practice in a number of different national education contexts, and framed at the level of 'technology education', it may be of use in analysing prevailing practices in other contexts. The theory may be used by initial teacher educators to challenge assumptions about the nature of technology education, and likewise by individual teachers to explore their day-to-day practices. Importantly however, as with any constructivist grounded theory, what is presented here should be treated as provisional. This means that conflicting evidence from practice that contradicts the presented theory may be considered valid. Subsequently, this may lead to further clarification or specification of the theory. As previously noted, the utility of the theory presented lies in its capacity to provoke thought about the nature of technology education(s)

6. CONCLUSION

6.1. Conclusions

In addressing the three research questions this thesis sought to investigate, the following conclusions can be made:

1. Through empirically investigating technology teachers' perspectives on practice through reflection on day-to-day activities, contentions between representations of technology education in the international rhetoric were confounded. Further to this, the complexity of understanding the nature of enacted practice and teachers' rationale for enacted practice was identified to be influenced by a multitude of factors.

2. In consolidating the factors which may influence enactment in technology education, a theoretical model acknowledging the epistemological basis of technology education was put forward. The ecologically situated model is presented to facilitate more systematic approaches to exploring enacted practice, teacher knowledge and teacher beliefs. The challenges associated with investigating practice within technology education were also problematised and recommendations were put forward.

3. Through progressing representations of technology education that go beyond descriptions of activity and conceptual goals for learning, an empirically grounded theory is presented. The theory presented three different conceptions of the purpose of teaching technology, offering a unified language for articulating the purpose(s) of teaching technology.

6.2. Additional works

Additional works which were conducted throughout my time as a doctoral student which informed this research are outlined below:

- The epistemological basis of technology education (Doyle, Seery, & Gumaelius, 2018)
- Philosophy of technology to problematise engineering education (Doyle, Gumaelius, et al., 2019)
- The assessment of technological capability (Canty et al., 2017; Doyle et al., 2017)
- PCK book review (Doyle, 2018)
- Introducing programming through Micro:Bit in Swedish schools (Doyle, Hartell, et al., 2019)
- Orientations towards teaching technology (Doyle et al., 2016)

- Preliminary framework (Doyle, Seery, Gumaelius, et al., 2018)

6.3.Author contributions to the articles

The articles comprising this thesis were written in collaboration with five co-authors: Niall Seery, Donal Canty, Jeffrey Buckley, Lena Gumaelius, and Eva Hartell. With each article, authorship is ascribed in descending order, according to the level of contribution to the article. This section provides a brief overview of each author's contribution to the works.

Article I was written with Niall Seery, Donal Canty and Jeffrey Buckley as co-authors. Following the framing of the study with Niall Seery and Donal Canty, as first author, I collected the data and conducted the initial analysis. Once this stage was completed, a series of iterative reviews between all authors and the data was undertaken, resulting in the framing of the contribution. The writing of the manuscript followed a similar process, once I compiled an initial draft, a series of reviews with all authors refined the text before submission.

Article II was written with Niall Seery, Lena Gumaelius, Donal Canty and Eva Hartell. Based on the findings of Article I, I undertook an analysis of the literature surrounding PCK in education, and as this progressed, in technology education more specifically. This review culminated in the development and presentation of the ecologically situated framework (Figure 5). All authors were involved in the review of preliminary models and reviewed Article II before submission.

Article III was written with Niall Seery and Lena Gumaelius as co-authors. Here, the initial idea was developed in discussion with Niall Seery over the implications of the framework presented in Article II for investigating enacted practice in technology education. Together we framed the contribution and I wrote the text. All authors reviewed the final transcript prior to submission.

Finally, Article IV was written with Niall Seery, Lena Gumaelius, Donal Canty and Eva Hartell. With this study, I framed the approach to data collection and analysis. Through collection and analysis however, the method required a number of reviews of the data relative to the pertinent literature. Once the contribution was framed, I wrote the initial draft and again, this was reviewed by all authors before submission.

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