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Operationalising pedagogical content knowledge research in technology education: Considerations for methodological approaches to exploring enacted practice

Andrew Doyle[a,*], Niall Seery[a,b] and Lena Gumaelius[a]
[a]*KTH Royal Institute of Technology, Stockholm, Sweden ;* [b]*Athlone Institute of Technology, Westmeath, Ireland*

Like many areas of curricula internationally, technology education has encountered difficulties in achieving continuity between the rhetoric of prevailing policy and the reality of enacted practices. In technology education, the conceptually oriented nature of curricular goals is theorised to play a significant part in influencing this relationship. One way in which investigations of this relationship have been approached is considering the application of pedagogical content knowledge (PCK) frameworks as a mechanism to understand the interaction of teachers' knowledge and enacted practices. However, understanding from the philosophy of technology, and the technology education literature, suggests that technology education treats knowledge differently to many other disciplines. As a result of this, the interactions between teachers' beliefs and knowledge are theorised to play a more significant role in influencing enacted practice in technology education. Building on this perspective, this article considers the need to investigate the roles of teachers' knowledge and beliefs, and the interactions between these, in the investigation of enacted practice. Further to this, the article problematises the potential for a dominance of exploratory research, though acknowledging the need for research within different paradigms; a common frame of reference is advocated. In advocating a more holistic approach to investigating enacted practice, and the factors which may influence teachers' enactment of teaching practice, it is envisioned that this article takes a step towards methodological coherence regarding the study of enacted practice in technology education.

Keywords: enacted practice; pedagogical content knowledge (PCK); teacher beliefs; methodological approach; technology education

Introduction

Like many areas of curricula internationally, technology education has encountered difficulties in achieving continuity between what is depicted in policy and curricular documents and the actuality of everyday practices. Often considered as a disparity between the rhetoric and reality of the subject area (Barlex, 2000; Kimbell, 2006;

*Corresponding author. Department of Learning in Engineering Sciences, ITM School, KTH Royal Institute of Technology, Osquars Backe 31, 11428 Stockholm, Sweden. Email: adoyle@kth.se

Spendlove, 2015), these difficulties are theorised to be in part influenced by technology education's technical heritage, where the explicit focus was on meeting culturally specific economic needs through the preparation of learners for the world of work (Dakers, 2005). Over the past number of decades, however, it has become increasingly clear that this educational agenda has become redundant, as focusing on the development of craft skills without any underlying understanding—or the ability to transfer learning to other areas in technology education—is not aligned with the goals of prevailing curricula (Hardy & Davies, 2015). Dow (2014) notes how curricula in technology education are now characterised by their ambition to develop learners' transferable knowledge, skills and attitudes. However, depictions of technology education as a subject area predicated on the transferability of concepts between different contexts are not new (e.g. Black & Harrison, 1985), and the problems associated with a disparity between policy and practice in the subject area can be traced back at least 20 years. For example, in the mid-1990s it was identified that teachers' conceptions of the purpose of (design and) technology education in England and Wales was restrictive relative to the goals of emergent syllabi, with the emphasis placed on technical outputs outweighing the divergent thinking advocated in the curriculum at that time (Mittell & Penny, 1997). Despite the many philosophical explorations of disciplinary goals (Petrina, 2000; Kimbell & Stables, 2007; Gibson, 2008; Ingerman & Collier-Reed, 2011; Dakers, 2014a,b) and developments in policy internationally (ITEA, 2000, 2002, 2007), it is argued that practice in technology education remains largely technical in nature (Dakers, 2018). Despite developments over the past number of decades in the articulation of disciplinary goals, therefore, the difficulties associated with shifting pedagogical paradigms in technology education (Banks & Barlex, 1999; Doyle *et al.*, 2019b) suggest the need for an alternative perspective on how the policy–practice disparity is considered.

In considering an investigation of the relationship between policy and enacted practice in technology education, the nature of technology itself should be considered as it differs from more conventional school disciplines. In contrast to conventional disciplines, where declarative content knowledge forms the boundary of a discipline, knowledge in technology education is recognised as having a unique interdependence with activity. As technological activity is conceived as goal-oriented (Norström, 2014; de Vries, 2016), 'relevant' knowledge only becomes apparent through engagement with the technological activity at hand (Kimbell, 2011). From this, depictions of explicit declarative technological knowledge become problematic as it is unclear what differentiates this knowledge from more conventional knowledge bases. A useful way of conceiving what this means for technology education is to consider the perspective put forward by Kirschner (2009) in highlighting the difference between learning science (in school) and doing science (as a scientist does). Although the relationship between direct instruction and more liberatory pedagogical approaches is contested in many disciplines (Bakker, 2018), in technology education this relationship is much clearer, as the interdependence between technological knowledge and technological activity necessitates that learners engage with technological activity, in that they must 'do' technology.

Although this perspective on technological knowledge has implications for policymakers concerning the prescription of content knowledge *for* technology, this also presents significant challenges for technology teachers. Considering a teacher's approach from the interpretation of curricula to the implementation of enacted practices, the additional complexities introduced through autonomy regarding what to teach require the engagement of teachers' beliefs about what is of importance to student learning. Although the engagement of these beliefs may be perceived as a unique advantage of technology education (e.g. Spendlove, 2012), differences between what teachers believe to be of importance to student learning and what is prescribed in curricula present significant challenges to the unilateral enactment of curricular objectives. As a result of this, there may not be a linear progression from a commonly agreed epistemology between teachers, which leads to accepted topics of enquiry and in turn, common practices. This also raises questions as to the consensus between teachers regarding the goals of the discipline.

It is because of the complexities implicit in the negotiation and justification associated with planning for teaching technology (Williams *et al.*, 2016) that existing methods of exploring enacted practice in general education are theorised to be inappropriate. This assertion is supported by De Miranda's (2018) exploration of the difficulties associated with the translation of pedagogical content knowledge (PCK) frameworks to technology education, where the need for a conceptual framework in the discipline was subsequently identified. As a result of the complexities associated with the evolution of practices in technology education and the disciplinary considerations which may negate the application of existing approaches to exploring practices, Doyle *et al.* (2019a) developed an ecologically situated theoretical framework for the exploration of enacted practices in technology education. Drawing on research from multiple disciplines and research paradigms, the framework may be used in a variety of different ways. As perspectives on the framework are essentially governed by researchers' paradigmatic assumptions and research agendas, this article will explore the variables which researchers must consider in the development of a methodological approach, and subsequently the design or selection of research methods to explore enacted practice in technology education.

Theoretical framework

Despite having been conceived over 30 years ago (Shulman, 1986, 1987), and the considerable attention given to the concept in the educational research community, there has been little consensus as to how PCK is conceived, explored or applied (Abell, 2007). As a result of this, attendees at the 2012 PCK summit held in Colorado developed the consensus model of teacher professional knowledge and skill, including PCK (Gess-Newsome, 2015). 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), it was identified that PCK is no longer considered as a general knowledge base for teachers, nor an individual teachers' knowledge base. PCK is instead situated in a specific teaching experience. This representation of PCK considers the relationship between PCK and practice to be largely congruent, as within this PCK is viewed as being a personal form of knowledge that is espoused in teaching and planning for teaching. In distinguishing between this conceptualisation of PCK and the types of knowledge that have traditionally been labelled as PCK, Gess-Newsome (2015) introduced two new forms of teacher knowledge: Teacher Professional Knowledge Bases (TPKB) and Topic-Specific Professional Knowledge (TSPK). These knowledge bases are described as being canonical in nature and held in the profession itself.

The transition between these canonical knowledge bases and teachers' personal knowledge is described as being mediated by a new concept termed 'amplifiers and filters' of practice (Gess-Newsome, 2015). Similar to the 'supports and hindrances' concept in research on beliefs in teaching (Buehl & Beck, 2014), this concept acknowledges that teachers operate as free agents, and gives recognition to both the limited generalisability of traditional approaches to investigating teachers' PCK and from this, the need for an ecologically situated approach.

In contrast to the depiction of amplifiers and filters of practice in science education (Gess-Newsome, 2015), Doyle *et al.* (2019a) theorised that technology teachers' beliefs may have greater influence on the nature of enacted practices. Supported by the difficulties associated with the prescription of specific content knowledge *for* technology education practice (Williams, 2009; Kimbell, 2011), an ecologically situated model of enacted practice, teacher knowledge and teacher beliefs was proposed (Figure 1). The model adopted the orientations towards teaching framework put forward by Friedrichsen *et al.* (2010), accounting for the beliefs held by teachers that are perceived to influence their planning and enactment of teaching practices. This perspective on enacted practice is supported by much of the longstanding work identifying teachers as living contradictions (Whitehead, 1989), in particular the identification of disparities between teachers' idealistic conceptions of practice and the so-called 'reality' of everyday teaching (Woods & Jeffrey, 1998).

Situating beliefs as a key factor in teachers' negotiation and justification for the planning of teaching technology is a departure from the conception proposed by Gess-Newsome (2015). However, in acknowledging the potential of the concept of

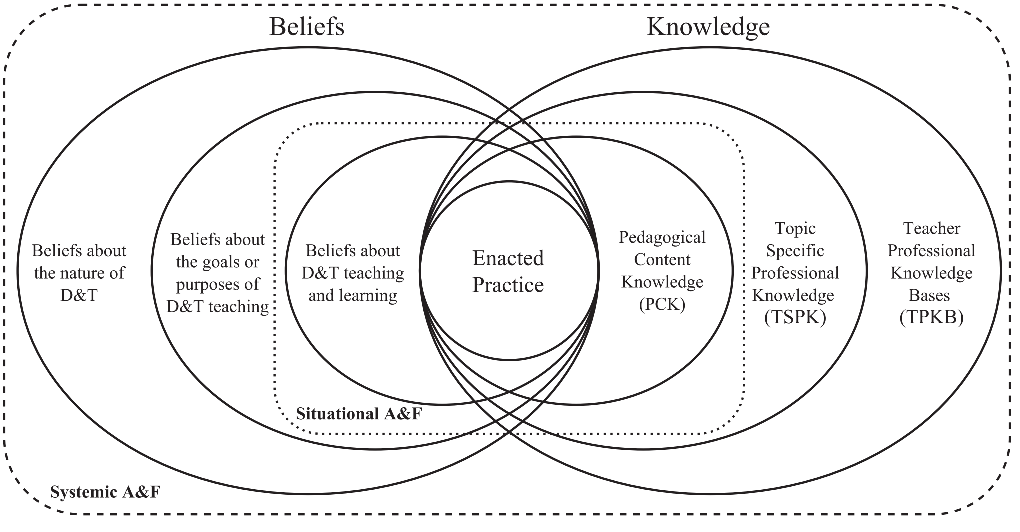

Figure 1. Ecologically situated model of enacted practice, teachers' beliefs and knowledge (Doyle *et al.*, 2019a)

amplifiers and filters, a differentiation was made between the everyday teaching factors (situational) that have the potential to impede or enhance a teacher's enacted practice, and more system-wide (systemic) factors which affect practices across different schools and classrooms.

Stemming from the nature of activity in technology education, the adopted framework facilitates a more robust exploration of enacted practices through recognition of the need to consider interactions between teachers' knowledge and beliefs, cognisant of both situational and systemic amplifiers and filters. Doyle *et al*. (2019a) assert that all of these factors must be considered in a comprehensive exploration of enacted practices, as only then may we understand the impediments to enacting curricular objectives in practice and in turn, strategically effect change.

Considerations for a methodological approach

As with any model, the theoretical framework outlined in the previous section is open to interpretation from multiple perspectives. Of particular interest here is the quantity of variables identified and the difficulties associated with exploring all variables identified in a singular study. As a result of this, decisions must be made about which variables to explore and appropriate methods for data collection. Although these decisions are ultimately governed by a research question or agenda, it is important that all possible variables in the educational transaction are considered. To facilitate future researchers, the following subsections will discuss each of the variables identified in the theoretical framework both in terms of a content description and the nature of data, which is illustrative of each variable. Following this, the design and implementation of methodological frameworks will be problematised.

Beliefs about the nature of technology

The wide differences in understanding within academia and the public discourse about the nature of technology and how it should be engaged (Keirl, 2015) have implications for the study of teachers' beliefs about the nature of technology. Paramount here are the difficulties associated with contrasting depictions of the nature of technology. Barlex (2015) proposed that the nature of technology is difficult to define, as different philosophical positions lead to different definitions. Similarly, when studying teachers' beliefs about the nature of technology with regard to technology education, the researcher's philosophical position will greatly influence the design of a methodological approach.

For example, within a positivist paradigm, the quantification of teachers' beliefs may be achieved through the adoption of an existing philosophical framework, such as Mitcham's (1994) fourfold classification of technology. Another approach to this may be in identifying teachers' beliefs relative to understanding among a community of practice. Such efforts have been made with a Delphi-type study in engineering and technology education (Rossouw *et al*., 2011), where five overarching concepts for study in the discipline were identified. Alternatively, a researcher operating with an interpretative paradigm may identify the need to explore teachers' beliefs about the nature of technology from a more qualitative perspective. An example of such an approach is the group discussions with initial technology teacher education students reported by Barlex (2011). Here, the focus was not on achieving consensus between what students believed the nature of technology to be, nor was it on measuring their beliefs relative to a particular framework. Instead, the focus was on opening a discourse between students regarding the nature of technology itself and its (potential) place on the English (design and) technology curriculum.

Belief about the goals and purposes of teaching technology

In considering teachers' beliefs about the goals and purposes of teaching technology, the educational context in which they are teaching emerges as a significant issue. Necessitated through the difficulties associated with achieving consensus regarding disciplinary goals, the importance of considering a teacher's educational context is supported by variances in technology education curricula internationally (Banks & Williams, 2013). This is further supported through contentions in the literature regarding the language use to describe disciplinary goals, notably technological literacy (Petrina, 2000; Ingerman & Collier-Reed, 2011; Dakers, 2014a; Williams, 2017), technological capability (Black & Harrison, 1985; Kimbell & Stables, 2007; Gibson, 2008; Kimbell, 2011) and, more recently, technological competence (Ropohl *et al.*, 2018). Although variances are apparent in different educational contexts and the research literature, Williams (2017) noted that there appears to be somewhat of a convergence of three broad conceptual principles and that disciplinary goals are generally constituted of an ability/use dimension, a knowledge and understanding dimension, and an awareness or appreciation of the relationships between technology, society and the environment.

The difficulties associated with atomising the goals of technology education beyond these three conceptual principles have implications for the exploration of teachers' beliefs. Although it may appear intuitive to represent curricula as explicit content and utilise this in the development of an instrument to measure teachers' beliefs about the goals of technology education, the nature of technological activity itself is noted to be less concerned with the development of specific knowledge and skills, instead being described as an environment where there are often multiple approaches and appropriate situations to problems (Kimbell, 2011). Accordingly, it may be appropriate to consider teachers' beliefs about the goals and purposes of teaching technology in a holistic sense (Stables, 1997). For example, in the context of initial technology teacher education students, Canty *et al.* (2012) used the term 'conception of capability' to describe student teachers' beliefs about the goals of the subject area. Although the method utilised by Canty *et al.* (2012) was independent of a particular teaching context, this may be advantageous depending on the research agenda, as this method potentiates the exploration of teachers' beliefs about the goals of the discipline relative to their enacted practices.

Another variable for consideration when investigating teachers' beliefs about the goals and purposes of teaching technology is the contextual expectations placed on teachers in terms of the purpose of teaching (not necessarily subject specific). For example, within the Irish educational context the highly performative nature of schooling (Hyland, 2011) is recognised as having a significant impact on the nature of teaching and learning, where teachers have acknowledged their circumnavigation of syllabus content to meet the requirements of summative assessment (Hennessy *et al.*, 2011). Stemming from such an example are concerns of naturalisation and the development or realignment of teachers' beliefs with those espoused on a systemic level.

Beliefs about technology teaching and learning

Although there is a wealth of research exploring teachers' general epistemological beliefs (Schraw *et al.*, 2002; Hofer, 2004) and ontological beliefs (Olafson *et al.*, 2010), over the past number of decades criticisms have begun to emerge of the disjunction between findings of this nature and everyday practice. With the emergence of empirical evidence identifying that the gap between research and practice is perceived as greater by teachers (Vanderlinde & van Braak, 2013), methodological approaches have begun to consider the importance of socio-culturally situated approaches to education research. With this, and in a shift away from binary conceptions of beliefs, more qualitative representations of teachers' beliefs about teaching and learning have begun to emerge. Central to this is the concept of implicit theories (Dweck, 1999), beliefs which have been constructed individually by teachers. Referred to as personal constructs (Kelly, 1955), folk pedagogies and psychologies (Olson & Bruner, 1996), amongst others, these theories are developed by teachers and held intrinsically, often being recognised as difficult to change.

Issues concerning the implicitly held beliefs about disciplinary practices have been discussed at length in technology education, where the difficulties in evolving practices in tandem with policy have been highlighted (Dakers, 2005). From this, Dow (2014) notes that the extent to which implicit theories govern action depends on both the strength of the beliefs held and the congruence between the implicit theories and the teaching context, highlighting the need for an ecologically situated, or at least ecologically cognisant, approach to studying beliefs of this nature.

Researchers are again met with several methodological considerations when designing or selecting an instrument for the capture of epistemological beliefs. Most notable here is the distinction between measuring beliefs and having participants articulate their beliefs. Although the distinction between the terms may appear minor, the assumptions associated with the selection of a method may have implications for the generalisability of findings, particularly when one considers the ontological difficulties associated with technology education as previously discussed. As a result of this, it may be appropriate to shift from the binary conception of beliefs that have traditionally been reported on and move towards more socio-culturally aware methods. Examples of these approaches include the use of reflective interview protocols (Luft & Roehrig, 2007) and vignettes (Olafson *et al.*, 2010) to explore teachers' relative commitment to described beliefs and events.

Teacher professional knowledge bases

As previously noted, in distinguishing between contemporary depictions of PCK and research which had been conducted in the field to date, Gess-Newsome (2015) introduced two new forms of teacher knowledge, TPKB and TSPK. TPKB are defined as general (not content specific) knowledge bases for teaching, such as assessment knowledge or general pedagogical knowledge. For example, assessment knowledge might include knowledge of the design and use of formative and summative assessments and how to use results from those assessments to design or modify instruction (Gess-Newsome, 2015). Importantly, these knowledge bases are commonly agreed by the education community and as they are topic and context independent, they are typically the focus of teacher education programmes. As knowledge bases, TPKB are normative and thus can be used to construct assessments to quantify what teachers know.

As knowledge of this nature is commonly agreed between educationalists, it is relatively easy to develop instruments to construct measurements of what teachers *know*. For example, such instruments exist in the mathematics research community regarding the quantification of teachers' content knowledge within specific topics (Hill *et al.*, 2005; Baumert *et al.*, 2010). The attractiveness of this approach to measuring teacher knowledge likely stems from the largely scalable nature of tests and from this, the broader generalisations which may be drawn from larger sample sizes.

Topic-specific professional knowledge

Whereas TPKB are held by a community of teachers at a professional level, TSPK is knowledge that is clearly recognised as codified by experts in a discipline. Derived from TPKB once attention is turned to teaching a particular topic, TSPK is shared between communities within a specific discipline. Gess-Newsome (2015) describes TSPK as being generated by research or best practice, having a normative function in terms of what it is that we want teachers to know about topic-specific instruction. From this it becomes possible to identify and describe TSPK to construct measures of what teachers know. It is important to note the difference between TSPK and the conception of PCK presented by Gess-Newsome (2015), as decoupling professional knowledge (TSPK) from knowledge held at an individual level (PCK) clarifies many previous attempts to conceive, explore or measure PCK. As a result of this differentiation between TSPK and PCK, Gess-Newsome (2015) asserts that many of the instruments previously used to capture or articulate teacher PCK, such as the Content Representation (CoRe) tool developed by Loughran *et al.* (2004), are in fact representative of TSPK.

The CoRe tool was developed by Loughran *et al.* (2004) to aid science teachers in articulating their content knowledge *for* science teaching (Loughran *et al.*, 2012). In essence, through engaging with a set of questions concerning the 'big ideas' in teaching a particular topic, to a particular grade level, teachers are asked to reflect on their experiences of teaching to begin constructing the CoRe. Through rationalising, linking and representing the *what*, *why* and *how* content should be taught, a group of teachers explicate their collective CoRe. However, as previously noted, the epistemological basis of technology education differs from more conventional disciplines. In the context of TSPK, this differentiation was perhaps best exemplified by Williams *et al.* (2012). In their exploration of the application of the CoRe tool to technology education, it emerged that teachers and content experts in technology education found the establishment of 'big ideas' more difficult than their counterparts in science education. The authors theorised that there was no schema of knowledge that was familiar to all technology participants, highlighting a difference between the nature of scientific and technological knowledge. As a result of the difficulties in articulating technological knowledge with the CoRe tool, Williams *et al.* (2016) conducted an action research project questioning the appropriateness of the traditional CoRe in technology education with a group of expert teachers. The research team found that the nature of questions in the CoRe developed by Loughran *et al.* (2004) primarily concerned knowledge acquisition, whereas the technology teachers identified that the application of knowledge in terms of both understanding and ability was an important part of technological activity. Further to this, much of the organisation of teaching in technology education is by project work, where technology teachers use projects as overarching organisers—each with a number of specific foci. Within each focus, a range of abilities or understandings were viewed as the preferred structure. These findings resulted in the development and presentation of Technology Education Content Representations (TCoRes). Although the differences between both instruments are not radical, the TCoRes are viewed as better representing the practical nature of activity in technology education, and its focus on concepts rather than specific topics for learning.

As well as highlighting the difficulties associated with the transfer of methods to study PCK between disciplines (De Miranda, 2018), these findings highlighted an important point of discussion regarding the use of the term 'topic' to describe content in technology education. In keeping with the conceptual goals of the discipline (Kimbell & Stables, 2007), perhaps the term 'concept' may be more appropriate when articulating curricular goals for teaching and learning in the subject area.

Pedagogical content knowledge (and skill)

In contrast to TPKB and TSPK, which are both canonical in nature and held in the profession itself, PCK is recognised as being a personal form of knowledge. From the definition of PCK previously noted, it becomes clear that PCK is no longer considered as a general knowledge base of teachers, nor an individual teacher's knowledge; PCK is situated in a specific teacher's experiences. This is supported by the consensus that PCK and associated classroom instruction vary 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 this conception of PCK, Gess-Newsome (2015) noted that PCK can be found in the instructional plans that teachers create and in the reasons behind their pedagogical decisions. In other words, this is the knowledge that teachers bring forward to design and reflect on instruction. From this, the relationship between teachers' PCK and practice is theorised to be inherently complex, as this interplay involves both knowledge-on-action and knowledge-in-action (Park & Oliver, 2008). Importantly, from this definition, PCK is derived from teachers planning for practice, their enacted practice, and their reflection on both planning for and enacted practice. Therefore, methods which derive data from anything other than these sources, although they may provide insight into the nature of teachers' PCK, do not constitute its capture. This causes some difficulties in defining PCK as knowledge (given its title), but interpretations of the concept in the research community appear to have surpassed this initial conception (Abell, 2007, 2008; Park & Oliver, 2008; Kind, 2009; Nilsson & Loughran, 2012; Gess-Newsome, 2015). On a similar note, the implications of situating PCK in practice highlights difficulties in measuring PCK in a normative form, as quantitatively representing the subtle and fine distinction between different forms of teacher knowledge has led researchers to question whether or not this is a valid enterprise (Gunstone, 2015).

Situating PCK in both teachers planning for and enactment of teaching thus provides researchers with two very different prospects when considering its capture. In recognising the potential differences between these contexts, Gess-Newsome (2015) differentiates between PCK as previously described and Pedagogical Content Knowledge and Skill (PCK&S). With PCK&S, teachers are recognised as being in the moment of teaching, intent on carrying out their instructional plans whilst also monitoring student involvement and adjusting instruction based on rapid clues. Teachers' knowledge-on-action is explicated in their decision-making around what to teach and why, and is evident in their instructional plans. In contrast, knowledge-in-action is both enacted and developed during teaching by reflection-in-action (Schön, 1983). As a result of this, PCK&S is much more elusive and may only be captured in reflective interviews, where teachers attempt to remember what they were thinking in the moment of teaching, considering what influenced their actions and why. Although PCK&S may also be inferred by researcher analysis of classroom observations, recently there has been criticism of the misinterpretation and over-analysis (Kennedy, 2010) of such educational interactions.

As a result of progression in understanding the nature of PCK and PCK&S, more robust approaches to exploring PCK have begun to emerge in the research community. Paramount amongst these approaches is the recognition of the need to develop a methodology to validly and reliably represent teachers' PCK and PCK&S. An example of such an approach is the learning study methodology developed by Nilsson and Vikström (2015), where data were triangulated between interviews, classroom observations and stimulated recall interviews of recorded lessons.

Exploring enacted practice in technology education

In alignment with the emergence of technology education as a school subject over the past number of decades, technology education research is a relative newcomer to the education research community. This has resulted in many different approaches to exploring the nature of enacted practice in technology education. Perhaps stemming from the difficulties in establishing a commonly agreed epistemology in technology education, these approaches may be perceived as under-evolved, as research(ers) in the area often shifts between established research paradigms. Similar observations have been made in engineering education research, where the eclectic nature of research practices leads to perceptions of the discipline as methodologically unsound (Pears *et al.*, 2012). Although research practices of this nature may be perceived as immature, the autonomy afforded in the design of methodological approaches may also be perceived as a unique advantage of the discipline, as without the imposition of strict research paradigms, researchers may design methodological approaches for more nuanced purposes. Importantly, however, bereft of guidance from an established paradigm, the potential for a preponderance of exploratory research (Daniels & Pears, 2012) suggests the need for a common framework to facilitate more pragmatic research. From this perspective, Doyle *et al*. (2019a) present their framework, which seeks to bring credibility to PCK research in technology education through facilitating a more systematic approach to studying enacted practice. Through opening a methodological dialogue regarding the design and selection of research methods which facilitate the investigation of the variables identified in the theoretical framework, this article seeks to provoke thought on how to use PCK research to better understand enacted practice in technology education.

In progressing this research, a critical point for discussion is the interpretation of the theoretical framework and the development of research methodological approaches, as the quantity of variables identified may become too difficult to manage in a single study. Here, the need for a specific research agenda comes to the fore, as without the rigorous paradigmatic beliefs and associated guiding principles, a technology education researcher's agenda will have greater influence on the design of a methodological approach. Importantly, the framework adopted herein does not mandate the investigation of data representative of each variable. Instead, it is advocated that appropriate data points are selected depending on the specific research aim. Subsequent to this, other variables may be controlled, or at a minimum considered in the design of the methodological approach. For example, in exploring the practice of newly qualified teachers, it may be possible to take their TPKB as common based on their background and the commonality between their teacher education degrees.

It should also be noted that a singular data collection method may have the scope to capture appropriate data from a multiple of the variables discussed. For example, although the CoRe tool has been discussed in the context of ascertaining teachers' TSPK, insights may be drawn into their beliefs about teaching and learning in technology as questions on the instrument pertain to this. Then, multiple methods may be utilised to validate the findings convergently through the triangulation of data (Crano *et al*., 2015).

An alternative perspective to validating findings convergently, however, is facilitated through the concept of amplifiers and filters. Predicated on potential misalignment between teachers' pedagogical aspirations and enacted practices, the identification of these factors at a situational or systemic level is of critical importance. Factors identified by these means may be used in the development of interventions which facilitate the (re)alignment of practices with policy. The identification of situational factors would be of 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 our understanding of the policy–practice relationship in technology education. In contrast, a misalignment between beliefs and enacted practices may be due to a systemic level impediment to the actualisation of curricular objectives. The identification of system-level factors is perhaps more advantageous, given the widely accepted difficulties in shifting pedagogical paradigms in the discipline (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. The existing evidence of such a disparity between technology education rhetoric and the reality of enacted practices warrants future research of this nature.

Conclusion

In summary, the theoretical model adopted herein recognises the vast array of variables which have the potential to influence enacted practices in technology education. Necessitated by the difficulties associated with exploring the tacit nature of knowledge used in teaching (Elliott *et al.*, 2013), and the role that teachers' implicitly held beliefs have in influencing enacted practice (Friedrichsen *et al.*, 2010), this article seeks to open a discourse on the relationship between teacher knowledge, beliefs and enacted practices. The additional variances associated with technology education as a subject area that does not adhere to conventional disciplinary dogma, in having a defined epistemological boundary, are seen to increase the need to consider the role of teachers' beliefs in this relationship. Through opening a discourse on the relationships between these variables and the multitude of different methods by which both the variables and the interrelationships may be studied, it is envisioned that this article takes a significant step towards methodological coherence regarding the study of enacted practice in technology education. This step may be viewed as creating the foundational understanding necessary to develop approaches to future research agendas.

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