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Subject(s) matter: a grounded theory of technology teachers' conceptions of the purpose of teaching technology

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Abstract
Technology education internationally has for some time struggled to achieve continuity between what is depicted in policy and curricular documents and the reality of day-to-day practices. With its focus often articulated through the nature of activity students are to engage with, technology teachers are recognised as having significant autonomy in the design and implementation of their practices. From this, it is important to understand teachers' beliefs about technology education, as their conceptions of the subject will inform practice. As such, this study sought to investigate teachers' conceptions of the purpose of teaching technology through reflection on their enacted practices. A constructivist grounded theory methodology was employed for the design of the study and analysis of data. According to our analysis, despite similarities between the nature of student activity that teachers designed and implemented, teachers represented the purpose of the subject in different ways. Three different conceptions of the purpose of teaching technology were identified; obtaining knowledge and skills for application, ability to act in a technological way, and ability to think in a technological way. Central to the three conceptions were contentions in the representations of what constituted subject matter knowledge in the subject, and the role that different application cases played in teaching technology. Without consideration and explicit articulation of the purposes for teaching technology, this lack of clarity and differences in rationale for teaching technology are likely to continue.

Keywords Teacher conceptions · Technology education · Enacted practice · Pedagogical Content Knowledge (PCK) · Constructivist grounded theory

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Introduction

The place of technology education in school curricula is not commonly agreed. Evidenced through the variety of curricular representations (Banks & Williams, 2022), variances in the articulation of what technology education endeavours to achieve has resulted in the subject(s) holding a widely different status in curricula internationally (Wright et al., 2018). Seery et al. (2019) noted that in some educational contexts, technology education has established an elevated status through additional time allocation or curricular reforms, while in other contexts, reforms are indicative of a decline in status as technology education subjects are being integrated or dissolved into the natural sciences. The reasons for this turbulence in curricular positioning and associated status is not necessarily apparent. Jones et al. (2013) noted that the abstract concepts used to define the subject, such as problem-solving, design, and creativity, facilitate a curricular malleability that may be to the detriment of technology education.

The limitations of describing technology education with such concepts are immediately apparent. Negotiating and maintaining space in an increasingly crowded curriculum becomes challenging and the potential pedagogical variances in how technology educators may approach teaching technology (Atkinson, 2017) leaves space for significantly different student experiences within the subjects. These are not new observations, having been reflected for some time in the technology education discourse. Often represented through the difficulties in achieving continuity between policy and curricular documents and the actuality of day-to-day practices, these rhetoric-reality tensions (Banks & Barlex, 1999; Hallström, 2018; Kimbell, 2006; Spendlove, 2012) suggest that technology education has encountered difficulties in gaining status beyond its vocationally-oriented technical heritage. Despite the apparent limitations of using these constructs in articulating the purpose of technology education, they continue to prevail in the discourse. Their prevalence suggests that they may be integral to defining the nature of student learning that technology education endeavours to achieve.

In the place of a more conventional articulation of *what is to be learned* in technology education, the associated negotiation and justification of learning intentions by individual teachers (Williams et al., 2016), the potential for teachers' practices, and in turn, student learning, to diverge beyond the remit of technology education increases. With recent findings suggesting that the reality of technology education practice remains interwoven with its technical predecessor (Doyle, Seery, Canty, et al., 2019), and in an attempt to understand how teachers navigate the processes of curricular interpretation and enactment, this study set out to investigate teachers' conceptions of the purpose of teaching technology through reflection on their enacted practices. The technology teacher is the focus of this research due to their unique position as intermediary between rhetoric, as reflected in policy, and reality, as reflected in enacted practices. In the search for a coherent theory of practice however, we must first consider how the extant literature represents the nature of technology education and what this means for studying the subject area.

Technology education practice

Technical education, the vocational predecessor of technology education (Barlex, 2007) 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. The 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, theoretical constructs such as technological capability (Gibson, 2008; Kelly et al., 1987; Kimbell & Stables, 2007), technological literacy (Dakers, 2014a, b; Gagel, 2004; Ingerman & Collier-Reed, 2011; ITEA, 2007; Williams, 2009), technological competence (Autio, 2011), technological perspective (Barlex, 2007), and, technacy (Seemann, 2009) have been put forward as representations of what technology education strives to achieve. These constructs endorse a holistic perspective on framing technology education, something which has been broadly accepted in the technology education rhetoric for some time (Hicks, 1983; Kimbell, 2009). Technology education's advocacy for a more holistic approach to conceptualising the goals of the subject area appears to reflect the abstract nature of technological activity described within the literature (Stables, 1997). Here, the prescription of specific subject matter knowledge (SMK) for attainment is viewed as somewhat problematic, as the relevance of technological knowledge is noted to be determined by its suitability for application to the problem under consideration (Kimbell, 2011). The problem under consideration here is important to note, with the technology teacher being recognized as having significant autonomy in defining the context of technology education for application. Resultantly, Williams noted that "skill does not lie in the recall and application of knowledge, but in the decisions about, and sourcing of, what knowledge is relevant (2009, pp. 248–249). In the place of a defined epistemic boundary denoting *the* SMK for technology education, there are a variety of problem-solving aptitudes, value-oriented perspectives, and manipulative craft skills that are considered essential to being considered technologically capable and/or literate.

Describing technology education through the broad characteristics that a technology education student should develop, results in the technology teacher having significant autonomy in their enactment of the subject. Doyle, Seery, Gumaelius, et al. (2019) proposed that the epistemological basis of the subject area adds an additional degree of complexity to the investigation of the relationship between teachers' knowledge and practices. Building on comparisons of pedagogical content knowledge (PCK) in science education with technology education (Williams et al., 2012, 2016), Doyle, Seery and Gumaelius (2019) posited that the additional negotiation and justification imposed through decisions regarding what to teach in technology may result in teachers' beliefs having a more significant impact on teaching technology than other subjects. Supported by the difficulties associated with the prescription of specific SMK for technology education (Kimbell, 2011; Williams, 2009), highlights the need to first understand how a teacher conceptualises technology education, before the complexities of enacted practice may be more comprehensively understood.

If for a moment we accept the theoretical construct (technological capability, literacy, competence, etc.) based approach to conceptualising technology education as the most appropriate way of framing the subject, this raises significant questions of the role of the technology educator. Operating as a free agent, a teachers' beliefs about societal goals for schooling, their orientation towards a preferred instructional strategy, or preferred organisation of content within a subject, will influence student learning in any subject (Gess-Newsome, 2015). If the various conceptions of the purpose of teaching, and the enhanced autonomy to define application cases for learning are also considered, the potential for misalignment between teaching and learning experiences may result in the provision of vastly different manifestations of the subject. Furthermore, if the variability of different education contexts, or national curricula are considered, in some cases where many subjects comprise technology education, the commonality of what in fact constitutes 'technology education' comes into question. This is further complicated by the Science, Technology, Engineering and Mathematics (STEM) agenda and the definition of *Technology* in STEM narratives.

It is important to emphasise here that the variability of the application case is in many ways reflective of the literature surrounding the construct-based approach to conceptualising technology education. The position taken is not that this is an unrealistic ambition for the subject, but that the role of the technology educator is amplified and should in turn receive particular attention. The associated variance in what may constitute technology education SMK, is of interest in understanding teachers' enacted practices (Loughran, 2019). In other words, although the PCK possessed by technology educators (personal PCK) will have a significant influence on the nature of teaching and learning within the subject area, their conceptions of the purpose of teaching technology, and what constitutes SMK will mediate their enacted practices (enacted PCK).

Research focus

Variance in the origin and rationale behind the inception of technology education, as well as questions of how technology relates to other subjects on curricula today, has resulted in very different manifestations of technology education internationally (Banks & Williams, 2022). Further to this, there appears to be a paucity of research that considers technology educators' role in the interpretation and enactment of policy (curriculum, syllabus, specification) and how this relates to the international rhetoric outlined previously. This research therefore set out to empirically investigate teacher's positionality in the interpretation and enactment of technology education, through addressing the following question:

How do technology educators represent the purpose of teaching technology through reflection on their enacted practices?

Methodological approach

To investigate teachers' conception of the purpose of teaching technology subjects, a constructivist grounded theory (GT) approach was employed. Constructivist GT (Charmaz, 2014) differs from classic GT, as developed by Glaser and Strauss (1967), primarily through the treatment of existing theory. Within classic GT, Glaser and Strauss emphasised the importance of adopting a purist approach to analysis, whereby the researcher delays the literature review until the later stages of analysis to prevent the contamination of data. Constructivist GT rejects this objectivist position and in acknowledging the difficulties associated with detaching the phenomenon under investigation from its social context, a constructionist perspective on the formulation of theory is advocated. Constructivist GT was selected for this study as the research focused on consolidating the extant rhetoric associated with the construct-based approach to conceptualising the subject area, with emerging evidence from teachers' representations of the actuality of enacted practices. Rooted in a relativist epistemology, constructivist GT assumes that data and theories are not discovered but constructed by the researcher(s) as a result of their interactions with the field and interviewees (Charmaz & Thornberg, 2021; Thornberg & Charmaz, 2014). Centred on the negative implications and difficulties associated with adopting an atheoretical stance to the area of study, constructivist GT acknowledges the researcher's assumptions and preconceptions and considers how they may affect a GT study. In assisting researchers' navigation between inductive and deductive approaches to research, towards an abductive approach, Thornberg (2012) presented seven data sensitising principles to assist conducting a constructivist GT study, namely, theoretical agnosticism, theoretical pluralism, theoretical sampling of the literature, staying grounded, theoretical playfulness, memoing extant knowledge associations, and constant reflexivity. These principles were adopted as the methodological framework throughout the framing, data collection, and analysis stages of the current study.

Context and participants

As the rationale for this study lay in the theorised disjunction between rhetoric and reality of technology education internationally, variance of educational context was deemed an important criterion for inclusion in the study. Although GT has traditionally been used to study social processes and actions within a particular social setting, in this study we elevate the setting to a conceptual space whereby 'technology education' is taken to include a number of variants of the subject internationally. In elevating this study to a conceptual space, the treatment of different national contexts for technology education is important to consider. New Zealand, Ireland, and Sweden were identified as national contexts of interest. Despite having different organisations[1] of technology education, these national contexts were selected as technology education has held a sustained place on curriculum for some time (Seery et al., 2019). Thus, in keeping with the construct-based approach to conceptualising technology education, the different national contexts under investigation were treated no differently than an individual teacher's selection of application cases for engaging students. The focus remained on identifying teachers' conception of the purpose of engagement within a singular dataset of 'technology education'.

As a result of the variance in technology education context under investigation, an inclusion criterion was added that participating teachers must be actively teaching students between the ages of 12 and 15. Initial teacher educators from the authors' professional communities were contacted to purposely identify participants for the study. Participation in this

[1] The national specifications for technology education are as follows: In Ireland, four optional subjects comprise technology education. Applied Technology, Wood Technology, Engineering, and Graphics. More information can be found at https://curriculumonline.ie/Junior-cycle/. In Sweden, technology education is a compulsory subject in school. More information can be found at https://www.skolverket.se/getFile?file=3984. In New Zealand, technology education is a compulsory subject with five distinct 'technological areas'; computational thinking for digital technologies, designing and developing digital outcomes, designing and developing materials outcomes, designing and developing processed outcomes, and design and visual communication. More information can be found at https://nzcurriculum.tki.org.nz/The-New-Zealand-Curriculum/Technology.

study was voluntary. A total of 18 interviews were conducted (New Zealand = 6, Ireland = 7, and Sweden = 5).

Approach to data collection

With the insights from the literature surrounding the constructs-based approach to conceptualising goals for technology education, a set of initial interview questions were designed to focus on four broad areas. The initial focus was on the interviewee's professional background and the teaching context. Following this, the interview was structured using the ecologically situated model of enacted practice in technology education proposed by Doyle, Seery, Gumaelius, et al. (2019). The three components of teachers' beliefs were used to guide the interview: (1) beliefs about technology teaching and learning, (2) beliefs about the goals or purposes of teaching technology, and (3) beliefs about the nature of technology. Where possible the interviews were undertaken in the room in which the participants taught. This provided the opportunity for interviewees to use existing resources and ongoing student activities to aid in explaining their reflections on enacted practices. All interviews were conducted in person. Semi-structured interviews allowed for the discussion surrounding teachers' conceptions of the purpose of teaching technology to guide interviews initially. At the point at which our interpretation of the interviews pointed towards a similar set(s) of experiences and common themes between interviewees, the structure of interviews shifted towards the investigating factors which influenced interviewee conceptions and actions based on their conceptions. The semi-structured format was decided as appropriate as it provided ample opportunity to trace emerging points of interest during the interviews, while at the same time facilitating the evolution and specification of research questions as the study progressed.

Ethical considerations

This study adhered to international ethical guidelines for the interviewing of human subjects (NESH, 2016). Prior to interviews, participants were provided with an information sheet which described the intentions of the research, the nature of data to be collected, and the intended uses for the data. Following this, a volunteer informed consent form was signed by all participants, including information guaranteeing participants' right to confidentiality, access to the data upon request, and the intentions to publish the findings of the research. Participants were also made aware should they wish to terminate the interview or to discontinue their participation in the study, that this was their prerogative. To facilitate the anonymity of participants, all data was anonymised during the transcription process. This involved the cleaning of data to remove all personal identification of participants, or participants' school information. A coding system was developed and used to facilitate this process.

Analysis of data

Interviews were transcribed and analysed on an ongoing basis using the methods from constructivist GT described by Charmaz (2014). In the initial open-coding phase, transcripts were read and coded line-by-line. The explicit focus here was in categorising teachers' representations of activity in technology education, their goals for teaching technology, and their beliefs about teaching and learning in technology education. Through axial coding, relationships between these categories identified that there were striking similarities in teachers' representations of activity, although the purpose behind selecting specific learning activities differed significantly, even in instances where teachers utilised similar learning activities. As representations of individual activities were found to be largely congruent in terms of how goals were articulated, the relationships between activities from year-to-year emerged as a useful focus for framing teachers' purpose for teaching (organisation of teaching and learning, i.e. progression). From this perspective, the research considered the organisation of technology education from a holistic perspective, rather than how a singular activity represents technology education. Based on this analysis, the focus of the interviews was refined to ask questions explicitly about the nature of SMK in technology and the role that different application cases for technology play in teachers' enacted practices. With a reanalysis of all interviews conducted to date, and a reflexive stage where the pertinent literature was used to explore the emergent relationships, the three conceptions of the purpose of teaching technology were formulated. An overview of this procedure is shown in Fig. 1.

The formulation of these conceptions is visually represented in Fig. 2, where the theoretical lenses of the role of *application case in technology education* and *SMK in technology education* were used to explore the relationship between teachers' organisation of teaching and learning and their goals for teaching technology. The association between activities within the subject, in striving for a more holistic perspective on conceptions of technology education is important to note here. In alignment with Thompson's (1992) distinction between beliefs (about a specific activity) and conceptions (about a subject more generally), the analysis of this relationship endorsed a holistic perspective on the subject. The relationships between activities from year-to-year and goals for teaching activities cumulatively were considered, rather than how a singular activity may represent an individual teacher's conception of the purpose of teaching. This approach is signified through the direction of the arrow in Fig. 2. The final cycle of data collection and analysis was undertaken to ensure that no new data contradicted the presented framework.

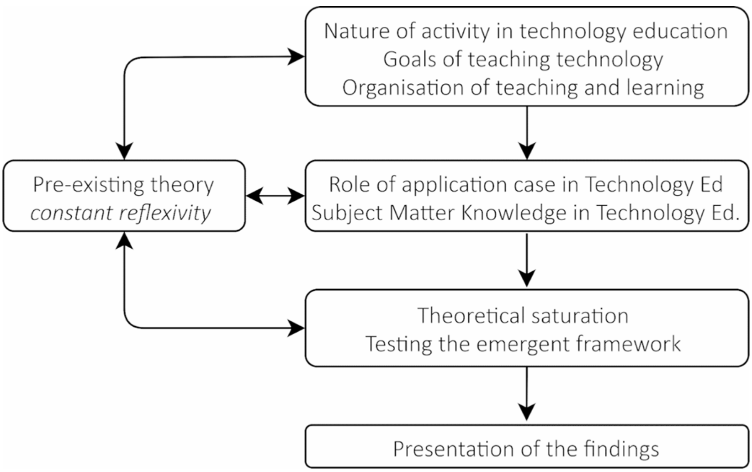

Fig. 1 Approach to data collection and analysis

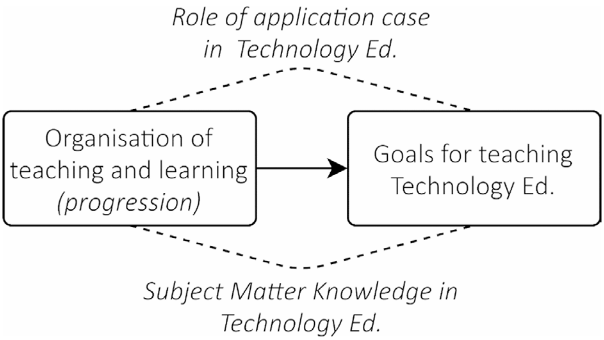

Fig. 2 Theoretical lenses for analysis

Throughout the process of data collection and analysis, memos were used to guide thinking about the data and analysis of the developing framework (Charmaz, 2014). This shared platform facilitated theoretical sampling (Charmaz & Thornberg, 2021; Thornberg, 2012) whereby explanations from the existing literature were sought to provide clarity on the development of codes, categories, and theoretical relationships. This constant reflexivity between findings and the literature involved using the literature as ‘lenses’ based on their capacity to provide explanations of the data, and to focus our attention on certain phenomena, aspects and nuances, very much in line with the logic of abduction (Thornberg, 2012). In keeping with the constructivist GT approach, the existing concepts, arguments, theoretical positions, and empirical studies were considered throughout the data collection and analysis process. It is important to note that the focus on using this extant theory was as a heuristic, to the extent that it facilitated an investigation of the phenomena when confronted with empirical data from the interviews. Thornberg cites Henwood and Pidgeon (2003) in their conception of theoretical agnosticism, meaning that the extant theories and concepts were treated as provisional, disputable and modifiable conceptual proposals. In keeping with the principles of abduction, this perspective was not applied at a distinct stage of the data collection or analysis process, but one that started at the formulation of the study and continued to inform throughout data collection and analysis.

Findings

Each interview conducted as part of this study focused on teachers’ representation of learning activities that teachers sought to engage students with. There were several codes which emerged from the initial stage of analysis that were common to all participants. Most notably here was the emphasis placed on students taking *ownership of learning* towards the later years of schooling discussed. Particularly in the final year of schooling, activity was predominantly framed as a *creative* act by interviewees. Here, *problem-solving* and *design activity* whereby students took autonomy over their work was held as the ideal and characterised teachers’ reflections on the processes they sought to engage students with. As noted earlier, variability in operationalising technology education is referenced as a defining characteristic of the subject area (Kimbell & Stables, 2007), where it is considered a unique advantage (Spendlove, 2012). Coherence at the level of creative problem-solving activity, unsurprisingly then, was observed to manifest in different ways with different teachers. Factors such as *student input* or *student driven* projects, *topical* or *emerging technologies*, and teachers' *personal interests* are all identified as motivators for the design or selection of specific learning activities. Importantly from this analysis, congruence at the level of representation of activity, manifested itself in different ways once attention is turned to the rationale for engagement with such activities, and the structural organisation of teaching and learning from year-to-year. Within this, questions arose as to the associations between goals for specific learning activities, and engagement with technology education as a subject. Reflection on interview transcripts highlighted that in some instances a sequential approach was adopted by interviewees, whereby foundational knowledge and skills were outlined as prerequisites to progression in the subject. From these findings, the next stage of analysis was to undertake a theoretical coding of the data with *progression* as a theoretical lens, whereby participants' organisation(s) of teaching and learning activities from year-to-year were scrutinised. In the following section, the different approaches to organising teaching and learning are presented, providing background for the formation of conceptions described afterwards.

Organisations of teaching and learning: progression and the role of application cases

An important point of note here is the dual use of *context* throughout the paper. To this point, *context* has been used to denote national curricular specifications. Throughout our analysis the role of contexts for technology education played a significant role, being identified as a useful distinguishing feature for the delineation and formulation of conceptions. In this instance, context refers to how interviewees situated learning activities within their respective technology education subject. To avoid confusion between national contexts of technology education subjects, and the role individual *contexts for* technology education played in interviewee's rationale for the purpose of teaching technology, the term *application case* will be used through this paper. When the theoretical lens of *progression* was applied to the data, the relationship between different *application cases* (contexts for technology education) was identified in the participants' reflections. There were three approaches to organising teaching and learning identified as a result of this approach: (1) Sequential application of technical knowledge and skills, (2) 'Doing' in a variety of application cases, and (3) Analysis of existing technologies.

Sequential application of technical knowledge and skills

The first approach to organising teaching and learning focused on the development of explicit knowledge and skills associated with a singular application case for technology education. Described as "training them [students] as to what is required" (Interview four, Ireland) to succeed in the subject, the approach can be characterised as the teaching and application of technical knowledge and skills. This approach was associated with an instrumentalist view of technology, where students are to be familiar with "using the technology available" (Interview four, Ireland) and "learning all about the technology you use" (Interview seven, Ireland). The organisation is sequential in that the relationships between learning activities from year-to-year is governed by the development and refining of explicit knowledge and skills. This approach was also reflected at a micro-level of specific activities, whereby students “practised” (Interview three, Ireland) a skill several times before applying technical knowledge and skills to a final project.

‘Doing’ in a variety of application cases

Whereas teaching and learning was specialised to a specific application case previously, here the objective was to engage students with ‘doing’ technology in multiple different application cases. The rationale behind the selection of application cases varied from teachers’ personal interests to student driven and to topical technologies such as prominent news stories (e.g., “driverless cars” [Interview one, New Zealand]) or popular culture (Interview three, New Zealand; Interview one and five, Sweden). Progression within this approach to organising teaching and learning was more difficult to articulate for interviewees. This appeared to be partly influenced by the unforeseen difficulties associated with engaging with technological activity in a novel application case. Importantly, student failure was embraced by interviewees across all conceptions, failure was identified as inevitable, encouraged even. The mandate for this appears to lie in encouraging students to take risks, with a broader understanding of the “technological process” (Interview five and Six, New Zealand) through engagement being held up as the panacea for engagement with technology education.

Analysis of existing technologies

The third approach to organising teaching and learning did not prioritise engagement with a physical ‘doing’ in technology education, instead the focus is placed on a form of reflective critique. Activities were structured in such a way that students identify and apply a series of “analytical lenses” (Interview five, Sweden) to various technologies. Technologies in this instance are taken in a broad sense to constitute “artefacts” (Interview one and five, Sweden), “systems” (Interview one, two and five, Sweden; Interview one, Ireland), “solutions to problems” (Interview seven, Ireland; Interview three, New Zealand), and “innovations” without problems (Interview five, New Zealand). The *analytical lenses* metaphor was used by several interviewees literally representing the need to adopt different “perspectives” (Interview one, Sweden) or “points of view” (Interview one, New Zealand) on the various technologies under consideration. With examples such as “historical” (Interview one, Sweden; Interview six, Ireland), “ethical” (Interview one, Sweden; Interview one and five, New Zealand), “social” (Interview five, Sweden) and “environmental” (Interview one and five, Sweden; Interview four, Ireland; Interview six, New Zealand) perspectives evident within the various application cases. The variance of technologies studied mandated that students switch between lenses and discuss which is appropriate or useful in a particular context. Here, how technological solutions and innovations have been developed, and how technological systems operated were all identified as appropriate application cases for study. For example, the “paper processing industry”, “school ventilation system” or the “traffic light system” outside the school were used by a single participant (Interview one, Sweden). When questioned on the commonality of student experience from year-to-year or indeed between teachers in the same school, interviewees cited the importance for students to develop an understanding “that technology is something much more than building” as the goal of teaching. The continuity of application cases from year-to-year appeared to be largely driven by teachers' interests, and outside of this, somewhat sporadic.

Conceptions of the purpose of teaching technology: subject matter knowledge in technology

Upon returning to the literature surrounding the organisation of teaching and learning within technology education and the role that different application cases play in technology education, the final phase of analysis adopted *SMK in technology education* as a theoretical lens for analysis. This analysis resulted in the formulation of three different conceptions of the purpose of teaching technology; (1) obtain knowledge and skills for application, (2) ability to act in a technological way, and (3) ability to think in a technological way. Importantly, although three different organisations of teaching and learning were identified, the relationships between conceptions, and approaches to organising teaching and learning activities over the three years of schooling was not necessarily linear. Different organisations of teaching and learning were used to achieve different, although interrelated goals. The implications for this will be discussed later.

Conception #1 – obtain knowledge and skills for application

The first conception identified from the data analysis was that the technology student would obtain explicit knowledge and skills for application within technology education (Fig. 3). Depending on the specific application case, a series of tasks and activities were represented by interviewees as the "typical stuff [content]" (Interview five, Ireland). It was often referenced that such activities were completed "20-something years ago" (Interview five, Ireland) by the teachers when they were students of previous technical subjects. Craft skills in such instances were presented as foundational to progression within the subject, and in the preparation for assessment, developing a number of skills was viewed as important. For example, in this excerpt an interviewee is explaining the approach to the third year of schooling discussed, and the design of an activity for students to engage with:

> … [We] want to build maybe two or three further skills quite quickly and not in a very long project. So, we want something… it doesn't even need to be a thing as such. Just experience in a little bit of laminating, experience in a little bit of veneering, and maybe one other … (Interview five, Ireland).

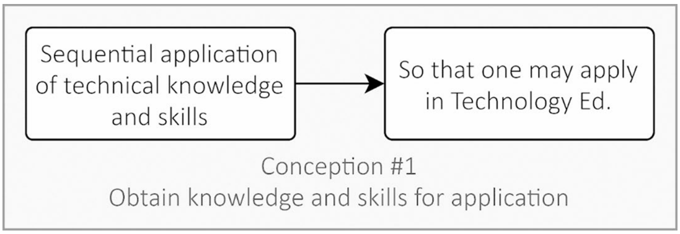

Fig. 3 Obtain knowledge and skills for application

Questions surrounding goals for engagement with technology education were dominated by such answers, for example to "incorporate four key skills" (Interview six, Ireland) or to evidence competence with "hand tools" (Interview six, Ireland; Interview six, New Zealand) at the end of three years in the subject. An important point of note is that the first year of schooling discussed was often dominated by this conception. However, for the majority of interviewees the development of technical knowledge and skills was viewed as a necessary precursor to students acting or thinking in a technological sense which will be discussed with the subsequent conceptions identified. It is here that a key distinction is drawn. Some interviewees held the view that the obtainment of technical knowledge and skills for application, remained the dominant focus of teaching and learning throughout the three years of schooling investigated.

Conception #2 – ability to act in a technological way

Whereas conception #1 held that the role of obtaining knowledge and skills was that one may apply, conception #2 holds that the purpose is to prepare students for acting outside of or after engagement with technology education (Fig. 4). As the critical differentiation here lay in interviewees' assertions of the role of technology education in the preparation of students for life after technology education, this conception was thus termed the 'ability to act in a technological way'.

The following excerpt exemplifies the difference between the more instrumentalist view of conception #1 and that which was held within conception #2. Interviewees often described technology education in this light through how it is differentiated from technical education:

> …a broader focus … in a building construction course we wouldn't get that diversity of solution. … Um, because the motivation was there because they had a solution in mind and a real need for what they were developing … there's a whole difference in the thinking process (Interview six, New Zealand).

Elaborating on the differences between an instrumentalist view of technology education and this conception, the more loosely defined application cases in which activity is framed consistently re-emerged as a defining characteristic. This resulted in "authentic activity" being placed at the centre of teaching and learning, as explained here in discussing the differing roles teachers have between conception #1 and conception #2:

> … the students come up with diverse solutions and so you've got to be able to manage that. Uh, equally the students need to manage that too … and I think that, um, it's much more interesting though, because as a teacher, you often get confronted with problems that you think "oh, that's a nice idea, but how are we going to do this?" And so you're working much more with the students (Interview six, New Zealand).

The approach to organising teaching and learning within this conception emphasised the importance of developing an ability to familiarise oneself with a novel application case, and the ability to traverse multiple application cases. In emphasising one's ability to adapt to and navigate novel application cases, the role of a singular technical area for technology was not emphasised, but rather the skills to make decisions and take actions within a new

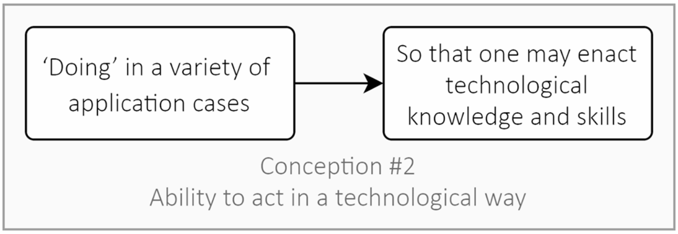

Fig. 4 Ability to act in a technological way

application case. In essence, this approach views action in technology as a prerequisite for action in technology, in that the SMK of the subject was one's ability to navigate multiple complex or novel situations. With this, a significant goal for learning activities lay in one's ability to develop the heuristics to navigate novel application cases. The stark contrast between the previous scaffolding approach towards skills development and the somewhat eclectic approach to which application case specific knowledge and skills are developed is illustrated here:

> …if they can take away some practical skills, the fact that they enjoyed it and it opened their eyes in the nine weeks that we've had them that they can do something that they didn't think they could do (Interview five, New Zealand).

That is not to say that SMK associated with a specific application case is not of concern for educators holding this conception, but rather the content knowledge and practical skills appear secondary to students' ability to act in a technological way. As with conception #1, the emphasis on this conception intensified as students progressed through technology education:

> I'm delivering a certain amount of content… I don't actually believe … I do think I'm doing more teaching at year nine and ten as a teaching practical techniques, teaching skills … at year 11, I should be there less teaching skills and more… triggering thinking. "Do you believe that that's the best way to do that?", "Have we learned a better way of doing that?" and "Why, you know, why could we use that?" And that's what I want to do. Rather than actually teach… and we do still do a certain amount of teaching practical skills, but I'm more of a guide (Interview five, New Zealand).

From these examples, the structuring of SMK, in terms of facilitating progressions between activities in technology education is represented as multifaceted, and subsequently there is an important distinction to be made between SMK as declarative knowledge and SMK as ways of acting in technology education. Through embracing a fluidity of application case, technological actions are framed as the SMK of the subject area. The implications for teachers in necessitating a fluid content boundary in technology education was noted multiple times. Here, technology education is presented as:

> … One of those subjects that may be frightening for some teachers in that it's not clearly defined. And it can't be clearly defined because it has to be fluid and it has to be modern. It has to be … kind of constantly changing… (Interview four, Ireland).

In this excerpt, the interviewee is responding to a question of what the content of technology is, when the three activities discussed are in apparently very different application cases:

> Participant: I don't really know … so that's … oh, I'm trying to think of the context that you've put content in because… Because… Content. What were we using … I guess the way I would look at it is that making [pause] thoughts into physical things. That's … I don't know. This is a tricky one. What is the content … We're making ideas real perhaps.
> Interviewer: Hmmm ….
> Participant: And that might be what we do… Without, without the thinking that we do, nothing would be created and so that's … our content is basically we look at anything outside the room or when you're walking down the street you go, "Hey, I look at that" … and that's what, to me the whole … the curriculum is trying to promote thinking and innovation … that's the content (Interview five, New Zealand).

This question, surrounding the articulation of content in technology education was added to the interview protocol after this interview. In the construction of the GT, the challenge of representing content was identified as a significant challenge, as shown in the excerpts below:

> I think it's so broad. Like, it's so broad and it's so dynamic and so evolving all the time, because I guess like the word "technology"… even technology when you look at it on a wider platform, like internationally, like, it is so utterly changing (Interview five, Ireland).
> I don't really know if I understand the question … even in chaos you have structure. So, I think what you talked… if I understand it right, if you have… because some teachers want it to be like, you know, straight lines. But I believe very much in autonomy … That's what I'm working with now, and I'm quite happy. But if you talk about technology we are not there yet. But they must learn how to use tools, and they must have a methodology how you actually work like… (Interview three, Sweden).

Conception #3 – ability to think in a technological way

The third conception identified as a result of our 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' (Fig. 5), this conception is founded on interviewee assertions of "technological thinking" (Interview five, New Zealand) and "technological mind-set" (Interview one, Sweden) as the ultimate goals for teaching technology. Rationalised through an evolving technological world, with an exponential rise in the technologies around us, and our dependence on these, this conception outlines the importance of being able to critically engage with new technological innovations. An apparent balancing of the investment in developing knowledge and skills associated with a specific application case[2], and the more broad-based theoretical lenses approach

[2] It is important to note the use of the term 'application case' in this instance, as students do not necessarily 'apply' anything. The terminology is maintained however as even in instances where technologies are studied (i.e. a historical perspective), students are studying an application.

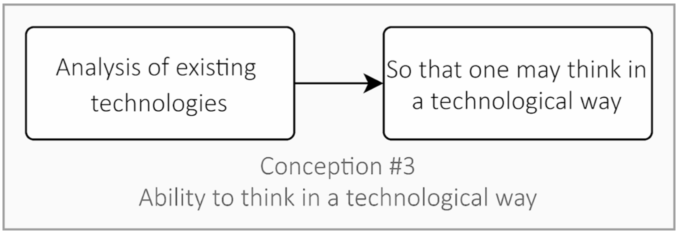

Fig. 5 Ability to think in a technological way

outlined previously is undertaken here. Through reflection upon existing technologies or reliving technological changes, the ability to think about the multiple stakeholders affected by change is foregrounded.

In acknowledging the variances in application case, and the difficulties with activities in the subject building upon one another and "come[ing] together" (Interview two, Sweden), interviewees found it difficult to articulate the purpose of the subject in a more specific way than the forms of thinking outlined previously with the theoretical lens metaphor. The reasons behind this appeared to be somewhat dependent on the associations between the term 'content', and content knowledge as declarative knowledge. Representations of content as declarative knowledge are "dictated by the context or projects that you are working in" (Interview six, New Zealand). For example, in response to a question on the specific 'content; of technology education, this interviewee suggested that although the SMK of technology education is difficult to define:

> …there are certain techniques and skills that people who are technologists need to have … the sorts of skills and knowledge that the students need to have as well. And so there is an underlying content, if you like, because you can't arrive at those outcomes [thinking and actions] without that… (Interview six, New Zealand).

An important point of note is that the conflation of technology education with science education was identified by interviewees specifically within this conception. The scientific nature of application cases for study appeared to influence this. This resulted in students "mix[ing] up the technology subject with the natural science subjects such as physics and so on" (Interview one, Sweden), mirrored by a sentiment that "other areas [departments] in the school don't really understand what happens" (Interview five, New Zealand) in the technology subjects. Although difficulty in explicating the SMK of technology education appeared to be challenging for interviewees, it was also viewed as a strength of the subject area:

> What the context is, and exactly where you might be drawing that knowledge from is not prescribed. That's an advantage. Too many people see it as a disadvantage because it's not prescribed. But it gives me as a teaching professional in the classroom the freedom to draw from whatever knowledge base I need to, to support the learning of the students. (Interview six, New Zealand).

These excerpts highlight the foundational principle associated with this conception. Irrespective of the application case in which the interviewee is teaching, there is a commonality in what it is that they want students to learn. Thus, whether the organisation of learning forefronts engagement with, observing, or indeed reflecting on historical technological innovations or advancements, the purpose behind engagement with technology is in developing a broad understanding of "what technology is and how it affects their [students] lives" (Interview one, Sweden) and the ability to 'think in a technological way'.

Discussion

This study sought to investigate technology educators' conceptions of the purpose of teaching technology through reflection on their enacted practices. Immediately apparent was the congruence in teachers' initial representations of the nature of technological activity. Framed as a designerly activity, whereby students engaged in a problem-solving act, with an emphasis placed on creativity, these representations broadly mirror the theory on activity in the subject area. Only once attention was turned to interviewee's rationale for engagement with such activities, and their organisation of teaching and learning from year-to-year were differences in conceptions apparent. Although representations of technology education have historically acknowledged teacher autonomy in planning for teaching and learning (Atkinson, 2017; Kimbell, 2011; Spendlove, 2015), whereby cultural or historical influences may colour the design of activities (McLain et al., 2019), variance in conceptions of the purpose of teaching are of concern. The identification of different conceptions of the purpose of teaching in a transnational study of this nature, concerning 'technology education', offers a unifying theory (Fig. 6) of how the technology education community may consider the purposes of teaching the subject. The power of this theory stemmed from its focus on teachers' conceptions of the purpose of teaching technology, as this orientation 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. Consequently, in developing a more nuanced understanding of what informs enacted practices, the identification of multiple conceptions has implications for other stakeholders in technology education (policymakers, teacher educators, assessment bodies, parents, and students). There are a number of important considerations identified in this study that highlight the significance and need for a unifying theory.

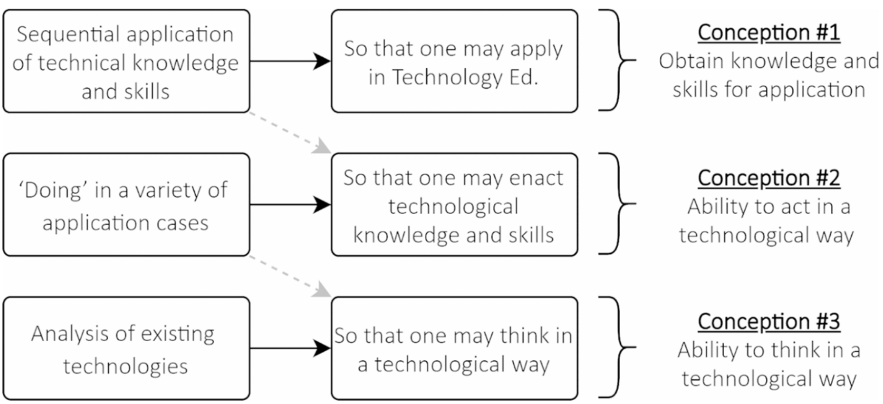

Fig. 6 Grounded theory of the purposes of teaching technology

Firstly, a conflation of technology education with science education was identified when presenting the third conception. The emergence of difficulties in distinguishing technology education from science education would appear to indicate a misunderstanding or miscommunication of what constitutes technology education. Going beyond questions of appropriate SMK for technology education, the conflation of scientific knowledge with technological knowledge raises questions as to whether this may be considered technology education. As outlined previously, technological knowledge is defined through its relevance to a technological issue or problem at hand. As such, in moving beyond a subject boundary as an epistemic boundary, the importance of technology educators (and students) developing an understanding of the epistemological basis of technology education should be emphasised. A recent study (Wu & Ding, 2022) highlighted these tensions in the Chinese context, where it was identified that while teachers valued the development of technological literacy, few teachers considered how students' views and attitudes on technology may be developed. One approach that has been adopted internationally supports the inclusion of the Nature of Technology to the technology curriculum (Compton & Compton, 2013; Pleasants et al., 2019). The theory presented herein, specifically the different perspectives on how SMK is conceived and represented may further support this approach.

The second point for consideration involves whether technology education should address a specific conception or combination of conceptions. It was identified that where teachers' conceptions of obtaining knowledge and skills for application were dominant, that learners found it "difficult to come up with their own designs" (Interview three, Ireland) when engaging with design problems. Instances such as this are of concern as they suggest that the SMK associated with a specific application case takes precedence over more holistic technological practices and technological knowledge. In their analysis of student teachers' conceptions about technological systems, Hallström and Klasander (2017) identified a similar pattern. Hallström and Klasander found that students could identify the tangible and visible parts of technological systems, but that the invisible or abstract aspects of systems, such as flows of information, energy or matter, were difficult to understand for a majority of students. Although at the micro level of a specific concept, student difficulties in abstracting between technological systems, and the overemphasis on the tangible components of systems supports the findings of this study. In other words, policy and rhetoric representations of technological constructs (e.g. technological capability or technological literacy), while presented as the ultimate goal of technology education, may be lost in the application to a specific technical context, as the tangible context specific SMK takes precedence. In suggesting the need for clarity around these issues, the following questions arise: Is the subject matter of 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 in this study indicate that both perspectives prevail in practice.

In both of these examples, interviewee intentions behind activities were not clearly articulated and resulted in student misinterpretation of the purpose of engagement with technology education. Despite a sophistication in the articulation of the nature of technological activity, evidence of the unknowing engagement with a singular conception, or interviewees unknowingly switching between conceptions highlights the need for a framework to discuss the purpose(s) of teaching technology. Although depictions of technological activity may be integral to representing the nature of learning in technology education, the rationale(s) for engagement has been contested in this study. With technology educations difficulties in shifting from the technical education paradigm (Dakers, 2005), and the potential for orthodoxy to become uniformity (Barlex, 2015), the significance of this grounded theory lies in its capacity to provide a unified language for thinking about the purposes of technology education that transverses contextual boundaries, be they national curricular boundaries or application case dependant.

Conclusion and implications

It is striking to hear a technology teacher describe their subject as being "frightening for some teachers" (Interview four, Ireland), particularly when the epistemic fluidity being discussed is not viewed as a negative, but as something to be celebrated within the subject area. Although it may not seem intuitive to go beyond the types of activities described in the technology education discourse, the observed commonality in rhetoric regarding activity, and variance concerning articulations of purpose, suggest the need for a common framework to inform thinking about the purpose(s) of teaching technology. Of particular importance is the individual teacher's navigation between conceptions throughout teaching technology, and their articulation of this navigation. Central to this articulation, clarity surrounding what constitutes subject matter in technology education, and thus what constitutes technology education as a school subject is of importance to consider.

From the perspective of technology education provision (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 three different national education contexts and framed at the discipline level of 'technology education', it may be of use in analysing prevailing practices in other contexts. Again, it is important to note here that evidence of all three conceptions were identified in each national context. While the sample within this study is relatively small, it provides a starting point to investigate different manifestations of technology education. The theory may be utilised 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. The utility of the theory presented lies in its capacity to provoke thought about the nature of technology education(s).

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