Curriculum Development in Technology Teacher Education: Integrating Epistemology, Pedagogy and Capability.

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ABSTRACT

Technology Education continues to establish itself internationally as a primary contributor to a broad and balanced curriculum that prepares students for the technological age that we are living in. It is critical that those responsible for the shaping and delivery of our subjects pay special attention to how they are conceived and delivered to students engaging in the associated subjects. A critical influencer in how technology subjects manifest themselves within the classrooms of our schools is the effectiveness of the teacher education obtained by those who choose to teach them.

This paper outlines a research informed integrated model of concurrent Technology Teacher Education curriculum design and offers insights into the design and delivery of Technology Teacher Education. The framework is presented from a learning perspective in an Irish context, focusing on catering for the contemporary values and competences outlined in national curricula. The paper provides valuable insights into the evolution of contemporary pre-service Technology Teacher education paradigms.

The paper concludes by offering a strategic alignment of content and context through a generative learning model to nurture the attitudes, skills and knowledge that act as the foundational building blocks of an effective, informed, innovative, reflective teacher of technology education.

Keywords: Initial Technology Teacher Education, Integrated Curriculum Design

Introduction

The successful enhancement and development of Technology Education in the future depends on continued research endeavours and subsequent discussions amongst the international community of technology education researchers and educators. From these joined-up efforts must come the integration of the findings of such research into the teaching and practices of technology education in our schools and classrooms. In this paper, the authors aim to consolidate and contextualise selected elements of education research outcomes to inform curriculum design for initial technology teacher education (ITTE). A critical aspect of ITTE curriculum development is the consideration of perspectives of student teachers as they navigate the dimensions of their teacher education. This is even more relevant when we consider these student teachers as the facilitators of future agendas within the subject area.

In an Irish context, it is timely to consider such curriculum development as the National Council for Curriculum and Assessment (NCCA) finalises the review of the four technology subjects being offered at lower second level. The new suite of subject syllabi being implemented for the first time in September 2019 will require a redefined conception of the contemporary goals outlined in the subject documentation. It is critical to ensure that these goals meaningfully materialise and are not merely addressed through surface level change of practices associated with the previous out-going syllabi. An apparent place to address this required change of pedagogical practices and attitudes is through the education of future technology teachers. This paper focuses on informing technology teacher education, maximising impact through the articulation of research contributions into the core structures of curriculum design.

Initial Teacher Education

Powerful teaching is increasingly important in contemporary society. Education is paramount to the success of both individuals and nations, and growing evidence demonstrates that (Darling-Hammond, 2006). This is highlighted in a European context where Buchberger et al. (2000) state that:

"Teacher education across the European Union is a mass enterprise; more than half a million teacher students receive initial teacher education in more than one thousand institutions dealing with teacher education where more than fifty thousand staff (e.g. teacher educators, specialists in academic disciplines) and a large number of co-operating teachers (mentors) work. In-service education as well as further education have to be provided for more than four million teachers."

Alongside the scale of the demand for teacher education, is the fact that it is also a complex area of study, both for undergraduate student teachers and faculty of educational institutions. If students of teaching are to genuinely "see into teaching", then they require access to the thoughts and actions that shape such practice; they need to be able to see and hear the pedagogical reasoning that underpins the teaching that they are experiencing (Loughran, 2007). Edwards et al. (2002) stated that something happens to pre-service teachers during their professional development courses. She outlines that the obvious question to be answered is; "what is it that they (student teachers) have experienced on their courses that allows them to graduate successfully? What is the unique knowledge-base that higher education offers to student teachers on their teacher education courses?"

Preservice teachers should be encouraged to be metacognitive and become more aware of *how* they learn in teacher education courses with the intention of informing their decision-making as they construct their personal pedagogies. (Baird and Northfield, 1992, Hoban, 2002) Northfield and Gunstone (1997) described in their set of principles for teacher education how the student-teacher has needs and prior experiences which must be considered in planning and implementing the teacher preparation program and the nature and intensity of these needs should shift throughout the programme. For students of teaching, their learning agenda includes learning about the specific content being taught, learning about learning, and learning about teaching (Loughran, 2007).

This paper acknowledges the breadth and complexities of teacher education, and specifically looks at the enhancement of technology teacher education with an emphasis on developing technological knowledge.

Philosophy of Technology Education – Technological Capability as Technological Knowledge

Technological knowledge is categorised by its normativity, collective acceptance, non-propositionality and context specificity which has an impact on associated teaching and learning (de Vries, 2016). Internationally, the acquisition of technological knowledge is described as the process for a student becoming technologically capable (Gibson, 2008), technologically literate (Dakers, 2006), or acquiring a technological perspective (Barlex, 2000). There is considerable overlap between these constructs, and different countries tend to emphasise one over the others. In Ireland, the goals of technology education syllabi are typically described under the terminology of technological capability (DES, 2007a, 2007b). This framing allows for a description of technological knowledge with more clarity, for example Buckley et al. (2018) illustrate how technological knowledge maps onto Gorman's (2002) typology of knowledge for technology transfer (Figure 3).

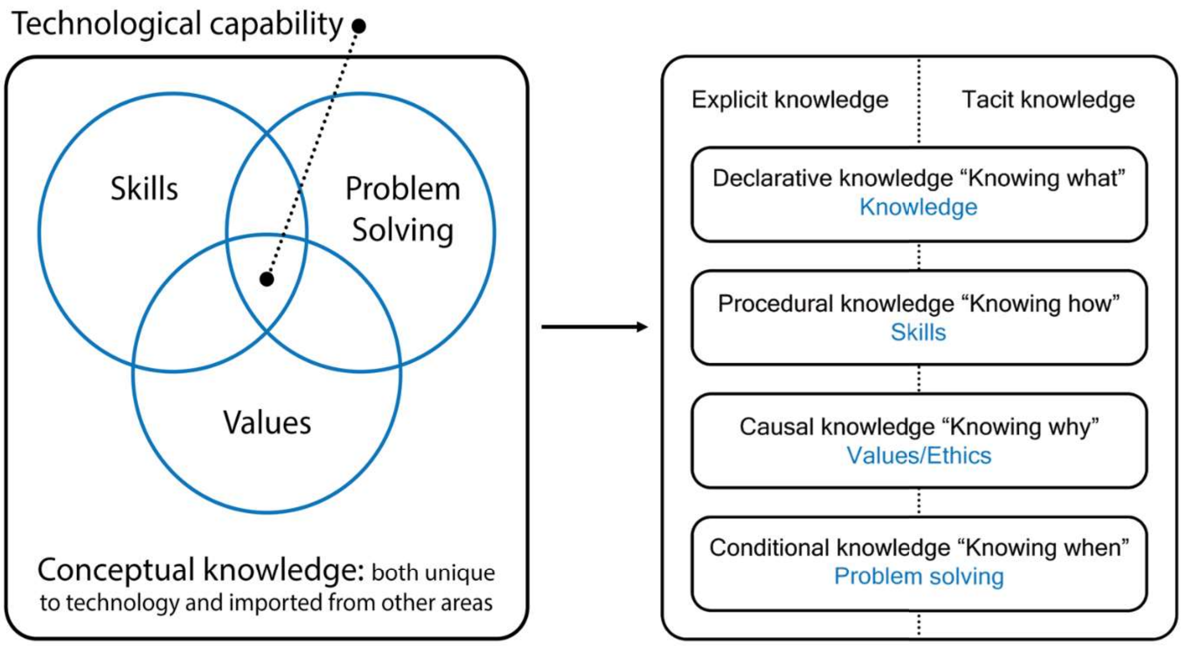

Figure 14. Technological capability as technological knowledge (Buckley et al., 2018).

Acknowledging the distinction between tacit and explicit knowledge (Collins, 2010; Polanyi, 1969), Buckley et al. (2018) describe the types of knowledge inherent to technology education as declarative leading to conceptual understanding, procedural, causal and conditional, and offer the following elaborations (pp.3-4):

- Declarative knowledge, synonymous with Ryle's (1949) knowing that and sometimes referred to as knowing what (Gorman, 2002), is the knowledge of terminology and facts (Huang & Yang, 2009).
- Conceptual knowledge is related to declarative knowledge (Gibson, 2008) in that it is associated with relationships between pieces of knowledge (McCormick, 1997).
- Procedural knowledge, synonymous with Ryle's (1949) knowing how, is knowledge about procedures, actions and steps (Pirttimaa, Husu, & Metsärinne, 2017) which Anderson (1983) notes is initially encoded as declarative knowledge before translating into procedural knowledge.

- Conditional knowledge (Alavi & Leidner, 2001), strategic knowledge (Gibson, 2008) or judgement (Gorman, 2002), also described as knowing when, relates knowledge of conditions and what to do in certain situations.
- Causal knowledge (Alavi & Leidner, 2001) or wisdom (Gorman, 2002), also described as knowing why, describes a knowledge of why certain actions should be taken both from a moral or ethical perspective and based on their causal effects.

This creates a clear understanding that students must acquire a certain body of declarative and procedural knowledge, which is culturally defined through post-primary syllabi, as well as through societal and technological advances, but that they must also learn to act within an ethical framework for the utilisation of such knowledge. To add further clarity in terms of the specific capability a technology student needs, Kimbell (2011, p. 7) describes how the declarative and procedural knowledge which is to be acquired is more akin to a "provisional knowledge" as it will be topic or task specific. Similarly, Williams (2009, pp. 248-249) argues that "the domain of knowledge as a separate entity is irrelevant; the relevance of knowledge is determined by its application to the technological issue at hand. So the skill does not lie in the recall and application of knowledge, but in the decisions about, and sourcing of what knowledge is relevant", highlighting that it is knowledge search heuristics which should form the basis of what is considered technological knowledge and what should be an undercurrent for the development of learning objectives and pedagogical practices in technology education.

Research Informed Perspectives and Associated Theories of Learning

Role of Direct Instruction

Due to the nature of technological knowledge (Buckley et al., 2018), in particular the emphasis on knowledge heuristics (Williams, 2009), inquiry based approaches can appear intuitive. However, these approaches lack necessary empirical support in terms of learning (Kirschner, Sweller, & Clark, 2006; Sweller, Kirschner, & Clark, 2007). There can be an assumption that direct instruction does not involve posing problems or allowing students autonomy. This is not true, as such activities are considered critical for developing a strong conceptual understanding, provided sufficient foundational knowledge is taught first. Contemporary curricular design should allow students to experience an increased level of autonomy and a decrease in explicit guidance over time as they develop a foundational knowledge base and gain the required expertise to engage in self-direct learning. The initial stages of a programme should see students having the highest number of contact hours, where they will learn basic discipline, foundational and professional knowledge which they can build upon. It is essential at this stage, that students are highly supported and make relatively few decisions concerning their own learning. In contrast, in the later stages of their teacher education, there will be much greater autonomy in practice where learning will take place at an individual level and be heavily associated with individual student competencies and interests. The direction and application of knowledge can only happen as a result of the student defining the context for their learning. This is a defining feature of technology education.

As there is novel information presented throughout a programme of study, it is important that the novice-expert continuum (Kaufman, Baer, Cropley, Reiter-Palmon, & Sinnett, 2013) is appreciated. The direct instruction framework cannot be applied simplistically but must fluctuate to correlate to the introduction of novel information, which typically occurs at a topic/task level.

The programme architecture must be built to support this delivery and therefore it is essential to consider empirical research that will aid the student in contextual comprehension. Such programme architecture must support and deliver an integrated approach based on a generative paradigm of learning.

Generative Learning Theory

Generative learning takes place when the learner engages in appropriate cognitive processing during learning, including attending to the relevant information (i.e., selecting), mentally organizing incoming information into a coherent cognitive structure (i.e., organising), and integrating the cognitive structures with each other and with relevant prior knowledge activated from long-term memory (i.e., integrating) (Fiorella, 2015). This approach to learning points technology education curriculum developers towards creating experiences that encourage students to initially consider the relevance of schema. From an ontological perspective, student teachers must be encouraged to consider what is relevant in today's global technological world, in our local cultures and communities and in the school settings that we live, teach and learn in. To coherently organise these "real" issues from an epistemological perspective requires student teachers to consider how these realities can inform what knowledge we should develop and how best to develop it. The integration of this knowledge is a methodological challenge, whereby suitable pedagogies for effective teaching and learning must be employed to ensure that acquired knowledge is aligned with prior experiences and values from within the learner's long-term memory. The application and emphasis of the generative learning theory can therefore lend itself to the development of a meta-cognitive technology teacher, with abilities to self-regulate their learning through selection, organisation and integration of schema. However, to develop the student technology teacher along a continuum from novice to expert requires the key skills associated with the discipline specific attribute of innovation, the underpinning research methods to enable meaningful inquiry and the associated reflective competencies of self-regulation and critique.

Technology Teacher as Researcher, Innovator and Reflective Practitioner

As Researcher

The concept of a teacher as a researcher has many interpretations. It has commonly been conceived that a teacher should conduct 'traditional' university research to inform theory (Flake, Kuhs, Donnelly, & Ebert, 1995) although there has been a shift towards conceptualising teachers as action researchers to reemphasise their primary role asj educators (Laurillard, 2008). This conception of Technology Teacher Education is underpinned by the idea that teachers as researchers needs to strike a balance. Of foremost concern to the teacher should be the education of post-primary students. In achieving this, contemporary foundational and discipline specific educational research should be accessible to teachers in terms of practicality and the capacity for engagement. Importantly, a culture of research must be fostered in ITE programmes which facilitates this. Teachers should also contribute to research and theory where possible to progress educational practices. Teachers should be encouraged to take the role of research participants, action researchers, or independent researchers depending on their interests, motivations, and capacity for engagement. However, the real value in a teacher as a researcher is in teachers having the capacity to best support their students by being able to analyse their own classroom environments and employ what are considered best educational practices appropriately to address learners' needs. The concept of teachers as researchers should be considered critically and contextually to ensure students gain the skills to engage with relevant educational evidence, thus supporting their continued professional development post teacher education, and such that they can use research skills in their own future classrooms, i.e. by creating and interpreting educational assessments validly.

As Innovator

Considering the constructs of technological knowledge and technological capability as knowledge specific learning objectives, there is a need to consider the nature of the activity that technology education espouses. In this sense, the student is being considered more holistically and the question of what a technology student or a technologist is, must be asked. Technology teacher education curricula should be underpinned by the concept of technology teachers as innovators. In saying this, a distinction between creativity and innovation must be made to fully appreciate why the idea of innovators is so important. Both creativity and innovations have many verbal definitions. Sternberg and Lubart (1999, p. 3) define creativity as "the ability to produce work that is both novel (i.e., original, unexpected) and appropriate (i.e., useful, adaptive concerning task constraints)" while Van de Ven and Angle (1989, p. 12) define innovation as “a process of developing and implementing a new idea”. Amabile (1996) differentiates them by describing creativity as the production of novel and useful ideas in any domain whereas innovation is the successful implementation of creative ideas within a domain. Further differentiations include the suggestion that creativity is about divergent thinking and innovation is about convergent thinking (Gurteen, 1998) and that creativity is the generation of novel and useful ideas while innovation is the process of bringing the best ideas to reality (Bisadi, Mozaffar, & Hosseini, 2012). Creativity underpins innovation, but the key characteristic of innovation and of technology students as innovators is that they make, craft, implement, or otherwise, to bring their creative ideas into reality in a purposeful way within a context.

This idea of technology teachers as innovators is reflected within the technology education literature, particularly in terms of the goal disposition of technology students and educators. Specifically, technology students should achieve a balance between being critical and speculative (Buckley & Seery, 2018; Buckley, Seery, & Canty, 2017; Seery, 2017). In this sense, being speculative is synonymous with being creative in the production of new ideas, whereas being critical emerges as technology students engage with the process of implementing their speculations in context. Indeed, being critical has been suggested as the signature pedagogy of technology education (von Mengersen, 2017) where being designerly is the primary activity (Stables, 2008). As such, in terms of the disposition and attitudes of technology education students, technology teacher education programmes should be conceived to promote a disposition of inquiry, requiring students to be speculative and critical, by engaging students in designerly activities. This approach and disposition afford potential for students to acquire technological knowledge and the pertinent associated knowledge search and evaluation heuristics, so they are enabled to go beyond observing the world as it is and envisaging the world as it could be.

As Reflective Practitioner

It is through the development of the previously two outlined professional attributes (researcher and innovator) that technology teachers can become capable reflective practitioners. Without an ability to conduct and/or integrate research into their pedagogical planning and delivery, technology teachers will lack a key competence in being able to reflect upon their teaching in relation to informed best practices. Likewise, if they do not personify innovative practice in their own teaching through creating innovative learning experiences and expose their pupils to engagement in innovative activities, then their ability to reflect on their fulfilment of the contemporary goals of technology education will be somewhat gauged against parameters that lack relevance.

Considering Curriculum Architecture

A suggested model of technology teacher education integrates specific content knowledge and foundational and professional educational studies, in line with the concurrent model, which is recommended as best practice for teacher education provision (Darling-Hammond, 2006). A suggested model is where the key areas of foundational studies, (i.e., curriculum studies, the history and policy of education, philosophy of education, psychology of education, and sociology of education) are all introduced in autumn semesters (i.e. initial semester of each year of study) and contextualised in education. In the subsequent spring semesters, each of these areas is considered again however the learning is contextualised in the area of technology education. This allows for an advanced treatment of the relevant knowledge, but through an approach that is tangible to the students learning holistically. Figure 2 illustrates how knowledge is acquired from a cognitive perspective. As illustrated, in autumn semesters the emphasis is placed on introducing new information and establishing the conceptual links within that information, whereas in spring semesters the emphasis is placed more on contextualising this information by providing additional knowledge to aid in assimilation and meaning making.

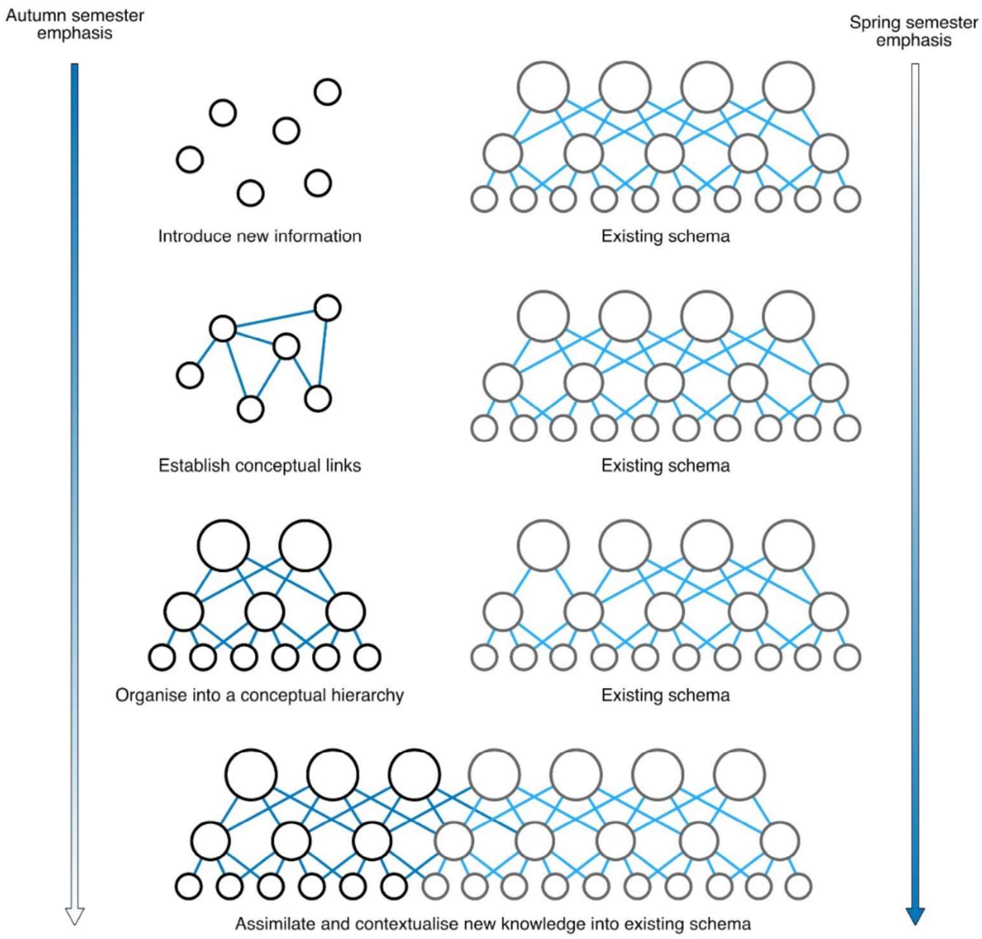

Figure 15 – Delivery and Contextualisation of New Knowledge

Conclusion

Due to a growing research knowledge base, Technology Education is now in a healthier position than it has ever been before. This paper has presented a conceptual framework for technology teacher education grounded upon general and technology education research, whereby an integrated, generative model of direct instruction is suggested to ensure the formation of critical perspectives amongst graduating technology teachers. Having a framework that is informed by empirical research allows us to demonstrate the effectiveness of teacher education provision and empower graduate technology teachers to enhance practices and exploit the full potential of technology education at post-primary level.

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