

Considering the relationship between research and practice in technology education: A perspective on future research endeavours

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Abstract

Technology subjects are a relatively recent addition to the discipline offerings at post-primary level, and have a short but interesting history in terms of associated educational research. In this paper, an overview of the evolving research agendas that emerged in response to the nature of practice, from the perspectives of the Technology Education Research Unit (TERU) and the Technology Education Research Group (TERG) is presented. A chronological account of their research activities is provided, demonstrating the perspectives, paradigms and foundations of their research endeavours. The purpose of this paper is to provoke reflection on the past, present and future of technology education research and practice, using both TERG and TERU for narrative purposes. Therefore, this paper concludes by sharing the evolution of research in TERU and TERG, so as to help consider and shape the future of relevant, contemporary, and progressive research activity.

Keywords

technology education research, Design and Technology education research, TERU, TERG

Introduction

Of the many different perspectives taken within technology education research, the majority share the same agenda of enhancing teaching and learning practices within the field. Despite the volume of effort being invested into this endeavour, there are substantial differences in the status achieved by the subject(s) internationally (Wright et al., 2018). For example, in some countries such as Ireland and Sweden, educational reforms are seeing an elevated status being granted to technology subjects through the development of new syllabi or through additional time allocation, while in other countries, such as the UK and South Africa, current reforms are indicative of a decline in the status of technology subjects as they are being integrated or dissolved into the natural sciences. The fact that technology education is suffering a reduction of status in some countries is an outcome of the problem that, as a subject area, it is not clearly conceptualised and its utility is not coherently evidenced, which

has resulted in a variety of interpretations of its efficacy within general education. Technology education research needs to respond to the discourse within this currently divisive climate but in order to do this effectively, it is paramount that new agendas can empathise this climate. Therefore, this article uses 'Technology' as a universal international description, that is respectful of the individual cultures, conditions, and curricula that define the specific contexts for individual subjects, and 'Design and Technology' (D&T) on occasion when making specific reference to the UK curriculum.

To understand why so many interpretations currently exist regarding the utility of technology education, and to contextualise future research endeavours, it is necessary to consider how it is positioned as a subject area in national curricula at the moment. To understand this, it is useful to consider how it has changed over time. Technology curricula in most countries have strong vocational origins and traditionally focussed on training explicit remits of craft skills. While the nature of the craft in terms of core materials, knowledge and skills could vary, expertise was visible and clearly demonstrable. Contemporary technology education has evolved to now espouse a more comprehensive view of craft and making such that aspirations of the subject now also include the development of more ambiguous competences such as technological capability (Gibson, 2008), technological literacy (Williams, 2009), and technological perspective (Barlex, 2000). This ambiguity and subjectivity have resulted in a large degree of variance and uncertainty within D&T practices (Kimbell, Stables, & Green, 1996) as while educators may share similar aspirations to develop these capacities there can be considerable differences in the pedagogical approaches which are used (Atkinson, 2017). Stemming from this, Technology as a subject area is regularly described as not having an explicit epistemological boundary and instead having a fluid treatment of specific knowledge in its endeavour to develop students' competences (Buckley, O'Connor, Seery, Hyland, & Canty, 2019; Buckley, Seery, Power, & Phelan, 2018; Kimbell, 2011; Norman, 2017; Williams, 2009). The positive aspects of this include the arguably elevated status now afforded to teachers as they have more autonomy, and the increased capacity of the subjects to cater for societal needs. However negative consequences also exist such as the difficulty in generalising research to practice due to the variability in practice. Additionally, without a clear definition of its goals, evidencing the utility of technology subjects beyond what could be provided by other subjects is difficult and provides a challenge to policy makers to assign value and justify the provision of these subjects. It is for these reasons of having a fluid epistemology, ambiguity of purpose, variable practice and resulting inconsistent stakeholder beliefs that technology education is facing challenges in many countries (e.g. Barlex & Steeg, 2017) and it is the aim of this paper to provide context for addressing these challenges through research on teaching and learning in the area.

To support the inception of new research concentrating on teaching and learning in Technology, this article presents a brief synopsis of the evolution of research conducted by two prominent research groups in D&T education, the Technology Education Research Unit (TERU) and the Technology Education Research Group (TERG). By describing how the activities of these groups responded to the needs of the subject at the respective times, context is given to a current challenge of legitimising the various interpretations of Technology within general education to its external stakeholders. It must be acknowledged, that many earlier initiatives and commentators (largely in the 1970's) shaped the then

landscape of the area, particularly in the UK and this formed the foundations of subsequent research activity. Although TERU and TERG are used to exemplify the development in thinking, importantly, there were many other prominent researchers and research groups active during this time who contributed greatly and continue to contribute to contemporary thinking in technology education. The use of TERU and TERG as examples serves purely to guide the narrative of the evolution of technology education research as key moments in the chronology of these groups share parallels with the challenges facing the broader remit of technology education researchers. TERU and TERG were established independently at a time when Technology was transitioning from being a heavily vocational subject to a more general subject. TERU was formally created first in the UK in 1990 and TERG, created in Ireland in 2010, was significantly influenced by the early work of TERU. Importantly, founding members of both TERU and TERG were actively researching in teaching, learning and assessment in Technology prior to their establishment of formal research groups. Initially, research by both TERU and TERG was committed to and heavily influenced by practice orientations and while research was rigorous and impactful, it was not represented or guided by an explicit educational research paradigm. Instead navigating the major research paradigms was an unconscious challenge that relied heavily on practice based experience and personally held beliefs of what was of value in technology education. Both groups operated in different contexts, eras, circumstances, and political landscapes, but were linked mainly by intuitive drivers. Founded two decades apart with very different starting points, the convergence of empirical insights and the identification of key priorities has over the years aligned their interests and agendas. Now, for both groups, research remains heavily influenced by practice, but there is an increased motivation to understand the implications of practice for learners at a more foundational level.

The significance of intuition: The beginning of a journey

Building on the significant discourse surrounding design education in the 1970's, the agenda crystallised with the Assessment of Performance Unit (APU) funded project for D&T in the mid 1980's. The APU project, conducted by researchers who would ultimately become TERU, was a significant milestone in establishing the worldview driving their research activity. The APU was the research branch of the Department of Education and Science (DES) in England. It was designed to answer questions at a systemic level about big-picture units of the education service rather than about individual students or schools. It was designed to provide hard data to assist the policy/planning function for the DES. TERU were commissioned in 1985 to develop the battery of tests in D&T, and following precedent, the expectation was to define the knowledge areas and develop tests for them. However, TERU proposed the idea that it is not exclusively about knowledge in D&T. The position was defended in the initial document which made the case for assessing the process of learning (Kelly, Kimbell, Patterson, Saxton, & Stables, 1987). Here it was argued that there was a need to understand what students could do in response to real design tasks. The inclusion of design challenged the universally understood and accepted epistemology that defined a school subject. The need to understand, acknowledge and celebrate the process was conceived and the intuitive drivers for the shift in knowledge treatment initiated a sequence of challenges. The shift from knowledge tests to focus on a process of design and

development was completely original and required a methodological rethink. TERU created the tasks and then developed a way to administer them remotely to 10,000 students (a 2% national sample), most of whom had no prior experience of design within formal education. Background data was also collected on those students allowing for their performance levels and their curricular experience to be equated. The research resulted in the capturing of 20,000 pieces of design performance from which a variety of findings about the impact of curriculum, context, gender and task type were produced (Kimbell, Stables, Wheeler, Wozniak, & Kelly, 1991).

The brief from the APU head office at the DES to 'find out what the nation's 15-year olds can do in D&T' was not original. It had been done previously in Science, Mathematics and for Modern Languages. However, the response of TERU was original as it did not define D&T as susceptible to explanation through short knowledge tests. TERU defined it as a process and then established methods to make it possible to assess that process. The collected data from this research resulted in the iterative model depicting the relationship between mind and hand (Kelly et al., 1987). The model proved capable of describing the performances observed and demonstrated that in D&T the most reliable form of assessment is holistic.

The results of this project framed the next stage of enquiry. The APU project explained practice in a quasi-experimental design, but the question of validity remained. The activities were artificial to the extent that they were based on short pieces of design activity, not real whole tasks. With strong evidence and a clear agenda, TERU secured funding from Economic and Social Research Council (ESRC) to examine the reality of the process model through case studies. Again, the originality was in the methodology. Driven by the authenticity of the evidence, it was essential to find ways to capture the entirety of the uncertain classroom processes. As a result, TERU developed an observation framework for following four students at a time in a classroom and recording everything they did every 5 minutes for the whole duration of their projects. Research enquiry focused on questions like, who is leading the activity, the teacher or the learner, and what are they doing? After much experimentation and methodological refinement, the approach resulted in 80 (4 students in each of 20 schools) detailed and authentic accounts of D&T performance and learning.

The authenticity of the data created a shift in focus to developing ways of analysing the data. The resulting datamaps were developed to enable the illustration of performance types. Interesting data emerged from that data that they showed how the balance of teacher as director and teacher as supporter varied across school years. The big discrepancy was with Years 7 and 8, the first two years of high school, where teachers were far more directive than the teachers at the top end of primary school. It also made visible girls' performance set against all the different APU test types. This was a complex problem and without the development of the datamaps, it would not have been possible to untangle the significance of the data captured. The data demonstrated that the high ability group performed consistently better than the mid ability group and that the low ability group performed better as the nature of the assessment changed to the point that their performance was almost indistinguishable from the mid ability girls by the end of the assessments. This provided insight about girls' performance in D&T and also about how different tests, tasks and contexts can impact learners' performance in D&T. The possibility that activities could be designed to deliberately favour a particular nominated group became clear. Additionally,

it appeared possible to design activities that largely eliminate bias or to at least balance one sort of bias with another, an act which would be of significant importance to educators.

The two projects were conceived as complementary in the sense that since the APU funded project was large scale and produced generalisable findings, the ESRC funded project needed to be small scale and detailed enough to capture and represent authentic performance. Considering both datasets provided for an informed position and emerged a set of theoretical propositions to explain D&T performance including:

- The iterative model was shown to be generalisably valid
- Tasks were shown to operate differently in different contexts
- The context effect was shown to operate as a hierarchy from broad contextual tasks with a frame of reference from within a context to specific tasks from within a frame of reference
- Thematic contexts also have an impact, i.e. where there was a personal context girls performed better, boys performed better when there was an industry context, and an environmental context proved to be more gender neutral
- Beyond context the tasks themselves could be set as open-ended or closed-ended and this affected group differences in performance
- Primary compared to secondary schools operated different models of practice concerning learner autonomy
- Concepts of 'progression' in D&T could be identified and exemplified
- Assessment practice was shown to operate better as holistic rather than as criterion referenced, and this could be rationalised

The iterative model of mind and hand (Kelly et al., 1987) evolved as a distillation of practice and the APU funded project was then a diagnosis both of learners' performance within it and of the behaviour of the instruments that were developed to probe that performance. The ESRC funded project then enabled those diagnostic elements when set within whole authentic activities to explore larger-scale classroom phenomena, such as progression, and for them to be characterised. The predominantly observational approaches of TERU furthered insights into practices by both aiding the conceptualisation of D&T as a subject in general education and, within this new conception, identifying what worked best for learners. This work paved the way for more predictive research which could both aid in refining the concept of D&T in education and identify more explicitly the underlying factors of performance, attitudes and motivation.

Establishing new pathways: Building research capacity

In an attempt to map out the territory, work commenced on pedagogy and assessment. Projects in TERU amounted to a series of controlled experiments designed to transform practice. For example, the Assessing Design Innovation project (Kimbell et al., 2004) focused on creating and structuring tasks to deliberately provoke creative performance. This grew into 'The Innovation Challenge' run by the exam board OCR as one of their GCSE modules in D&T. It then developed into the Advanced Innovation Challenge at A level which is still running (OCR, 2018). This experience resulted in the evolution of the e-scape project to

begin liberating digital technologies which made possible a quite different approach to assessment, Adaptive Comparative Judgment (ACJ). ACJ was born out of a recognition for the value of the whole, the rationale for the tasks and the capacity to capture the process of learning authentically and in real-time.

Later and overlapping, as TERU was unpacking the significance of their work, researchers who would ultimately become TERG began the task of independently conceiving a research agenda in the area of technology education. Very much lead by intuition, the early work of TERG focused on macro level thinking with regard to the landscape as it emerged from traditional and vocational influences. Much of the work focused on the ideas and the personal enquiry of people in the group. TERG focused primarily on the development of research capacity and the creation of a supply chain of researchers as this would be needed due to the substantial curricular changes which were occurring. Work on the transition of the discipline area, linked to motivations and interests within the group, formed the foundational position to develop a more applied research focus. The pipeline of researchers enabled a strategic development of the research activities that related to practice but concentrated on external validity. Projects tackled 'big' issues and explored new understandings in context, a context very much influenced by the thinking and work of TERU.

The 'worldview' of TERU had a multi-faceted impact on the development and endeavours of TERG. The outcome of the early work of TERU framed the nature of the process, theorised the core interactions in D&T, and highlighted some of the thematic agendas that warranted further investigation. Working within these thematic areas and others depended on member's individual interests, projects within TERG evolved and built upon each other. As the research capacity increased there was a strategic linking of research agendas so as to build comprehensive insight. The dominant strands were qualified by research in attitudes and interests, pedagogy and assessment, and cognition, with much overlap.

Due to the ambiguity in articulating the vocational, neo-vocational or general educational merits of the discipline area, TERG set to establish an understanding of the current learning and the purpose of learning within the discipline of Technology. Research initially attempted to contextualise and explain the variance in training and education at a macro level and highlighted the need to fully understand the meaning of education when translated to educational tasks and activities. This initial work helped articulate a clear position on what contemporary provision should look like. The epistemological position enabled an exploration of the influences on performance and resulted in a predictive model for the academic performance of engineering students (Lynch, 2009). Interest inventories coupled with second level performance established student-course alignment and could confidently predict future success. Questions then emerged with respect to curriculum design, educational interventions and learners' attitudes towards learning (Dunbar, 2010). The early work of TERG also afforded the opportunity to engage with external moderation and as a result it built confidence in the intent and direction of their 'worldview' as applied to technology education research. At this juncture, the newly developing research capability of TERG, strategically interfaced with TERU and the following phase of work in both groups was largely open-minded enquiry into poorly understood territory. An investigation into the application of ACJ in teaching and learning strengthened the TERU/TERG collaboration

beginning through the work of Canty (2012) which investigated the impact of ACJ on student learning. Work at TERG then focused on the idea of supporting discourse in D&T through technology mediated interactions through the PhD work of O'Connor (2016) which critically combined all the existing knowledge and experience built from the initial APU project. Simultaneously, TERG worked on a number of projects that focused on cognition and learning specifically based around modelling and influenced by the iterative dialectic model proposed by TERU. TERG committed significantly to foundational research in the newly defined context of technology (through design) education. Such work explored sketching (Lane, 2011), heuristics (Buckley, Seery, & Canty, 2017; Spillane, 2014), problem solving (Delahunty, 2014) and spatial cognition (Buckley, 2018) as they apply to practice.

Contemporary challenges in D&T: Where to next?

The previous sections, using the evolution of TERU and TERG for narrative purposes, have described some of the chronology of technology education (including the context of D&T) research that has brought the field to where it is now. There is an understanding that the dominant classroom activity is design, and through the use of ACJ there is a valid and reliable tool capable of assessing performance in terms of product outcomes and design processes. Much is understood about creating design challenges for students in terms of the context effect, and about how students should articulate their design journeys through portfolios, building on our understanding of the nature of discourse, communication, and behaviours as they manifest in Technology. Additionally, as a field, there is significant research capacity to address future concerns. Current research effort needs to be invested in uncovering the problems faced by Technology practice today and finding ways to address them. As previously described, there are many beliefs regarding the utility of Technology as a general education subject with the result of this being international variance in its status. This needs to be addressed and will require providing clear evidence that Technology has a positive effect on students. However, in order to achieve this, coherency regarding Technology (all contextual variations) needs to be established. It is argued that this will predominantly involve addressing two areas; the ambiguity of Technology aims, i.e., technological capability and literacy, and what is the purpose and effect of using design to meet these aims.

In terms of the aims of the subject, achieving more coherency regarding what it means to be technologically capable or literate is only the beginning of the solution. There are multiple models for each of these (e.g. Black & Harrison, 1985; Gibson, 2008; Ingerman & Collier-Reed, 2011; Williams, 2009) due to the difficulty in defining them (Gagel, 2004), and there are multiple interpretations of these models, such as considering them to be describing knowledge types rather than a broader form of capability or literacy (Buckley et al., 2018; Pool, Reitsma, & Mentz, 2013; Rauscher, 2011; Underwood & Stiller, 2014). These models suffer the same limitations of other difficult to define constructs. For example, the construct of intelligence is contentious and difficult to ascribe a verbal definition to. In terms of intelligence, Meehl (2006) notes that verbal definitions have never been adequate or achieved a consensus, but the work of Carroll (1993) and Jensen (1998) provided a solution to this problem. The solution here was to provide empirical rather than verbal definitions for intelligence which consisted of factor structures describing the components of intelligence that could be explicitly measured and which had practical use or validity. This approach

would likely be appropriate for describing the ultimate goals of Technology. There are models for technological capability and literacy, but these have limitations such as not commanding consensus, having ambiguous verbal components, and having components which are too broad to measure. It would be advantageous to create an internationally agreed upon model which has hierarchical levels of specificity either in terms of definition or context, and where the components can be measured validly and reliably to determine their utility for students in relation to both Technology and beyond it.

Considering design as the dominant activity used to support learning brings further difficulty legitimising the subject. While it is clear that being able to design is of significant importance, it is the manifestation of this within a classroom that requires continued discussion. One of the major elements of this discussion is whether, within Technology, we are teaching to design or through design (with varying degrees of complexity depending on curriculum). If the goal is teaching students to design, what does this mean? To be able to design is an innate capability (Stables, 2008) and could be regarded as a biologically primary activity (Geary, 2007, 2008), that is humans have evolved to be able to design and as a general capacity, like problem solving, it cannot be taught. However, much like problem solving, when a context is applied, e.g., engineering problem solving or engineering design, these capabilities become biologically secondary activity and can be taught. This creates the question, within Technology practice is design considered in general and if so what is actually being taught, or is there a context and if so what is the context, what context specific design skills are being taught and do these have practical utility to students?

In addition to teaching to design, teaching through design is an idea that requires further exploration. D&T education is often described as containing a substantial degree of uncertainty (e.g. Kimbell, 2011) due to the presence of design. Discourse surrounding knowledge suggests that within Technology it has qualities such as being normative, context specific, and applied (de Vries, 2016) and that acquiring it outside of a context is not important (Williams, 2009). The big question is, what does the uncertainty describe? Who is uncertain? It is one thing for Technology students to be uncertain, that is a necessary prerequisite for learning to occur. It is another thing for teachers to be uncertain in terms of knowledge acquisition and learning objectives. For example, students may be engaging in a design task where there is a learning objective concerning craft, or acquiring a specific piece of knowledge. If the teacher is uncertain that the students will engage with the craft process or piece of knowledge central to the learning objective, the design activity may not lead to the desired result. Therefore, the teacher may be uncertain about much of the activity and auxiliary knowledge and skills encountered and used, but there should be absolute certainty that the use of design will allow learning objectives to be achieved. Additional discourse around design suggests that it creates an opportunity for students to learn to apply knowledge. In any design activity students will have to apply knowledge. The question remains though, if this a skill that can be improved? Can a student become better at applying knowledge, and what does this actually mean?

Conclusion

Capturing the importance of the intuitive drivers that created the 'worldview' of technology education, the early years of TERU research was directly seeking to explore and understand the practice of teaching and learning in design & technology. As if to underline this priority, at the end of the first decade of TERU research, resulted in the publication of 'Understanding practice in design & technology', summarising the significance of that decade of research for teachers and schools. Thereafter, priorities shifted.

It is one thing to describe learners' performance, and seek to provide an explanation of it by reference to the nature of design practice, or of the task, or perhaps by reference to the learners' gender. These external, observable variables had been the focus of early TERU research. But it is a completely different thing to seek to explain the idiosyncrasies of individual performance in terms of learners' foundational qualities. Why do certain tasks have certain effects on specific students? These effects are driven by inner qualities of the individual that are less easily observed, and these began to take centre ground in TERG's developing research programme. Inevitably this forced the researchers into quite different research methods and data collection models.

The emerging research agenda concerning the uncertainty of Technology and the treatment of knowledge became more critical and evidence based for two reasons. There is a need to ensure all Technology students receive equitable provision, and because otherwise the subject area will become increasingly at risk of being delegitimised due to a lack of clarity around its aims, functions, treatment, and benefit to students in terms of both within and outside of education.

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