# Research in Technology Education: looking back to move forward

## Introduction

It has proved very difficult to get a measure of the state of research in Technology Education, and after this paper as the outcome, the feeling lingers that it is inadequate. However, as an overview, and as an opportunity to reflect on research, I trust it is useful.

This paper attempts to summarize the focus of the research that has recently taken place, and from that suggest a trajectory for future research trends. Some research that is considered particularly seminal to the profession is summarised, and the conclusion is some reflections about what research is important.

## Past Research about Research

Few reviews of research in technology education have been conducted in the past. Sherman, Sanders and Kwon (2010) reviewed 24 research articles published between 1995 and 2008 on middle school technology education from four journals: Journal of Technology Education, Journal of Technology Studies, Journal of Industrial Teacher Education and the International Journal of Technology and Design Education. This review indicated that a significant number of these articles were focussed on  the process/content development of new technology education curriculum on (p. 375), and to a lesser extent examined methods by which these new curricula can be successfully presented to teachers (p. 375). They concluded that 'relatively little is known about contemporary middle school technology education teaching' (p. 377).

In an editorial in 2003, deVries surveyed volumes 4-10 of the International Journal of Technology and Design Education with the questions:

- What and why to teach and learn about technology?
- To whom, and by whom to teach and learn about technology? and
- How to teach and learn about technology?

He identified four groups of 'hot topics' in the 99 articles he examined. These were, i) design and problem solving, ii)values and pupils and teachers concepts and attitudes, iii) studies related to national curriculum, and iv) the identity of technology and technology education and its relationship with science. deVries concluded that:

- the field of curriculum goals and content is well covered in the articles surveyed,
- more attention is being paid to educational practice than in the past, but
- research into pupils understanding of technological concepts is very rare, unlike science research into student concepts.

A more limited study was conducted by Petrina (1998) who reviewed the 1989-1997 issues of the Journal for Technology Education. He found that most research was about curriculum, and very few studies dealt with teaching and learning in technology education. A little earlier, Zuga (1997) reviewed journals and abstract databases and her conclusion also was that a significant majority of the research was about curriculum content, and very little research focussed on students and teachers, and the effectiveness of technology education.

## Review Method

In order to develop a picture of the focus of current research, I analysed research that has been published in three journals and presented each year at four conferences since 2006. The journals were The Journal of Technology Education (edited in the US and published in paper form and on the Virginia Tech website), International Journal of Technology and Design Education (published by Kluwer in the Netherlands) and Design and Technology Education: an International Journal (journal of the professional association in the UK). The conferences reviewed were the annual UK Design and Technology Association conference, the PATT conferences which occasionally have more than one in a year, the biannual Technology Education New Zealand professional association conference and the biannual Technology Education Research Conference (TERC) sponsored by Griffith University in Australia. This analysis resulted in 472 manuscripts which were either published or presented.

The methodology for this analysis was admittedly somewhat idiosyncratic, and there is much research taking place in, for example, South America, northern and eastern Europe and Southern Africa that was not considered in this presentation. This represents a limitation of the findings. Within those limitations, the research approach was inclusive, and so considered papers which were clearly and identifiably research, posing an empirical question and using quantitative or qualitative methods, but also papers which were more theoretical position papers, retrospective analyses and presentations of practice. The logic for this broad approach was that it would provide a more representative indication of academic pursuit within the community of technology educators.

**Findings**

A matrix was developed to represent each of the seven sources of research and what developed into twenty-seven topic areas covered over the five year period. The most productive source of research papers was the PATT conferences (145 papers) because of their frequency, for example there were two conferences in each year of 2007, 2008 and 2009, one each year in conjunction with the International Technology Education Association Conference in the USA, and one in Scotland, Israel and the Netherlands respectively. Fortunately now, most of the PATT conference proceedings are available through the International Technology Education Association website (http://www.iteea.org/Conference/pattproceedings.htm). The most productive of the three journals was the International Journal of Technology and Design Education (79 papers). This is the only technology education journal consistently cited in international lists of 'High Impact Journals' and so has a significant status within the profession. It is available online by subscription.

The most common research topics to be covered in the journals over this period are largely predictable:

- Journal of Technology Education: the fact that *STEM* topics were covered most frequently (16%) is not surprising given the emphasis that is being applied to STEM initiatives in the USA.
- International Journal of Technology and Design Education: there seems to be no obvious reason why the most frequently published research topic is around *sustainability/environmental* issues in technology education.
- Design and Technology Education: an International Journal most frequently published research related to *design* (10%); not surprising in a curriculum context where the school subject in England is called Design and Technology.

The research presented at the UK Design and Technology Association conference followed the Associations journal pattern and was most commonly about *design* (19%). *Technological literacy* was the most frequently (16%) presented topic at the PATT conferences, and research about *values and beliefs* in technology education was most commonly presented at the TERC conferences. At the New Zealand professional association conference there was no specific topic which most frequent.

It was significant that no single topic had an outstandingly high frequency of papers, so a broad spread of research interest within the profession was represented. A meta-analysis indicated that the most common topic (42 papers) across all conferences and journals was *design*; this included the conceptual foundations of design and other theoretical perspectives, analysis of pupils design decisions, exemplars of and correlations between design practice in school and in industry, design teams, designing and teaching styles and elements of student design.

After *design*, in order of frequency, the following topics were the focus of research papers:

i) *Curriculum* covered a range of subtopics including technology curriculum content, industry links, engineering in the curriculum, consonance and dissonance, development and implementation, country analyses, indigenous technologies and related to specific areas (for example, food) or projects (for example, robotics).

ii) *Technological literacy* (*TL*) was a common topic (34 papers) partly due to a number of themed PATT conferences, and included theoretical papers on the constituents of *TL* (creativity, entrepreneurship, product evaluation, oral history, language), teaching to develop *TL*, measuring *TL*, TL standards, the role of creativity and the rationale for *TL*.

iii) *Thinking* (32 papers) was quite a diverse topic including the importance of critique, complex thinking, analogical reasoning, intuition, popular culture, cognitive processing, thinking through play, vocational cognition and using repertory grids.

iv) The three areas of *PATT*, *teacher training* and *teaching* each had 29 papers. Included in the *PATT* category were a number of classic PATT studies, but also papers related to the effect of curriculum on attitudes, improving attitudes and the effect of teacher knowledge. *Teacher training* topics included the use of the DEPTH model in pre- and in-service teacher education, specific country and institutional descriptive studies and using a constructivist approach. *Teaching* topics include the use of physical modelling, problem-based learning, teaching through design, metaphor and pedagogy, and the constituents of effective teaching.

This information is summarized in Table 1.

**Table 1.** Frequency of research topics.

| Rank | Topic | No of papers | Rank | Topic | No of papers |
|---|---|---|---|---|---|
| 1 | Design | 42 | 8 | Sustainability/environ | 22 |
| 2 | Curriculum | 34 | 9 | Teachers PD | 20 |
| 3 | Tech Literacy | 34 | 10 | Creativity & STEM | 18 each |
| 4 | Thinking | 32 | 11 | Mobile/online delivery | 16 |
| 5 | Teaching, PATT, & Teacher training | 29 each | 12 | Systems | 15 |

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|---|---|---|---|---|---|
| 6 | Learning | 27 | 13 | Assessment | 13 |
| 7 | Values/beliefs | 25 | 14 | Classroom interaction | 10 |
| Other lower ranked topics included, in order: primary technology education, rationales for technology education, information technology, innovation, ethics, conversations, gender, emotion, learning styles and electronics. | | | | | |

Maybe by virtue of this review encompassing more papers than the previous reviews cited, it seems that the scope of research in technology education in recent years is broader than in the past. Certainly the inclusion of conference papers in this review has essentially broadened the scope of research by including researchers from many countries, and consequently comparisons with past reviews must be made with caution. But a possible alternative interpretation is that the profession is developing a level of research maturity which is reflected in the diversity of topics. As technology education has become a more securely situated component of school education, a preoccupation with the curriculum seems less necessary, and has been overcome to enable researchers to broaden their agenda. However to a certain extent, the research tendency to focus on curriculum continues, with papers in this category being the second most frequent in this review.

An additional explanation for the increasing breadth of research in this survey is the significant imperative for academics to be research active. This imperative impacts technology education professionals for two reasons. One exists in the context where teacher training was traditionally done in Colleges of Education (or similar institutions) in which the practice of teaching was paramount. As the colleges became integrated with universities, the expectation of being an active researcher was applied, and so individuals who had focussed on teaching in the past had to begin engaging in research. This phenomenon of novice researchers beginning to develop their research profile continues in a number of countries.

The other context lies in the practical origins of technology education. Developing as it did from the crafts and industrial arts, its early practitioners generally valued effective practice over the development of articulated theory, in fact many current classroom teachers entered technology teaching after a practical, skills oriented career. This practical tradition has impeded the development of a substantial body of research about technology education, but current research may indicate the weakening of this impediment.

As more people engage in research, their recommendations for further research become increasingly diverse. So when potential researchers search the literature for research ideas, they are increasingly confronted with greater breadth. This is also a plausible explanation for the diversity of research that has been revealed in this review.

**Research Trends**

It is a fraught exercise to try and predict future trends, but nevertheless an attempt follows to provide some plausible reasons why technology education research will continue in certain directions.

The most frequent topics of research cited in this review will continue. They have been identified as common in previous reviews of research, and are like the ‘bread and butter’ of technology education research; these include *design, curriculum* and *technological literacy.*

The next most frequent topic will also continue to be prominent, *thinking*, because it reflects a professional awareness that understanding about how students think and learn is pivotal to successful technology education programs.

The notion of Pedagogical Content Knowledge will be a topic which increasingly frames research about teaching because of its capacity to accommodate the complexity of variables that result in successful teaching. This will enable research to more accurately represent the complex reality of the classroom.

Research related to STEM was the 10th most frequent topic in this review, but I suspect this area of research will become more frequent as the STEM agenda, particularly in the USA, UK and to a lesser extent in other countries, becomes more politically embedded in policy and also in research funding criteria. Research is certainly needed in this area in which education institutions are progressing a STEM alignment in the absence of a sound learning rationale and tested models of effective practice that integrates these subjects.

There seems to be an increasing number of research papers developed as retrospective analyses of various aspects of technology education. It is a sign of a maturing profession that it begins to document its own history. This trend received significant impetus with the 2005 PATT 15 conference in the Netherlands which was titled Technology Education and Research: Twenty Years in Retrospect (deVries, 2005). At the recent Technology Education Research Conference 2010 (Middleton, 2010) in Australia there were a number of papers presented which were reviews of aspects of technology education, including technological knowledge and curriculum. This trend to begin documenting the history of technology education will continue.

One would hope that future research in technology education would respond to the current and predicted needs of society. In a future characterised by expert thinking and complex communication, skills in the effective application of knowledge across subject matter and contexts should theoretically stand technology in good stead as a component of general school education. Where students are engaged in designerly activities, seeking and applying the knowledge needed to solve the technological problems they are confronted with, they will develop the transferable skills necessary to find fulfilment in society. This is the theory; it needs research to test strategies to ensure that transferability is effective, and to develop a suite of pedagogical approaches that will facilitate this complex goal achievement.

Shifts in views of learning from a cognitive constructivist perspective to a more sociological view which considers the cultural context and interactions between people, should also impact on future research in technology education. Pedagogies to ensure students are active participants in the learning process, and the embedding of student design activities in a social context are aspects of technology education that need verification through research. This more social constructivist perspective aligns well with the essentially social manner in which technology is developed through design teams, for example, and so further supports a collaborative classroom environment in technology education.

The 2010 Horizon Report (Johnson, Smith, Levine and Haywood, 2010) identified and described emerging technologies which are likely to have an impact on teaching, learning and research in the short term. Cloud computing, collaborative environments and mobile learning were identified to impact education within the next couple of years. How these developments could impact on technology education has begun to be researched (*mobile/online* research ranked 11th in this review) and will continue through enquiries into e-portfolios, mobile learning and digital assessment.

The future trends for research in technology education will continue to be diverse, and increasingly so, in order to address the needs of this developing profession.

**Seminal Research**

The following section outlines five areas of research which are considered to have either been particularly influential to the profession, or relate to practice in a very specific and in many instances, unheeded manner.

1. **The technology process is diverse and complex**. There is no single piece of research which illustrates the diversity and complexity of the design or technology process, but a significant amount of research which either applies this notion to the task of teaching technology, or examines professions which focus on design and analyses the approaches that design professionals take (Lawson, 2005).

   Despite this research which indicates both the diversity and complexity of the design process, many teachers continue to teach it in either a simple lock-step manner, ignoring the research and denying the diversity and individuality of students who bring a range of approaches and experiences to technological activity in the classroom, or in a superficial way in which the complexity of design is reduced to a form of decoration.

2. **The nature of technological progress.** While a number of researchers have attempted to define what it means to get better at doing technology (Compton & Compton, 2009), Kimbell's large Assessment of Performance study developed a model (1994) which remains relevant, even in the light of later research.

   The diagram in Figure 1 which was one of the outcomes of this study summarizes the notion that progress develops through the interaction of thinking and doing, and as students get better at designing, the more fluid this interaction becomes. This implies that one of the tasks for the technology teacher is to facilitate this interaction, and to structure class experiences which move students between thinking and doing activities.

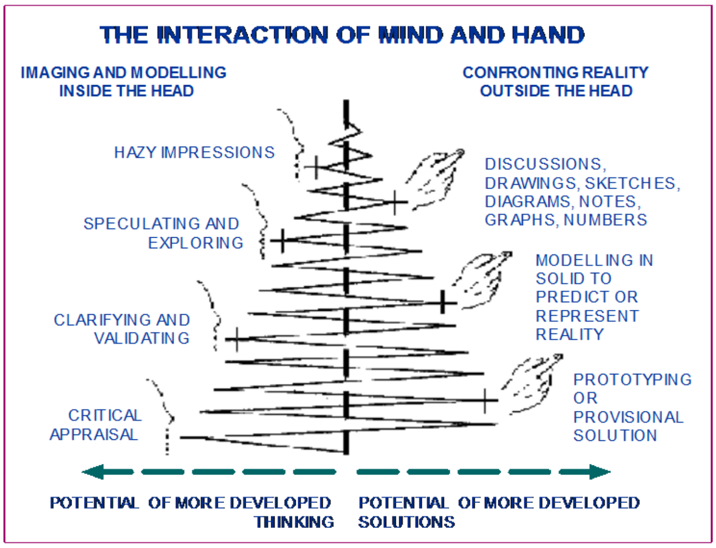

**Figure 1**. Progress in technological thinking (Kimbell, 1994)

3. **Students think creatively in series, not parallel.** This small research project by Welch & Lim (2000) in Canada is a very useful piece of research but is often contrary to teacher practice. The research supports Kimbell's model of progress, and indicates that students find it very difficult to think creatively at a time determined by a teacher, but rather need longer periods of time with stimuli provided to aid the development of creative ideas.

   Many teachers develop worksheets for students in which there is an expectation of the student to sketch a number of different ideas as solutions to a problem or brief. Invariably the outcome is a number of variations on one idea, confirming that students find it very difficult to think of a range of different ideas at the same time. A more appropriate response to this research would be for the teacher to ask for one idea, and then do something with that idea, and then develop a new idea, and so on.

4. **Students learn most effectively if they are taught at the time of need.** Research by Levinson, Murphy and McCormick (1997) indicated that students learn better if they have a sense of need for what they are being taught. In technology, this applies to both cognitive and practical skills.

   The task of the teacher then becomes one of manipulating the classroom environment so that students feel the need for what is being taught, there must be an immediacy of application. This issue relates to the debate about student progression in teaching design: do students first need to have a practical skill set and an understanding of materials in order to later develop designs that work, or should they be engaged in design activities at the same time as developing practical skills and understandings? This research would indicate that the latter approach is more effective.

5. **Smart assessment – teachers teach to the examination not the curriculum**. In response to the understanding that teachers will teach to an exam rather than a syllabus if there is dissonance between the two, this research by Williams (2010) is developing and trialling examinations in performance based subjects in which evidence of performance is collected electronically. The resulting alignment between the essence of the subject, the syllabus and the nature of the examination ensures that teachers and students are not conflicted about what to study.

   This research currently applies to Engineering, Physical Education, Languages and Information Technology, subjects in which student performance constitutes a significant component of the nature of the subject, but which has been difficult to assess in the traditional paper and pencil test.

**Research organization**

Individuals in technology education need to be both strategic and opportunistic in progressing their research. An ideal scenario is to focus on a specific type or area of research and develop recognized expertise in that area which requires careful strategising. On the other hand, opportunities coincidentally and occasionally arise to join research teams or pursue research in unanticipated areas, which should be capitalized on. As technology education in many countries is yet to be accepted as a core element of schooling, and as the international community of technology education scholars is relatively small, both strategic and opportunistic approaches to research are necessary.

Each individual's research experience is different, but in this concluding section, I have outlined my strategy for maintaining research activity, which has fallen into three categories.

The first category is the 'big' research – those projects for which funding is nationally competitive and are conducted by a team of researchers over a number of years. For most of us we only get a few of these in our career, but from a personal perspective, they are the stuff of which promotions are made, and more generally the results have the potential to make a difference beyond the researcher's immediate environment. Apart from the project report, a number of publications and presentations are typically produced from this type of research.

For example I am concluding a large research project in Western Australia in 2011 for which I was a co-director working with a team of five assistants over three years to develop and trial electronic forms of authentic assessment. A number of publications and presentations have arisen throughout from the research from members of the team, and the examining authority (and part funder of the research) has begun implementing the research findings.

The second category is that research which has attracted smaller amounts of funding, generally enough to buy out some teaching time, pay for a research assistant or attend a conference to present the findings. This research may span a year or so and involve just one or two researchers.

For example, research I recently conducted involved determining the effect on students of the immediacy of feedback on electronically submitted assignments. The research funding paid for a digital tablet which could be used to write on student submissions regardless of the format – powerpoint, CAD or text. The research resulted in a seminar presentation, and contributed to refining the practice of teachers submitting electronic feedback on assignments.

The final category is that research which is unfunded but it is done because of a strong belief in its significance. It is often closely related to practice and conducted by a single researcher. For example a number of years ago I initiated a link between the university and a local secondary school which enabled secondary students to attend university and work with technology teacher trainees in studying robotics. The research was conducted to determine the effectiveness of the project, and to track its evolution over a number of years.

While these different types of research have varying rationales and result in different outcomes, they are all important, and a mature research approach will encompass this range of activity. A researcher recently shared with me their notion of research as "hard fun": thinking very hard about something that you are really interested in or excited about and then researching it. We should all have as much 'hard fun' as we can.

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