

# Changing Practice and Changing Lenses: The Evolution of Ways of Researching Technology Education

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## Abstract

This paper provides a tentative analysis of the evolution of methodologies used to research technology education. At the time of the first PATT conference, the dominant research methodologies employed to research the ways in which technology education was taught and learnt were quantitative and based on the assumption that the important ways of knowing and doing were mathematically or linguistically mediated. Where other knowledge modalities were acknowledged, their presence was often regarded as largely redundant. For example, knowledge in the form of mental images was regarded as providing no additional data to that provided by linguistic accounts of learning activity. It is argued in this paper that technology education practice includes features unique to the area and that the evolving methodologies are helping to reveal these features. Furthermore, the research methodologies being pioneered in technology education research are providing lessons for researchers in other areas of human learning and action and challenge the long held practice of privileging certain ways of knowing.

## Introduction

*A person standing under a street lamp looking for his keys at night is asked by an observer where he lost them. He replies, "over there" (in the dark) when asked why he is looking where he is when the keys are somewhere else he replies "the light's better here" (anonymous contribution)*

The quote above was originally used to ridicule quantitative research by suggesting that this form of research sought to examine that which was easy to examine but in the process failed to examine anything that was worth examining. I will argue that there is a degree of truth in the joke in terms of technology education research at the time of the first PATT conference. I think there is evidence to suggest that maybe we were looking in the wrong places, for the wrong things and drawing the wrong conclusions.

## A little historical context

In many countries, technology education grew out of a variety of earlier studies including, industrial arts, crafts, Sloyd and industrial or manual training to name a few. These earlier programs tended to evolve as practice-based practical studies. In many countries the preparation of teachers for these subjects was undertaken in institutions whose focus was teaching rather than research. As a consequence, practice evolved and was shaped through the influence of entities such as professional associations, curriculum advisors and departments of education. I need to say at the outset, however, that some of the generalisations I make hold up for much of the world but not for the USA. For example, technology education departments (Industrial arts) in the USA had strong research outputs from early in the 20<sup>th</sup> century, and this appears to have declined during the course of the last thirty years. The first PhD in the area in the USA was awarded during the 19<sup>th</sup> century,

whereas in Australia, for example, the first was awarded during the 1990's. That being said, the general thrust of the argument I will develop holds true for most countries.

In developing the argument presented in this paper I am drawing on papers examining research in technology education that together span the period since the first PATT conference. The papers comprise works by De Vries, (2000), Petrina (1998), and Zuga (1997). While drawing on these papers, my purpose is singular and different from that of the authors of the papers. De Vries sought to establish the match between the outputs of technology education research and the needs and priorities of teachers. Petrina examined the papers published in the Journal of Technology Education (JTE) to establish the kinds of research being published as a way of informing what should be published in the future while Zuga examined technology education in the USA through journal articles and dissertations to draw some conclusions about what kinds of research had been done and what needs to be done.

In this paper I am arguing that the kinds of research methodologies that have been employed over the last twenty years are evolving in ways that are making them more suitable for researching the things that need to be researched about technology education. I am not arguing that all research in technology education is compatible with this evolution but that there is evidence that it is happening. My purpose in doing so is based on the belief that using the correct research tools is as important to achieving the research aims for technology education as researching the right topics. Further, some research tools are necessary for the conduct of certain research so that availability of tools can, to some degree, determine what is researched, and what we are able to discover. Lastly, evolution can be ordered or entropic. To ensure that research provides outcome that allow technology education to evolve in an ordered and positive way it is important to highlight positive developments in research methodologies as well as research findings.

### **Desperately Seeking Scientific (respectability) through sameness**

At the time of PATT 1 much of the research in technology education was either highly quantitative, highly descriptive or both. In her 1997 analysis, Zuga indicates that during the period 1987 to 1993, 62% of studies in the USA were descriptive studies of the current status of technology and 38% about curriculum developments. Zuga cites only three studies that provide critical analyses of, for example, how teachers implement curriculum (Cox, 1991; Scarborough, 1993; Zuga, 1987). Zuga goes on to conclude that most of the studies used Delphi methods but restricted those surveyed to state supervisors and teacher educators, rather than teachers or students.

Why were we doing these kinds of studies using only these methodologies? I would argue that one of the reasons was that we were still suffering from the inferiority complex that the social sciences and the humanities had finally thrown off. That is, we were still desperate to achieve academic respectability. We reasoned that the best way to do that was to do our best to replicate the methods of science. We were asking questions in very measured but limited ways, and often they were not the right questions and not asked in the right ways.

In addition, I think it is arguable that we were suffering from what I would call a belief in the stratification of human ways of knowing. That is, the idea that different ways of representing knowledge should be accorded different status. In this hierarchy, knowledge represented by numeric symbols is accorded highest status, knowledge represented by language or language-like representations are accorded the next highest level, knowledge represented in images

next and knowledge represented by action last. Everyone has seen cartoons with Einstein with  $E = MC^2$  in the text balloon. The implicit assumption taken from Einstein's work is that he, along with other great scientists and inventors, thought predominately in abstractions, despite the plentiful evidence indicating that many eminent people in these fields used images or the manipulation of concrete objects to develop ideas (Weber & Perkins, 1992). The translation of these ideas into abstract representations occurred, in Einstein's case, after the initial imaginal representation of the idea (Holton, 1971/72).

At the other end of the spectrum, until the work of Polanyi (1983) on tacit knowledge became widely known and its veracity acknowledged (for example, Sternberg, 2000), the idea that knowledge might reside in a representation that we could not describe using symbols was new and contested. It still is but less often now.

### ***What was the effect?***

To examine the effects of these studies and the methodologies used to conduct them some context is required. In the period leading up to and during the early PATT period newly created (re-created) technology education, or design and technology education programs were appearing. Technology teachers, researchers and curriculum and pedagogy specialists were looking at different ways by which teachers might teach and students might learn. The proposed teaching methods represented a significant pedagogical change, which at its simplest could be described as a move from teacher-directed to student-centred learning or at another level described in terms of a move from didactics to constructivist theories (Von Glaserfeld, 1987) about learning.

The kinds of research projects and the methodologies being used during that period were not suitable for illuminating such questions as how students solve ill-defined problems or how students generate new ideas, or how teachers provide appropriate scaffolding to students engaged in developing design solutions. Illumination would not come about through isolating single variables or quantifying collective opinions, however, eminent or considered they might be. More importantly, research outcomes that might inform practice were not being produced. As a technology curriculum consultant at the time of the first PATT conference I was often asked questions like "what do I do if a student tells me they have read the brief, done some research and can't think of anything"

The effect of the concentration on quantitative, descriptive research, was that little real help was provided to practitioners in working out how this new way of teaching and learning might happen. Where practitioners worked it out for themselves, research was often unable to provide the analysis of what was happening and why. These would have been useful things to have done because when you examine documents about the introduction of new curricula in the early PATT period the documents often spelled out a list of hopes and expectations without any research to support what was intended.

I think it is arguable that the limitations in the early research hindered our understanding of the new pedagogies and, as a consequence, the successful introduction of new technology education programs. They weren't bad, they were just limited in what they could tell us and how, what they did tell us, related to what we needed to know. In turn, our capacity to argue the merits of the new technology education programs was limited by this lack of suitable research findings. Practitioners were left making statements of belief rather than being able to argue on the basis of evidence. In many cases teachers rejected design approaches as unworkable because their background didn't provide a suitable preparation and research

wasn't filling the gap. My own Masters degree (Middleton, 1993), illustrates the point I make. It examined whether design based high school industrial arts courses developed creativity in students more than traditional courses. I used the Torrance Test of Creative Thinking (1972) and established that, yes, design based industrial arts courses did develop creative thinking abilities in students more than traditional courses. However, the quantitative methodology provided no examination of why that might be so.

### **Comfortably Cornering Clarity through explorations of uniqueness**

I want to move now to more recent times that I will call the later PATT period. What one sees emerging is research in technology education that has some distinctly different characteristics to earlier research. The characteristics can be categorised as involving new methodologies, attempts to interpret rather than only describe or quantify, and the greater use of mixed methodologies to answer the why as well as the what, and existing methodologies not previously used in technology education research. What was the motivation for the change?

The introduction of problem-solving into technology programs was probably one motivating factor. During the early 90's we were discovering differences between technological problem-solving and the existing research on problem-solving (Newell & Simon, 1972). Technological or design problems couldn't be explained by the existing theoretical models that were derived from research in mathematics and puzzles (Schon, 1992). Design problems didn't have the clearly defined starting points of mathematics and the solutions were anything but clear (at the outset). In addition, it was usually the case that the voyage from problem to solution was not restricted to a limited range of options (Middleton, 1998; 2003).

The socially constructed, hierarchical view of knowledge, dominant in the early PATT period, was being seriously challenged during the later period. For example, in the early period, Pylyshyn (1973, 1981) argued that mental images as representations of knowledge simply didn't exist. The later work of Kosslyn (1994+) provided physiological evidence via the use of new technology (Positron Emission Tomography) to verify the existence of both imaginal and symbolic modes of mental representation in human beings. Moreover, other researchers (Weber et al, 1990) attempting to explain the thinking processes of contemporary inventors found that mental images were used for quite complex processing and in fact, were more efficient for processing certain kinds of information.

An examination of historical evidence suggests that mental imagery is an important representation for the processes of discovery and invention (Perkins, 1992). So, rather than being a representation that is at the bottom end of the hierarchy in terms of importance as a way of representing information in problem-solving and learning, the more recent literature suggests it deserves a higher status.

Similarly, tacit knowledge is being re-evaluated and seen in a new light (Sternberg et al, 2000). Tacit knowledge is regarded as a key feature that distinguishes the expert from the merely very good in areas as diverse as motor racing and surgery. That is, the feature that puts Michael Schumacher ahead of the next-ranked Formula One driver is not superior conceptual or procedural knowledge but superior tacit knowledge. We still don't know enough about tacit knowledge but it is a feature of technological activity and therefore a reason to look for ways to examine its role in learning. Moreover, it is an area where research in technology education might reveal more general insights into this important aspect of human knowledge.

The move to design based technology program is probably one of the prime motivators for the change in research methodologies. Quantitative methods can tell us if a particular process in a directed or competency-based learning approach is more efficient than another in imparting highly specified learning. The task of unpacking what is happening in a design laboratory requires more sophisticated methods. An extension of this is the introduction of technology education programs in primary schools. What kinds of technological problems are appropriate for students at particular stages and how are they thinking and responding to those problems requires innovative research approaches, providing another motivator for looking at new ways to examine human phenomena.

Finally, technology educators are coming out of their cosy cocoons. Many technology educators felt secure in what they did, even if their laboratories were seen by school administrators as dumping grounds for less able or disruptive (usually male) students. If technology departments in schools had a secure future, then so did departments in universities. The closing down of technology education departments in schools in a number of countries across the globe and the axing of university programs at institutions such as the University Maryland and Sydney University, sent some alarm bells ringing. Protestations that what we were doing was good had ceased to be compelling in a world that wanted hard evidence.

### ***What is being done?***

I will touch on a few examples of recent work to illustrate the change in research in technology education. We are using new methodologies and discovering new things. In 1994 Lloyd and Scott examined the conventional wisdom that images in the form of drawings and sketches did not contribute anything new to verbal protocols. The conventional view was that the sketches were simply mirror images of the verbal data. Lloyd and Scott tested the assumption by videorecording design activity using protocol analysis procedures where subjects verbalise anything that comes into their head, produced transcripts of the verbal activity and removed the sound track from the videorecording. They then asked people to view the transcripts and describe the images they would expect to find. Another group were given soundless video to view and asked to predict the dialogue that would accompany the images. The degree to which people could do this was about 20%. The new method was able to disprove a long-held view and one that was not positive for technology education.

We are making greater use of research findings and methodologies from other disciplines not previously used in technology education, and we are utilising theory to provide frameworks for analysing research. The Walmsley study (2004) drew on Cognitive theory (Anderson, 1983), Setting theory (Barker, 1972) and activity theory (Engestrom, 1987) to provide the framework for analysing data about what students thought about their learning environment. The data consisted of a questionnaire, and videotape data of the students engaging in technological learning. Similarly, the Banks et al (2004) study drew on curriculum theory (Shulman (1986), cognitive theory (Gardner, 1983, 1991) and the European tradition of didactics and pedagogy (Verret, 1975; Chevillard, 1991, in Banks, 2004), to devise tools for technology teachers to reflect on professional knowledge.

### ***What is the effect?***

We are developing a more complex understanding of what is involved in teaching and learning in technology education. In addition, we are learning more about how to do technology education better. Our increased understanding of the thinking processes students

engage in when solving technological problems, the kinds of psychological blocks that tend to get in the way of them finding solutions, and the kinds of teaching strategies that can be used to overcome these are areas where we now know more and more importantly, have a better understanding of where we need further research.

We are also learning more about how to learn more about what we are doing. That is, we are finding the most appropriate ways to examine the particular characteristics of technology education. Ways that acknowledge its multi-modal characteristics and the particular kinds of problem-solving involved when students are presented with a design brief and required to come up with a solution.

We are engaging more with the wider educational research community. At the technology education research conference hosted by the American Association for the Advancement of Science (AAAS) in Washington in 2001, presenters included cognitive theorists, science researchers, information technology researchers and curriculum research specialists, in addition to technology education researchers.

We are verifying, quantifying and qualifying some long-held beliefs. The research by Walmsley (2001) confirmed, albeit in a limited way, that providing a design-based learning environment did encourage technology students to engage in higher-order thinking more than was the case with a directed learning environment. Research by Purcell and Gero (1996) is quantifying the effects of fixation in the design process and research by Middleton (1998) is qualifying the previous understanding of problems as they apply to design problems.

We are contributing to knowledge more generally and by challenging some firmly entrenched assumptions about what is important in terms of how knowledge is represented in thinking and of how people solve problems most efficiently. The research by Lloyd and Scott, Walmsley and Gero and Purcell all challenge existing assumptions.

### ***Does it matter anyway?***

The changes in the kinds of research technology education researchers have been engaging in during the later PATT period are significant in a number of ways beyond those mentioned already. I would argue that the research output from many of these more recent studies have been important because increasingly we need to justify the existence of technology education programs in ways that are credible to general education decision-makers. Findings that eminent technology educators think that technology education programs are important (Newcombe, 2004), while heart-warming, are probably less useful in convincing educational administrators of the value of technology education programs than studies that verify important learning outcomes from those programs using measures verified elsewhere (Walmsley, 2001).

### ***What can one conclude?***

There are a number of conclusions to be drawn from this paper. Over the period since the first PATT conference research in technology education has evolved from the use of reasonably simple methodologies to the use of methods that are better suited to the complex nature of many aspects of technology education, and of what we need to find out. We are finally able to verify some long held beliefs about the nature of learning in technology education classes and disprove other views about knowledge that have not supported the value of technology education. We need to continue with these studies so that we can:

develop a better understanding of the discipline; contribute to knowledge in general; and for purposes of advocacy.

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