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Research in Purpose and Value for the Study of Technology in Secondary Schools: A Theory of Authentic Learning

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ABSTRACT: This paper briefly examines the literature on (a) problem-based learning (PBL), including constructivism and problem solving, and (b) learning in context, including mediation, embodiment, distribution, and situatedness. We use this literature, our previous research [Hill & Smith Journal of Technology Education 9(1), 29–41 (1998)], and some initial findings from our present research as a basis for a theory that we call *authentic learning*. The Theory of Authentic Learning provides a theoretical framework on which to scaffold purpose and value for the study of technology in secondary school curriculum. Initial results from Year One of our present three-year study contribute to the refinement of our Theory of Authentic Learning. First, we present some relevant literature, then we illustrate the Theory of Authentic Learning, and finally we conclude with some preliminary findings from our present research.

Keywords: technology education, research, theory of authentic learning, secondary school

PROBLEM-BASED LEARNING

Torp and Sage (1998) define problem-based learning (PBL) as, ''focused, experiential learning (minds-on, hands-on) organized around the investigation and resolution of messy, real-world problems. It is both a curriculum organizer and instructional strategy, two complementary processes'' (p. 14). A close examination of curriculum organizers and instructional strategies used in secondary schools for the study of technology reveals common grounds with PBL. This is owing to the hands-on nature in the study of technology to solve problems through projects. This hands-on approach to solving problems through projects has historically been used as the pedagogical approach to teaching and learning technology in secondary schools. However, technology educators, with their affinity to doing, have not documented, in textual form, this history and development over the years. As such, we turn in part to medical education for literature on PBL.

PBL is well known as a pioneer pedagogy in medical education and can be traced back to the Faculty of Medicine, McMaster's University in Ontario, Canada in the 1960s (Barrows & Tamblyn 1980; Camp 1996; White 1996). This pioneer program found its framework in the work of John

Dewey and inquiry-based learning (Jones 1996). Today PBL is evident in most medical schools around the world (Jones 1996; Vernon & Blake 1993) and has spread to other schools unrelated to medicine (Camp 1996), such as education.

The most recurring characteristics of PBL in the literature (Albanese & Mitchell 1993; Barrows & Myers 1993; Barrows & Tamblyn 1980; Boud & Feletti 1991; Camp 1996; Greening 1998; Jones 1996; Savery & Duffy 1995; White 1996; Woods 1985) are that PBL is a curriculum development and instructional strategy that: (1) is based on a constructivist philosophy where learners construct their own contextualised knowledge; (2) is grounded in real-life problems where knowledge acquisition is steeped in practice; (3) actively engages learners in authentic tasks, activities, and environments where problems are ill-structured; (4) requires an iterative process to solve problems where learners work in groups for collaborate study and where social negotiation of meaning is required in the problem-solving process; (5) encourages learners to think critically and creatively; (6) requires learner engagement in exploration; (7) encourages an interdisciplinary approach to learning; (8) encourages reflection, an important meta-cognition aspect of PBL; (9) results in deep understanding as students retain knowledge much longer; (10) results in transfer of knowledge due to metacognitive activities; (11) is student-centered where students assume responsibility for their learning; working independent of the teacher and identifying gaps in their understanding in the context of the problem at hand; and (12) is faculty facilitated where faculty guide, probe, and support group and individual learning.

In addition to characteristics, models of PBL are found in the literature, notably that of Barrows (Barrows 1985, 1992; Barrows & Myers 1993). While there are now many definitions, models, and case studies for PBL in the literature, common features are that it is defined as constructivist pedagogy and a subset of problem solving (Greening 1998; Savery & Duffy 1995).

Philosophy serves as a framework for how educators view the world, and this framework influences their preparation for classrooms and their actions and activities in classrooms (Hill 1997). Constructivism is one philosophical view and it is here that PBL is positioned. Savery and Duffy (1995) provide a succinct overview of PBL within a constructivist framework. They posit three primary constructivist propositions and propose eight instructional principles that evolve from the propositions. Not surprisingly, the propositions and instructional principles align with characteristics of PBL. In addition to a constructivist framework, PBL is seen as a subset of problem solving (Greening 1998; Savery & Duffy 1995).

The dynamic of problem posing and problem solving in the study of technology is most commonly known as the ''technological method or process''. Lewis et al. (1998) indicate that problem solving in technological education manifests itself in numerous forms, ''including experimentation, design, invention, and troubleshooting'' (p. 22), depending on the

technological field to which it is being applied. In addition, Hill (1998) posits that in the real world, technological problem solving is interactive, not linear and step-by-step, because exploring connections between knowledge, skills, and different materials is fundamental to technological processes. As Wiener (1993) points out, ideas are important to new inventions, but "there is a further conditioning (of ideas) in terms of the materials and processes available" (p. 37). These connections, the joining of thought (head) and action (hand), are critical in technological processes (Arendt 1958; Franklin 1990) of real-life, situated contexts because there are many distinct technological fields, each with its own knowledge base, problem solving process, and materials usage (Hill 1998; Hill & Anning 2001a, b). One way to bring the complexity of real-life, situated contexts into secondary school programs is to link problem solving to projects needed in the community, or to what Hill (1999) has coined *community-based projects*. This approach encourages problem posing, which Lewis et al (1998) believe to be at the creative end of the problem-solving continuum. Activities such as these that are engaging to secondary school students in their study of technology comprise most, if not all, of the characteristics of PBL, of the propositions and principles of constructivism, and of the dynamics of problem-solving discussed here. But it is worth pushing the envelope a bit about this view to further advance our understanding of student learning, teacher teaching, and programs grounded in constructivist pedagogy.

In a critique of constructivist pedagogy, Richardson (2003) reviews constructivist theory and writes that there are many forms of educational constructivism, and recent writings about constructivism (Phillips 2000) "represent constructivism as a construct and movement that is massively complex" (Richardson 2003, p. 1624). Richardson describes two forms of constructivism, social constructivism and psychological constructivism, and states that "the two forms are beginning to come together with a focus on the social aspects of classrooms" (p. 1624). She posits that psychological constructivism has received greater attention, focusing on the individual student within a subject specific context, and outlines five characteristics of constructivist pedagogy for this representation; characteristics that she sees as elements, not "specific practices", and as "imperatives, approaches to teaching toward which one initially aspires and which then become fundamental aspects of the *teacher's* praxis" (2003, p. 1626). Richardson makes an important point about teacher knowledge in constructivist pedagogy. She clarifies that depth of teachers' subject-matter knowledge is essential. Student responsibility to their learning and process is not substitute for a lack of teacher knowledge.

Richardson (2003) indicates that most research in constructivist pedagogy has investigated student learning because constructivism is seen as a theory of student learning rather than a theory of teaching. Even so, she advocates for additional research to examine student learning; she points to the inquiry approach used by Ball and Bass (2000). Looking ahead, outlines three critical areas for future research in constructivist pedagogy: (1) the

relationship between teacher beliefs and values as they relate to breadth and scope of their goals for students, and how these translate into teachers' classroom enactments of the curriculum; (2) constructivist teaching because little research has been done in this area and theory development is badly needed; and (3) the cultural critique of this pedagogy which "may take us beyond constructivist pedagogy" (p. 1636). She suggests that future research pay close attention to "ideological bias" (2003, p. 1635) inherent in constructivism.

Next we report on our research that, at present, is concerned with student learning. This research (Hill & Smith 1998) into student learning in secondary school technological education courses provides a basis for our Theory of Authentic Learning. This theory demonstrates purpose and value for the study of technology in schools.

THE THEORY OF AUTHENTIC LEARNING

In earlier research, Hill and Smith (1998) determined that the exemplary technological education classroom that they studied displayed all the essential qualities of the Theory of Authentic Learning. In this classroom in Manufacturing Technology, learning processes diverged sharply from traditional settings where the emphasis is on abstract and decontextualized concepts of little apparent relevance to the students. Instead, activity in the exemplary classroom resembled that of everyday learning where learning and context are inextricably linked as people engage in various forms of culturally-relevant activity. In this classroom, learning, ability, product production, and intelligence were as much a part of the situation as they were of the individual (e.g., Barab & Plucker 2002).

More specifically, this exemplary classroom exhibited four qualities of authentic learning that will be outlined here (i.e., mediation, embodiment, distribution, and situatedness) and two supporting qualities (motivation and multiple literacies). These assorted qualities are esteemed by many modern educational theorists and practitioners and constitute the heart of their theories and practices. These qualities will be summarized next.

Mediation

The view that learning is mediated originates with the notion that humans use cultural tools, or mediational means, when engaged in action of various forms (Wertsch 1998). Examples of mediational means include language, musical instruments, hoes, and hammers (Smith 1995; Wertsch 1991). The theory supporting mediation has several roots, but the works of Peirce (1992, 1998), Dewey (1938), and Vygotsky (1978) are cited most frequently. Although the secondary school student is usually treated as a passive recipient of knowledge (e.g., Davis et al. 1990; Dreyfus 1995), the mediated view of learning emphasizes the need for learners to engage in authentic

cultural tasks using relevant cultural tools (Martin 1995). As shown in the classroom studied by Hill and Smith (1998), where students constructed such items as bikecars and a dome, human action is shaped by the cultural tools in use, including paper, pencil, drill presses, and welding torches. Hence, authentic learning exposes students to a wide range of cultural tools and their use in cultural tasks.

Mediation and authentic learning are closely associated with what is known as activity theory, which originated with Soviet psychologists and philosophers such as Vygotsky, Leontiev, and Zinchenko (e.g., Martin 1995; Ratner 1996). Activity theory is "particularly concerned with the ways in which tools, collectivities (or communities), and historical and material conditions together form actions and contexts of problem solving and knowing. It is also known as sociocultural analysis, sociohistorical and cultural-historical psychology" (Leigh Star 1998, p. 314).

Embodiment

Authentic learning recognizes that learning involves the body as centrally as the mind and embraces cognitive, emotional, physical, and social dimensions (Epstein 1994; Hutchins 1995; Johnson 1987; Smith 1999; Varela et al. 1991). In embodied learning, cognition, perception, cultural tools, and action all work together in the learning process. For example, in building a bikecar in the Manufacturing Technology classroom (Hill & Smith 1998), students made key design decisions based on their own body structures and sizes in determining, for example, where to place the bikecar's seat, foot pedals, and steering mechanism.

To illustrate, one grade 11 student talked about laying out pool cues at home and adjusting chairs on the classroom floor so as to establish proper dimensions for his team's bikecar.

Distribution

Authentic learning claims that learning is not confined to the individual mind, but extends outwards to include the ongoing actions provided by cultural tools and other persons (Clark 1998). This contrasts with traditional formal schooling that treats learning as individual and private with students completing their own individual assignments, readings, exercises, and tests. The idea of learning as distributed also recognizes explicitly that many tasks cannot be completed by one person working alone, such as docking a ship (Hutchins 1995) and that, in the classroom, knowledge is distributed among all class members (Rogoff 1990; Vygotsky 1978). This perspective conforms to that of most work places, where individuals must work cooperatively in pursuit of common goals and where different abilities are needed to complete projects successfully (Hill & Smith 1998; Loney 1995; Premier's Council 1988, 1990). The distributed nature of everyday, authentic learning was evident in interviews with the community partners interviewed by Hill and Smith (1998). As one contact person indicated, she

could not think of any job that did not involve teamwork. In such settings, no one person has a monopoly on knowledge. Further, distributed learning is characterized by the fact that both individual and collective memories often reside in artifacts and actions that lie outside the brain (Kirlik 1998).

Situatedness

In contrast to the view that most learning is abstract and generalizable, research over the past two decades has emphasized the situated and contextually-grounded nature of authentic learning (e.g., Brown et al. 1989; Cobb & Bowers, 1999; Greeno et al. 1998; Lave 1988; Saxe 1988). Situatedness in learning, also referred to as "learning in context", is a critical feature of authentic learning. Findings from various studies have shown consistently just how situation-specific most knowledge is and just how little transfer takes place automatically. In completing the "same" tasks both inside and outside school, students can show marked discrepancies between performances. For example, Hill and Smith (1998) showed that involving students in genuine projects derived from community needs, such as garden tables for a retirement home and a spool rewind system for a major tire manufacturer, provided specific contexts for engaged student learning.

Student motivation to learn

Motivation has usually been considered essential for positive learning to occur. Over the past century, many explanations have been advanced to explain student motivation (or its absence) in school. However, at its most basic, motivation is grounded on the will to survive as a biological and cultural entity. On the cultural side, survival is enhanced by becoming competent in the signs valued by the surrounding culture (Smith 1992). In school, the drive for survival is achieved by students becoming competent in matters of concern to them (White 1959). Generally, these matters are essentially sociocultural in nature and should be placed in the context of meaningful classroom tasks while recognizing the need to support students' self-esteem and autonomy in learning (Beane & Lipka 1984; Harter 1986). Student and teacher interview data provided by Hill and Smith (1998) showed that these motivational characteristics in students were supported by the technology courses that they studied.

Multiple literacies

The preceding factors address four qualities of authentic learning and the supporting element, or engine, of motivation. However, another central factor involves the multiple capacities of the learners themselves. Most people recognize that we differ from one another, often dramatically, in our capabilities and interests. These observations have been supported by both theory and research that have established that we possess an assortment of ability systems. These systems have been represented by Gardner (1983,

1999) as eight primary intelligences (linguistic, musical, spatial, logical-mathematical, bodily-kinesthetic, intrapersonal, interpersonal, and naturalistic) and by Smith (2001) as seven distinct signways (which parallel Gardner's array). Authentic learning recognizes a range of abilities and talents and deliberately seeks to foster them across a variety of contexts (cf. Hill & Smith 1998). For present purposes, these different abilities, intelligences, or signways will be termed "multiple literacies" (e.g., Berghoff 1998; Leland & Harste 1994).

Because successful school programs pay attention to many of Gardner's intelligences, not just two or three, the assessment of learning should also be carried out in a number of different ways (cf. Armstrong 2000; Campbell et al. 2004). One relevant and current approach is called "authentic assessment" (Wolf et al. 1991). Both the grade 10 and 11 Manufacturing Technology courses examined by Hill and Smith (1998) demanded much more of students than language and logic. Student assessment was based on a variety of achievements, such a weekly reports and portfolios, final design reports, final product assessment of the projects, formative quizzes, a summative exam, and class and group participation.

PRELIMINARY FINDINGS FROM PRESENT RESEARCH

Our present research examines how the study of technology contributes to the development of young adults' lives. It does so by following the lives of 12 students in three different technological education programs at three different secondary schools over a three-year period. The Theory of Authentic Learning is contextualized and supported by student data and quotations from this qualitative research.

In a preliminary analysis of some of the data from our present research, findings are emerging that confirm the four central factors (mediation, embodiment, distribution, and situatedness) and two supporting elements (motivation and learners' multiple literacies) that comprise the Theory of Authentic Learning (Hill & Smith 1998). This preliminary analysis serves as a trial run for the analysis model that will be used to analyze all data as the study progresses over the three-year period. The preliminary analysis used the qualitative data analysis program titled, Atlas.ti. Initial interviews, or primary documents, from two of four students at one of the three research sites were analysed to determine if the four factors comprising our original Theory of Authentic Learning were identifiable. All four factors were identified. The analysis consisted of using Atlas.ti to identify the quotations that related to the four factors, to create codes for the four factors, to apply the codes to the appropriate quotations, to determine the links and relations of the codes, and to generate the network for the codes (referred to as nodes in our network). Together these analyses form the hermeneutic unit used in our preliminary analysis reported here. In addition to the original four

factors of the Theory of Authentic Learning, the expected two supporting qualities of motivation and multiple literacies were also noted. However, preliminary analysis of the partial data also suggested the existence of the four additional factors of identity, career planning, human relationships, and teacher attributes. Atlas.ti was again used in the same procedural and analytical way to incorporate the additional four factors into the hermeneutic unit. The hermeneutic unit, with its 10 factors, was then used for theory transfer. The theory is depicted in Figure 1.

Mediation is the use of cultural tools of all kinds, such as language, hammers, and computers. These tools are used in authentic cultural tasks, but knowledge of use can extend beyond the specific task at hand. Embodiment is learning involving the body and, especially, emotion. It involves the senses and the feeling of comfort in the setting. Distribution is learning and knowledge not confined to one mind or body, but extends out to include others' thoughts and actions using cultural tools, for example, group work. Here, some tasks need more than one person to complete them. Memories reside in both the tools or artifacts and the cultural activities. Situatedness is where learning is situated in the existing context. Multiple literacies is multiple ways of making sense in the world, or multiple intelligences, or abilities, or signways. Motivation is the desire, need, or want to achieve and, presumably, to become competent in given domains. It includes surprise, leading to abduction, and the removal of doubt (Peirce 1992, 1998). As well, it is connected to feelings. Identity is

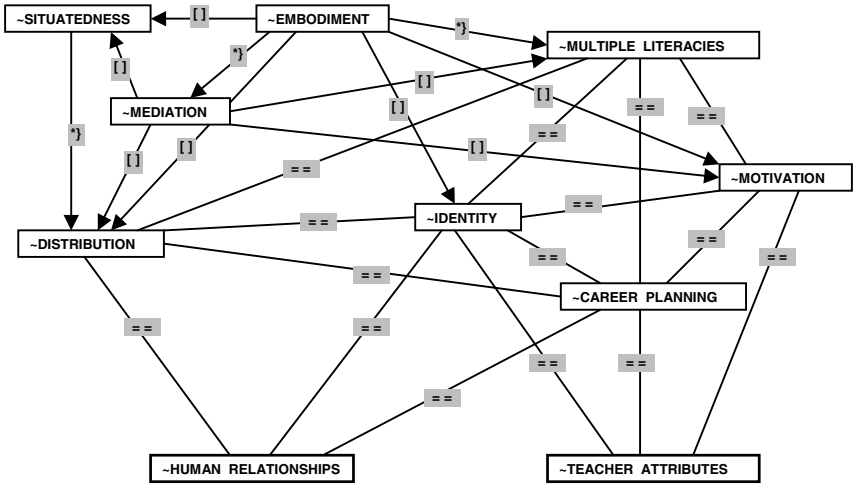

Figure 1. Paths to Meaning in Authentic Learning (Preliminary Analysis) The symbols below the figure help to decode the relationships. = = indicates that a code (factor) is *associated with* another code (factor) and that attribute is symmetric. **[ ]** indicates that a code is *part of* another code and that attribute is transitive. *} indicates that a code is *the property of* another code and that attribute is asymmetric. □→□ indicates that there is direction to the link □—□ indicates that there is no direction to the link.

personal growth and the development of identity (who one is) and a sense of self. Career planning involves references to future courses, programs, careers, apprenticeships, or other postsecondary education. Human relationships are expressions, either positive or negative, about being with others, especially peers. Teacher attributes are teacher or supervisor attributes or abilities, including personality, use of humour, and interest in the students. Figure 1 depicts how these 10 factors are linked and their relationship to each other.

The symbols below the figure help to decode the relationships. = = indicates that a code (factor) is associated with another code (factor) and that attribute is symmetric. [] indicates that a code is part of another code and that attribute is transitive. *} indicates that a code is the property of another code and that attribute is asymmetric. indicates that there is direction to the link, and indicates that there is no direction to the link. According to the theory transfer in Figure 1, Mediation is part of ([]) distribution, motivation, multiple literacies, and situatedness. Embodiment is part of distribution, identity, motivation, and situatedness. However, it is the property of (*}) both mediation and multiple literacies. Distribution is associated with (= =) career planning and human relationships. Situatedness is the property of distribution. Multiple literacies is associated with career planning, distribution, identity, and motivation. Motivation is associated with teacher attributes. Identity is associated with career planning, distribution, human relationships, motivation, teacher attributes, and multiple literacies. Career planning is associated with human relationships and motivation. Human relationships does not have any direct relationships of its own. Instead, distribution, identity, and career planning are associated with it. Teacher attributes is associated with career planning.

This preliminary analysis of some of the initial data from our present research indicates that the paths to meaning found in situations of authentic learning provide a far richer educational environment for students than traditional classrooms, regardless of career path. ''I've know since Grade 8 that that I'd like to be an architect.'' ''I want to be a construction teacher, like, in a high school.'' These types of leaning opportunities provide young adults with both academics, ''we use a lot of thinking like logic, problem solving, math, for example building that sawhorse, and English in writing journals.'', and technological skills and knowledge, ''I'm learning how a house goes together, learning the terminology, learning how to read plans, estimate supplies needed to build a house.'' They also foster a sense of appreciation and value for school and for what is learned in school because relationships between what is learned in school and life beyond school are inseparable; the learning environment in school reflects the complexity of the environment it represents outside of school, ''School is really, really important so if I hadn't done this program, I probably would have just graduated and work at Swiss Chalet (a restaurant) for the rest of my life.'' ''It's more useful. What we learn here we kinda use.''

PURPOSE AND VALUE FOR THE STUDY OF TECHNOLOGY

The study of technology in secondary school has historically been grounded in a hands-on approach to solving problems through projects. Theory on PBL, a sub-set of constructivism and problem solving, previous research leading to the Theory of Authentic Learning (Hill & Smith 1998), and this present research that documents paths to meaning in authentic learning environments together provide a basis for the purpose and value for the study of technology in secondary school education. They do so by expanding the dialogue beyond dropouts or non-university bound student paths. They add purpose and value to the study of technology by documenting its contribution to education at large and how it can enrich the education of all students. In these learning environments, schooling is meaningful because learning is situated, distributed, mediated, and embodied, "Well, everything is hands on. You can't do math without grabbing a piece of wood and having to write down on the wood or you just write on the walls. I mean you are always doing something. You are never just sitting around." Multiple literacies are attended to. This attention to multiple ways of making sense in the world motivates students and leads to both individual and cultural identity, as well as a sense confidence in career planning. Human relationships are important to all factors found in authentic learning environments, as are teacher attributes that guide students in their many paths to becoming young adults.

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