Pushing the Envelope of Technology Integration

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Introduction

The impetus for the work reported in this paper came as the result of an effort to find a way to teach technology integration in a novel teacher education program. Since the key approach to stimulating inquiry within this teacher education program is through sets of cases, it seemed appropriate to pursue a similar approach to inquiring into the integration of information and communication technology (ICT) within the Alberta curriculum. Through a series of funded projects four digital cases were developed and piloted[1]. While it is tempting to simply declare the project a success and move on to other things, our experience with pilot-testing these cases is leading us to look more closely at the experiences of professional students working in an inquiry environment. We state our own prejudice at the outset that we believe inquiry-based learning has much to commend it and therefore should be pursued. However the intricate relationships among subject knowledge, pedagogical knowledge, and environment of application that exist within teacher education present a special instance of inquiry-based learning that warrants careful examination. Nowhere is that intricate relationship more evident than within ICT integration. Therefore the experience of trying to teach ICT integration through inquiry learning may well be a special and instructive case of this approach to professional education in general.

Before describing the actual outcomes which we observed among those who pilot-tested the ICT cases, it is worth looking more closely at the rationale for pursuing this *modus operandi*. It is only against this rationale that the outcomes we found can be judged. There are three subsets to the rationale: the notion of meaningful learning, the increasing prevalence of constructivism as a means of understanding and interpreting learning, and the need for those expected to follow an inquiry-based approach in schools to have a rich experience of inquiry-based learning themselves.

Rationale

It is useful to begin with Ausubel and the distinction which he drew between *rote* and *meaningful* verbal learning (Ausubel, Novak & Hanesian, 1978). A fundamental distinction between the two is contained in the notion that rote learning is retained in form and substance as it has been received by the learner—it is not repackaged in any way that leads to a sense that understanding has taken place (e.g., paraphrased) nor is it reformulated in any manner that connects it to the personal experience or knowledge of the learner. Finally it will probably not be drawn upon for application beyond what is required for *remember verbatim* (Merrill, 1983).

In contrast to rote learning, meaningful learning exhibits multiple characteristics from the following list: it can be paraphrased in language with which the learner is familiar; it can be connected (possibly in multiple ways) to other knowledge which the learner possesses; because of the multiple connections, the learner becomes aware in a critical fashion of nuances that have not been made explicit by an instructor and is able to think of new possibilities—*far transfer* in contrast to *near transfer* (Perkins & Salomon, 1988). While rote learning is not to be despised under certain circumstances—remembering one's postal code, for example—it is nevertheless generally valued less than meaningful learning which is seen as necessary for scholarship, for making one's way in a complex world, and for engaging in problem solving. In current education debates, a recurring criticism of schools is that they have fostered rote learning at the expense of meaningful learning.

Meaningful learning does not require a case-based approach or the more generic form, inquiry-based learning. However, there is a broader context that makes this attractive, viz., (1) the desire to encourage student volition, (2) the sense that learning in complex environments is not simply an intuitive extension of learning in discretely presented ones, and (3) the belief there is an important agenda associated with problem solving which needs to be superimposed on any curriculum. Furthermore, there is a move away from the notion of "the canon" in favour of recognizing that the world is now available too richly to be constrained to a single, bounded perception of it, and that students should be able to engage that richness with critical curiosity that is to be cherished and fostered. Finally, there is a widespread perception that this richness can be encountered best in a cooperative fashion, and environments which combine complexity with cooperation constitute better environments for education.

Current views that lead to much the same conclusion as Ausubel consider the topography of learning as a continuum. At one end of the continuum is the perception of learning as largely having a bounded, static topography. In this view, teaching is about transmission, and questions are largely a means of setting parameters for predetermined outcomes. It is informed by a prescriptive approach that favours an objective view of the world, a non-negotiable space into which learners' voices are not invited. At the other end of the spectrum, learning is perceived to take place within a living topography in which *big questions* spark and are sparked by learner curiosity. Inquiry is a stance more so than an activity, and conversation is critical. Learners bear down on critical elements, grapple with underlying principles, and work with ill defined problems. In learners' creation of knowledge,

> …ideas are treated as real things, as objects of inquiry and improvement in their own right. Knowledge building environments enable ideas to get out into the world and onto a path of continual improvement. This means not only preserving them but making them available to the whole community in a form that allows them to be discussed, interconnected, revised, and superseded (Scardamalia & Bereiter, in press, p. 5).

Constructivist theories have grown to be a dominant philosophy in education. Duffy and Cunningham (1996) acknowledge there are numerous interpretations of the term constructivism. In their examination of constructivist theories, they found a general commitment to the notions that "(1) learning is an active process of constructing rather than acquiring knowledge, and (2) instruction is a process of supporting that construction rather than communicating knowledge" (p. 171). The learner is central to the learning process. The opportunity to interact with other learners in sharing, discussing, constructing and negotiating meaning leads to knowledge construction.

There are various levels of constructivism. In their examination of shallow versus deep constructivism, Scardamalia and Bereiter (in press) argue a shallow approach has students engage in activities where "ideas have no overt presence but are entirely implicit" (p. 4). In contrast, deep constructivism involve

> …practices such as identifying problems of understanding, establishing and refining goals based on progress, gathering information, theorizing, designing experiments, answering questions and improving theories, building models, monitoring and evaluating progress, and reporting are all directed by the participants themselves toward knowledge building goals (Scardamalia & Bereiter, in press, p. 4).

Scardamalia and Bereiter (in press) argue constructivist approaches (e.g., inquiry-based, project-based learning) can lie between shallow and deep constructivist perspectives. In the middle, learners are

> …engaged to a greater or lesser extent with ideas and they have greater or lesser amounts of responsibility for achieving goals, but the overarching responsibility and means for advancing the frontiers of knowledge are either absent or remain in the hands of the teacher or project designer. The idea of 'guided discovery' suggests this middle ground. Middle-level constructivist approaches are best categorized as constructivist learning rather than knowledge building. Knowledge building calls for deep constructivism at all educational levels; it is the key to innovation (p.5).

Inquiry-based Learning and Knowledge Building

Above we described inquiry-based learning as being a *stance* rather than a *method*. It is useful to differentiate between inquiry-based learning of the variety of which we speak and other constructivist approaches such as discovery learning or guided discovery-learning. First, inquiry is "a dynamic approach to learning that involves exploring the world, asking questions, making discoveries, and rigorously testing those discoveries in the search for new understanding" (Inquiry Learning Forum, n.d., ¶ 1). Wells (n.d.)

concurs stating “inquiry is not a "method" of doing science, history, or any other subject, in which the obligatory first stage in a fixed, linear sequence is that of students each formulating questions to investigate” (¶ 34).

Second, inquiry-based learning fosters a more generative orientation to learning. Inquiry-based learning occurs within a context that has a structure negotiated by the inquirers, and is open-ended and flexible to allow inquirers’ creativity and curiosity to lead the inquiry. It does not structure the learning experience to follow set procedures to arrive at predetermine conclusions. Wells (n.d.) argues “it is an approach to the chosen themes and topics in which the posing of real questions is positively encouraged, whenever they occur and by whoever they are asked. Equally important as the hallmark of an inquiry approach is that all tentative answers are taken seriously and are investigated as rigorously as the circumstances permit” (¶ 34). The inquirers’ logic guides the process as they unpack and/or repack the inquiry.

Third, collaboration and dialogue are valued assets in inquiry. The opportunity to interact and work with others in questioning, sharing, discussing, constructing and negotiating meaning leads to knowledge construction. There is a constant negotiation and re-negotiation occurring among learners as a result of their individual and collective experiences.

Fourth, as part of the student-driven learning experience instructors and students are cast as co-inquirers. They draw on their varied and collective knowledge, skills and resources in their interrogation of ideas. Learning is the responsibility of the learner, yet shared among all who participate in the inquiry.

Fifth, inquiry-based learning involves iterative cycles of observation, action and reflection (Jardine, 2001). Jacobsen (2001) describes the inquiry task as "an iterative and disciplined cycle of research, reflection, writing, and revising one's knowledge and understanding…the iterative cycle of inquiry is not 'done' when the project, or product, or paper, is finally presented to the group…It is impossible to 'know all' about a subject or topic. There is always more to know because the subject itself keeps changing" (p. 17). Further, through the inquiry process there is a constant negotiation and re-negotiation that occurs among learners as a result of the experience they personally and collectively encounter.

Inquiry and ICT in the Faculty of Education

Over the past three years, we have developed, implemented and evaluated inquiry-based technology cases with pre-service and in-service teachers in the Faculty of Education at the University of Calgary. We are of the opinion that achieving deep constructivism results in *good work* but also demands hard work. Living the inquiry process generates struggles and sparks rebellion as beliefs and understandings about teaching, learning and curriculum are probed in new and unfamiliar spaces. But through the hard work, the

critical reflective pedagogical discussions and appreciating the end result teachers begin to develop an understanding of the power and potential of inquiry-based learning.

The use of inquiry-based learning has been the vehicle in which students in the Faculty of Education begin to examine their beliefs and develop their understandings of the world of teaching, learning and technology integration. The cases have been designed to trigger exploration of both pedagogical and technological issues, and critical factors that confront educators with the implementation of the Alberta ICT Program of Studies. Two key goals have been established for the case work. The first goal is to foster independent and confident teachers who are critical, creative thinkers and co-inquirers. Within the inquiry-based process used with the technology cases, learning opportunities have been designed to foster critical thinking that assists in the development of enduring understanding and informs practical actions for technology integration. The second goal is to provoke discussion, challenge assumptions, inform perspectives, and complicate simplistic images. Fundamental to the cases is the creation of dissonance as a means of getting teachers to explore technology integration in relation to their own pedagogical practice.

The inquiry-based technology cases are presented in a digital format and are independent of each other. The cases can be used in whole or in part within undergraduate and graduate programs. Through the case experience, teachers grapple with issues and are given the opportunity to develop pedagogical understandings and strategies needed for the integration of technology. The versatility in the cases allows for a greater scope for what people wish to pursue in their own inquiries. Teachers have the opportunity to make decisions about the type of and nature of how technology will be used as an integral component of their particular inquiry experience.

Pilot testing of the cases occurred with undergraduate students in winter 2003 and graduate students in summer 2003. Data were gathered (1) to further refine the cases and inform future development decisions, and (2) to provide insight into the impact the cases have on if and how student teachers and teachers reframe their thinking about curriculum, technology and teaching.

Thirty-two undergraduate students, seven graduate students and four instructors participated in the study. Each group of undergraduate students focused on one case and each group completed a different case. Graduate students completed three of four cases. In terms of entry-level comfort with technology, all participants felt comfortable using word processing and e-mail. The majority indicated that they felt comfortable working with spreadsheets, databases, World Wide Web, online chat, scanning and using software for concept mapping. Less than 40% indicated comfort with using web authoring tools, creating digital movies, digital media editing software, online conferencing, online gaming, simulations and e-mail distribution lists.

Findings

It is evident from the data there was a change in most of the participants' thinking about technology. There was an investment on the part of the students to produce quality work. Students took pride in the work they produced as a result of the completion of the case tasks. There was a level of sophistication in their work that was reasonable for where they were at that point in their program and for the amount of time they had with the case(s). It was evident that participants had developed greater awareness of technology and technology integration. However, there was a tendency for the focus in the work and discussions to be *about technology*. Missing was a substantive amount of reflection that would suggest a shift of focus from the technology to broader issues of curriculum and inquiry.

The cases did stimulate critical inquiry into technology integration. The case content and tasks were designed not to be *about the technology* or *how to do it*. Rather, through this approach, participants began to develop a deeper understanding of the complexity of both the *how* and the *why* of technology integration in relation to teaching and learning. As they became immersed in the cases they confronted philosophical, ethical and rationale issues. The majority of the students felt the cases evoked critical thought in relation to the relationships among pedagogy, educational philosophy and ICT learning outcomes. They found the case tasks complex enough to expand their understanding of the topic, and rated their understanding of the subject matter at the end of the case as being very good to excellent. They had a greater understanding of curriculum and multidisciplinary teaching possibilities and what is possible with technology in the classroom. Through their case experiences they began to appreciate the importance that it is not *about the technology* and skill acquisition. Rather, it is about creating meaningful learning environments where technology is seamlessly interwoven throughout the fabric of the learning process.

An unanticipated challenge in using inquiry-based cases has been in relation to students' prior experience with inquiry-based learning. The undergraduate students took comfort in the familiarity of the case format, given it is the corner stone instructional approach used in the teacher education program at the University of Calgary**.** For them it tended to be a less threatening approach to learning about technology and technology integration, and the fact that they were working with digital cases added a new dimension to inquiry through a case approach. In contrast, graduate students were less comfortable stepping into an inquiry learning environment. They indicated that they expected the course to be focused more on training and learning various software applications. They had an expectation of working within a teacher-centred environment to learn *how to do* and the *quick fix* of technology integration. There tended to an initial resistance in being cast as inquirers. To some degree, they struggled in creating their own student-driven learning experience based through the particular case context. Being challenged to work through inquiry and direct their own inquiry required initially significant scaffolding to be in place by the instructor to assist the students.

Reflecting on Individual Differences

From our perspective, we would say that what we found from observing the participants was positive. We had hoped that they would develop a better understanding of the intricacies of curriculum and gain a deeper understanding of multidisciplinary teaching possibilities. We found that many of those who engaged the cases achieved these goals. We anticipated that the users would also develop an awareness of and openness to new possibilities for using technology to enhance the curriculum. For the students in the teacher education program it meant working with technology in an inquiry environment that was familiar to them. This was consistent with how they were engaging other content in their program which did not pose the disjunct which would have occurred had we attempted a didactic mode. These results, however, were not uniform. It is this lack of uniformity that we are beginning to explore, not only for its potential implications for how to teach ICT in an inquiry-based teacher education program, but for clues to understanding differential outcomes of an inquiry approach to professional education in general.

Salient differences that we observed among the users of the cases included:

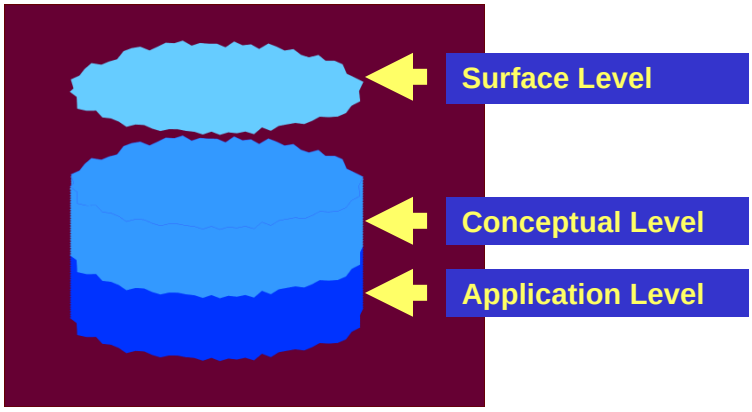
1. Degree of engagement
2. Demand characteristics
3. Counterproductive distinction between theory and practice.

The most noticeable were differences in the degree of engagement with which students approached the content. In this we posit something akin to the notion of invested mental effort explored by Salomon (1983) in his investigation of efficacy of learning from different media. To engage the cases *deeply* required students in three of the cases to actually learn and experiment with software, and in the remaining case to carefully examine artifacts that accompanied the video in addition to dealing with the obvious "conceptual" content of the cases. We found, however, that while some of the students indeed engaged the cases in the depth we expected others did not. Some of this difference in turn may have been due to four other differences that we observed.

One of those differences was in the set of expectations which students brought to the cases, perhaps not unlike Salomon's (1983) notion of *perceived demand characteristics* (p. 47). While some came with the sense that learning required hard work with considerable thought and effort, others came perceiving that an exchange of opinions was sufficient. We were also intrigued by the role which individual beliefs about technology influenced how students approached the cases. This probably should not have surprised us given a constructivist view of the world which holds that present knowledge is the starting place upon which new knowledge is built. Students came also with different dispositions toward the task—open-mindedness and close-mindedness toward considering new ideas about technology and learning. If learning is about negotiating meaning, some were prepared to engage in that discussion and others were reluctant. The final set of differences lay in an understanding of what it means to "inquire into ICT"—

does it mean just to talk about presently held understanding, does it mean to investigate it conceptually, does it mean to immerse oneself thoughtfully in its application?

Figure 1: Pool as metaphor for case.



What became a salient point for us was that the time-honoured bipolar distinction between theory and practice was not appropriate for inquiry-learning. As a tentative means for considering what we were observing, we considered each digital case as a pool of liquid the density of which increases the deeper one plunges. At the top is the *surface level*, below it is what we are calling the *conceptual level*, and at the bottom lies the *application level*. None of the labels quite capture what we want, particularly the last. To talk about *application level* sounds like the theory/practice distinction that we wish to avoid. It is our sense in an inquiry-based learning environment one cannot have the clean distinction between theory and practice, concept and application, which has customarily been applied in professional education. Further one cannot even talk about a *dialectic* relationship between the two. Many of our colleagues are falling back on Greek terminology such as *praxis* and *phronesis* (practical wisdom) to try to capture the world where theory and practice are one.

We considered the metaphor of a beam of light entering this pool, and depending on the angle of incidence of its entry it behaved differently: (1) reflecting off the surface or (2) refracting through the conceptual level or (3) plunging deep and refracting through the application level. Consider the differences we found among the three levels:

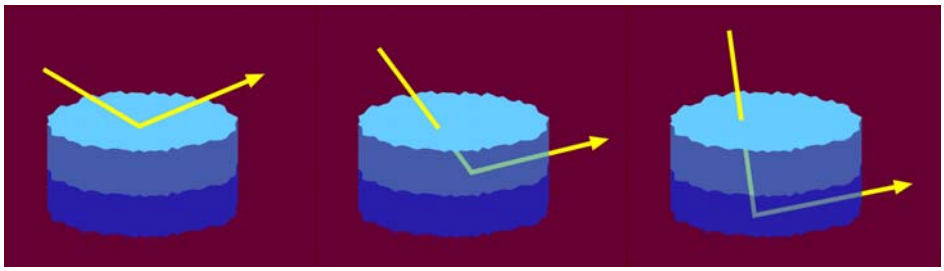
> ***Surface Level***. Students tended engage in exchanges that had the net effect of reaffirming myths about technology and education, focusing on barriers to the use of technology in schools, reinforcing preconceptions, and/or looking for simplistic solutions.
>
> ***Conceptual Level***. At the conceptual level we found students breaking away from preconceptions, and beginning to formulate a conceptual framework for ICT

integration. However the discussion was largely *about* technology. Inquiry as an approach to learning remained firmly planted in the background if it was considered at all.

Application Level. At the application level, where students actually engaged in the *doing* of ICT, we found increasingly sophisticated conceptual frameworks being developed. Of equal interest we found the emphasis shifting away from preoccupation with technology and much greater preoccupation with inquiry as an approach to teaching the curriculum.

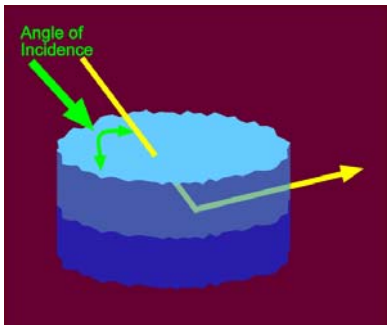
As a further means of considering what we were observing we refined our metaphor to include a beam of light reflecting off the pool of liquid or entering it and refracting through one of the deeper layers (Figure 2).

Figure 2: Metaphor of reflecting/refracting beam of light



Since reflection is governed by the angle of incidence of the beam of light to the surface (Figure 3), it is a small step to consider the angle of incidence as an appropriate metaphor for what we want to investigate next, the factors that influence the "angle of incidence" or the depth at which students engage the cases. If Salomon's (1983) notion of the relationship between invested mental effort and perceived demand characteristics holds, then there is need to pay closer attention to how the use of cases is framed, and how that framing interacts with the predispositions that students bring to casework and the nature of group interaction.

Figure 3: Angle of incidence



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[1] The four cases can be found at http://www,ucalgary.ca/~ipt, http://www.ucalgary.ca/~ipt2, http://ucalgary.ca/~ipt3, and http://ucalgary.ca/~ipt4.