In Teacher Education, *The Future Is Now*: The Importance of Modelling Effective Technology Integration in Mathematics Education Classes

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Abstract

An elementary pre-service teacher recently stated, regarding the integration of technology into her teaching: "I was unable to use it in my class because I did not have time… but I would definitely use this technology in the future." As a mathematics educator in a faculty of education, I am beginning to realize the limitations of offering pre-service teachers specific courses and focused modules in educational technology during their teacher education program. Such an approach, while addressing both basic technology skills and higher-level technology-based activities, does not appear to be significantly affecting school classroom practice. It is believed that the promises and possibilities of technology enhanced teaching and learning are unlikely to be explored in meaningful ways in school classrooms unless there is effective modelling of technology integration during the teacher education experience.

A goal of this paper is to report on the initial findings of a research project (referred to as the iTeacher Ed project) that aims to develop a model for the integration of Information and Communications Technologies (ICT) into teaching and learning for faculties of education. As a mathematics educator on the research team, I will discuss particular initiatives that are currently underway in mathematics education classes to address the challenges and barriers to effective ICT integration in teacher education programs. In this paper, these challenges and barriers are discussed in the context of the themes of effective modelling and changing educational practice.

Introduction

An elementary pre-service teacher recently stated, regarding the integration of technology into her teaching: "I was unable to use it in my class because I did not have time… but I would definitely use this technology in the future." Such a comment begs the question of what kind of modeling and/or experiences do pre-service teachers require in order to integrate, in an ongoing manner, the pedagogical approaches being learned in teacher education programs.

This paper comprises a dual focus. The first part of the paper provides an overview of a current action research project that explores best practices and models for the integration of Information and Communication Technology (ICT) into a faculty of education at a Canadian university. The overview briefly describes the purpose of the project (named the iTeacherEd project), the approaches to data collection, and a few key themes and recommendations emerging thus far from the study. The second part of the paper provides a reflection on practice from the perspective of a mathematics educator in this same faculty of education. The reflection outlines a few initiatives that have been incorporated into a secondary mathematics curriculum course, as well as a reflection on the challenges and barriers encountered in modeling ICT integration in mathematics teaching and learning.

Overview of iTeacherEd Project and Recommendations

The iTeacherEd research project is a two-year action research process (2002-2004) in the Faculty of Education, University of Regina, aimed at integrating ICT into the teacher education curriculum. The research initiative is sponsored by Industry Canada-School Net and involves four faculty members as the core research team, along with pre-service teachers, and several practicing teachers and school system personnel. The overall goals of the project are aimed at developing a model for the integration of Information and Communication Technology (ICT) into teaching and learning for faculties of education.

As part of the iTeacherEd research project, several technology modules were delivered to more than one hundred pre-service teachers in their third year (pre-internship year) of a four-year undergraduate teacher education program. The content of the technology modules includes basic technology skills such as web browsing and use of e-mail programs as well as instruction in higher level technology-based activities such as the critical assessment of online materials, using online resources to support instruction, and creating online resources such as electronic portfolios, webpages and WebQuests (web-based inquiry-oriented activities). These modules are fully developed and available online at http://education.uregina.ca/iteachered.

After these technology modules were delivered, questionnaires were distributed to the students to determine the influence of the modules on students' evolving ideas of integrating ICT into their teaching. As pre-interns, the students had several opportunities to teach in school classrooms while they were simultaneously taking courses at the university. The iTeacherEd research team was interested in knowing how or if these students integrated technology into their pre-internship classroom as a direct outcome of the skills and processes they were learning through the modules. In the questionnaires, pre-service teachers were asked to comment on the use and value of the technology modules in terms of their perception and understanding of the integration of technology into their pre-internship classroom and into classrooms in general. A synthesis of the information provided through students' responses to these two questions yielded a network of themes. The emerging themes include issues of time (creation and management), communication between schools and the university, different levels of student comfort and competence with technology, and general (mis)understandings of the *meaning* of integration.

The intention of this paper is not to present a detailed analysis of the ideas and experiences of pre-service teachers who have completed the technology modules and questionnaires. Such a detailed presentation of results can be found elsewhere (Nolan, in press; Friesen, Maeers, Nolan, & Couros, 2004). After presenting a brief overview of the significant learnings from pre-service teachers in their pre-internship and internship semesters, this paper explores how the learnings have lead to key recommendations.

Pre-internship and Internship Learnings

Insufficient time was the major impediment to integrating technology into the pre-internship and internship classrooms, even though several questionnaire responses indicated other significant impediments that related to school computer infrastructures. One pre-intern commented: "... there's just not enough time to do something of that magnitude in the semester, in addition to all of the other expectations". It is difficult to distinguish between pre-service teachers' comments about time in relation to being a student or a teacher. It is not known precisely whether they are referring to the time spent learning the ICT course modules in the Teacher Education program or the time actually spent in a classroom teaching students. There is

substantial evidence, however, to suggest that time in general is a factor in pre-service teachers' decisions about integrating new ideas into their practice. Some students indicated that the ideas and skills learned in the modules would be put into use "later", i.e., some time in the future.

> [The modules] made me more aware of the technology resources available for classroom instruction (possibly in the future). (pre-intern comment)

It is believed that, underlying this reference to time as an impediment, there is another reason of even greater significance. Pre-service teachers stress the importance of teaching "the basics" first before tackling a technology integrated and interactive approach to teaching and learning. What they have not yet integrated into their thinking is the importance of critical reflection on teacher-directed approaches as only one of many possible instructional strategies. Often, pre-service teachers convey the belief that alternative instructional approaches are "add-ons" to incorporate once the more traditional approaches have been used to "cover" the content.

Recommendation for ICT Integration

In addition to the iTeacherEd initiative, the Faculty of Education at the University of Regina has, in general, taken significant steps over the past ten years toward effective integration of technology into its teacher education program (Couros, 2002). The faculty firmly believes, however, that school classroom practice is unlikely to be significantly influenced by the possibilities of technology enhanced teaching and learning unless there is effective modeling of technology integration during the teacher education experience. Studies have shown that, while the number of computers in classrooms has increased dramatically over the past few years (Ertmer, et al., 1999), many barriers to effective integration still exist in teaching practice. The iTeacher Ed project researchers are attempting to understand more about how to effectively (and affectively) address these and other barriers. In other words, the research team wants to determine what is integral to integration (Nolan, in press).

Several recommendations have emerged in an on-going manner from the iTeacherEd research with pre-interns and interns. One key recommendation of the project is that teacher education programs need to focus on integrating ICT into curriculum and instruction courses. Pre-service teachers need to experience effective ICT integration within all courses in their teacher education program and that this modeling of ICT integration must be happening in all four phases of the teaching and learning cycle: planning, instruction, student activities, and professional development. The next section of this paper draws attention to how this recommendation has begun to be addressed in a secondary mathematics education course.

ICT Integration in Secondary Mathematics Education

As a mathematics educator and one member of the iTeacherEd research team, I realize the limitations of offering pre-service teachers specific courses and focused modules in ICT during their teacher education program. Such an approach, while addressing both basic technology skills and higher-level technology-based activities, does not appear to be significantly affecting school classroom practice. As mentioned in the previous section, such an approach often isolates the possibilities for ICT integration from relevant and curriculum-based contexts. This part of the paper briefly outlines a few of the activities I have recently initiated in a secondary mathematics curriculum and instruction course. One of my goals in modeling ICT integration has been to provide opportunities for students to take notice of the promises and possibilities of meaningful technology enhanced teaching and learning.

Use of Java Mathematics Applets

There is a rich and extensive source of student learning tools through the use of on-line, interactive java mathematics applets. In my mathematics curriculum course, students were given examples of lessons that incorporated mathematics java applets. They were then asked to locate and integrate such an applet into the development of one lesson in their unit plans. A deliberate effort was made to ensure that students did not make the java applet the focus of the lesson, but instead viewed the applet's function merely as an effective interactive tool for enhancing student understanding of the concepts involved.

Use of Online Curriculum Guide

The province of Saskatchewan in Canada is moving toward the termination of printing and distributing paper copies of curriculum guides. Saskatchewan Learning's commitment to continual renewal and updating of resources is more feasible if they focus on electronic online curriculum guides. It is therefore critical that students become familiar and comfortable with linked and approved learning resources as well as with the technological skills to negotiate the electronic version of the curriculum guide. To this end, students developed and performed scavenger hunts of the online mathematics curriculum guide.

Development of a Course Website

While not claiming to use state-of-the-art web design software, it was possible for me to create a very rudimentary course website for the dissemination of student projects (including lesson plans, annotated bibliographies, and student-designed problems) and teacher class notes (PowerPoint presentations, Internet resources, and example problems). Such a repository of course materials makes it possible for students to share their coursework in formats that can be readily adapted to each student's future teaching situation, while significantly reducing the necessity for excessive photocopying.

Encouraging Learning Station Models

One very important learning for the iTeacherEd research team was that students have very little practical knowledge of the use of a mini-lab environment in classrooms. Effective and seamless integration of ICT into teaching and learning no longer implies the existence of a large computer lab, with a ratio of one computer to one student. More and more school classrooms are moving toward a mini-lab approach (4-6 computers per classroom). Pre-service teachers need to experience this approach in their curriculum and instruction classes as part of effective modeling of ICT integration. In the secondary mathematics education course, students were encouraged to make use of Apple i-books during class. The i-books were used for various student activities at various times (not all students engaged in same activity at same time). For example, students used the i-books to explore and evaluate websites, to research and develop their Problem-Based Learning WebQuest assignment, to search for useful resources in the development of their unit plans, etc. A key emphasis was the use of the i-books as one tool for research, while other learning centres occurring simultaneously focused on other tools and manipulatives for learning.

It is clear from this brief summary that incorporating major ICT integration initiatives was not the goal. Rather, the summary provides a glimpse into a selection of straightforward ideas for integrating technology into mathematics classes. I believe students are better able to identify with a number of smaller scale ICT initiatives and strategies, making the modeling effective through its perception of attainability. There have been many challenges and barriers

(as well as successes) in these attempts to model effective integration of ICT into mathematics teaching and learning. The challenges and barriers will be presented in the context of a discussion of two themes: effective modelling and changing educational practice.

Effective Modelling

Teacher educators cannot dismiss comments made by pre-service teachers that they do not have the time to integrate technology because in faculties of education we come across many of the same comments from faculty themselves. Effective modelling of ICT in teacher education programs requires teacher educators to have open and reflexive approaches to pedagogy and the tools of the trade. One often hears instructors comment that the tools they are using (and perhaps have used for several years) are effective within their subject areas. For example, they may assert that overhead transparencies and instructor-directed PowerPoint presentation are effective means of presenting the subject material to students. Perhaps it has taken a considerable amount of time already for an instructor to become comfortable with the use of e-mail communication technologies with his/her students, and so she/he may not be interested in moving beyond this approach to consider WebCT discussion forums, chat rooms, and other forms of communication technologies.

Keeping up with the fast pace of ICT changes and advances is a major challenge for many faculty members, especially since it is often not a central focus in their research and teaching. The move to new ways of teaching with ICT at the university level involves a high degree of change and paradigm shifts in beliefs and practices related to teaching and learning. To adopt a reflexive approach means to be determined to critically assess and bridge the developing gaps between university, schools, and society when beliefs and practices do not mesh. Faculty in teacher education programs must be willing to critically assess when and where ICT integration becomes enabling and empowering in student learning, and be willing to work toward effectively modeling such practices. This takes a considerable amount of time and effort but it is important that such an effort is consistent throughout a faculty. As it is, pre-service teachers seldom see extensive modeling of ICT integration in school classrooms so a paradigm shift is unlike to occur in education unless teacher educators at the university take a collaborative and united approach to changes in ICT practices.

Changing Educational Practice

From my experience with pre-service teachers, the situation of changing mathematics education is very complex. Their experiences of mathematics education have emphasized very dichotomous beliefs about knowing in math—one either knows it or they don't, one is either good at it or not (Nolan, 2001). For the most part, pre-service teachers describe their experiences of learning mathematics as being very procedural in nature, in both instruction and assessment. Whether they were good at it or not was determined primarily through direct teaching and then testing, and seldom through other forms of instruction and assessment. In their mathematics curriculum classes at the university, they are exposed to various forms of instruction and assessment, including multiple avenues for the integration of ICT into their teaching. When students begin to have classroom experiences (during the pre-internship and internship semesters of the teacher education program), they observe co-operating teachers and students 'doing' mathematics. What they often report back to the university is that the "new-fangled" ideas being discussed and emphasized in mathematics curriculum classes are not actually happening in classrooms, and the credibility of these ideas is quickly lost in the theory/practice divide. Pre-

service teaches seldom observe alternative instruction and assessment, such as ICT integration, problem-based learning, journal writing, etc., in mathematics classrooms. In addition, even if they are determined to try such approaches during their practicum, co-operating teachers often feel it is their place to advise pre-service teachers against these approaches because they take too much time and there is too much content to get through. It is both easy and disheartening to see how the theory/practice divide experienced by pre-service teachers leads to the perpetuation of the cycle of mathematics education that is already in place instead of a critical examination of the status quo. In other words, new teachers can (almost by default) adopt the belief that there is so much content in the mathematics curriculum that one cannot integrate ICT until all the basics are first covered, and perhaps *best* covered, through traditional pedagogical approaches.

Admittedly, these two challenges depict a worse case scenario for the future (and present!) of mathematics education. However, a pre-service teacher's philosophical orientation and identity formation relating to what it means to be a teacher are so closely linked to their K-12 experiences that there is often deeply embedded (and unacknowledged) resistance to change. As an alternative to change, it is easy to create a mental image of an isolated ivory tower of university teachings that do not relate to the reality of practice. The resistance to change has been expressed in many ways in my secondary mathematics curriculum class, through conversations, assignment writing, and discussions with colleagues. It has also been expressed through pre-service teachers' responses on the iTeacherEd questionnaires. One preservice teacher commented: "There's not enough time to 'do it all'."

Believing there is not enough time and there is too much content to cover require deconstructing in order to get at the heart of what is important in teaching and learning. Without such a deconstruction, the barriers to the promises and possibilities of ICT integration, and the barriers to shifts in the practice of teaching mathematics in general, remain too substantial to overcome. Addressing these challenges and barriers must be the starting point for *the future of mathematics is now*.

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