Design and Implementation of Research-Based Resources for STEM Teacher Education

Marina Milner-Bolotin, Ph.D.
Department of Curriculum and Pedagogy, the University of British Columbia, Vancouver, Canada

Abstract

Educational technologies, such as electronic response systems, computer simulations, and live data analysis tools, have a vast potential in Science, Technology, Engineering, and Mathematics (STEM) education [1-8]. Yet, they are often underutilized in Teacher Education even when they are readily available. There are a number of reasons for that, including: (a) STEM teacher-educators often have limited experiences with these technologies; (b) Teacher-Candidates (TCs) haven't experienced these technologies as learners; and (c) There is a lack of research-based pedagogically-proven materials to support the implementation of these technologies in K-12 classrooms. The Mathematics & Science Teaching and Learning through Technology Project sponsored by the UBC Teaching and Learning Enhancement Fund addressed this problem by creating such resources and implementing these technologies in STEM Teacher Education through relevant methods and inquiry courses.

Introduction

Modern STEM teachers employ a variety of educational technologies. In order to succeed, the teachers must acquire the technological skills and positive experiences with technology-enhanced pedagogies. This project focused on the development of these skills and experiences in the context of UBC Teacher Education Program for STEM TCs. We explored four technologies:

Clickers: Peer Instruction [7] is a formative assessment-driven pedagogy that uses electronic response systems (clickers) to engage students in responding to conceptual multiple-choice questions during class. The results of student voting are immediately displayed and the students are invited to discuss their answer with peers. Then the voting is repeated. The teacher then adjusts the lesson to address their difficulties and possible misconceptions (Figure 1).

PeerWise (https://peerwise.cs.auckland.ac.nz/): It is an online system that allows students to create, discuss, answer and edit multiple-choice questions.

Logger Pro: The software and hardware (www.Vernier.com) that allows collection and analysis of real time data. This is especially useful for conducting experiments and testing scientific hypotheses.

Computer Simulations: Allow TCs to model physical phenomena through conducting virtual experiments. One of the widely used collections of STEM simulations today is PhET: http://phet.colorado.edu/ (Figure 2).

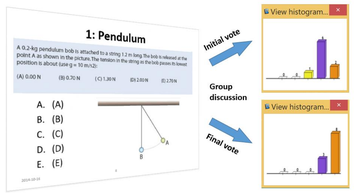

Figure 1: Peer Instruction in action. Results of pre- and post voting on an a conceptual question: 9 Teacher-Candidates took part in voting.

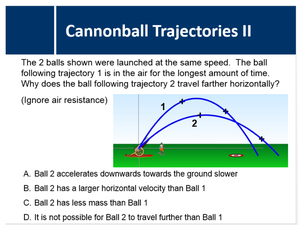

Figure 2: An example of a conceptual question designed by a Teacher-Candidate that uses PhET computer simulations.

Project Methods and Scope

Since 2012 over 200 Teacher-Candidates (TCs) were directly affected by the project. All secondary physics and mathematics TCs were engaged with the Mathematics and Science Teaching and Learning through Technology resource as learners and as future teachers. It also was integrated into the inquiry courses and professional development opportunities. TCs also incorporated the resource in their lesson and unit plans for the school practicum. The technology-enhanced pedagogies supported by the resource were modeled in the STEM methods courses for elementary TCs (200+) and presented to all TCs during special professional development events. Moreover, the resources designed by TCs through their participation in the PeerWise collaborative system were consequently incorporated in the resource database and shared with all the Teacher Education community. TCs' feedback on the resource has been continuously collected and incorporated to improve the resource.

Results

The results of the project indicate that:

1. Modeling technology-enhanced pedagogy in STEM methods courses increases Teacher-Candidates' (TCs') interest in active learning;
2. Technology-enhanced pedagogy is a powerful vehicle for developing Pedagogical and Content Knowledge of STEM TCs while helping them become reflective and inquiring educators;
3. Technology-enhanced pedagogies, that utilize Peer Instruction, PeerWise, Logger Pro and computer simulations (PhET) are useful for identifying and addressing the gaps in the TCs' Content Knowledge.
4. Through active engagement (Table 1) with collaborative educational technologies TCs acquire positive attitudes about technology-supported student-centered learning environments and are more open to using these technologies in their practicum and after graduation [1-4].

Table 1: An example of physics Teacher-Candidates' (TCs') engagement with PeerWise online collaborative question database during the first six weeks of the Physics Methods course.

	Designed questions	Submitted answers	Comments written
TC1	12	72	10
TC2	18	22	21
TC3	21	68	17
TC4	12	37	22
TC5	19	29	25
TC6	18	21	20
TC7	13	24	14
TC8	13	124	39

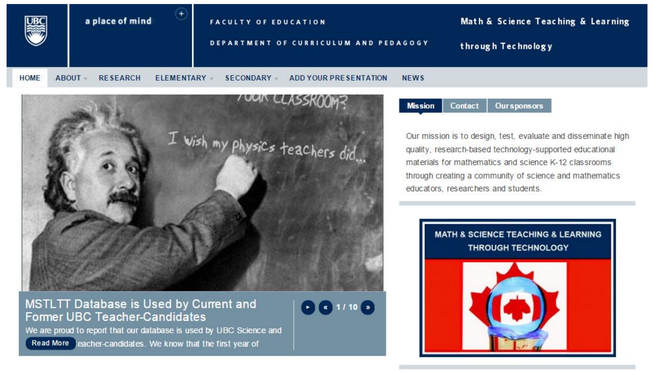

Figure 3: Mathematics and Science Teaching and Learning through Technology database has more than 1000 K-12 resources: http://scienceres-edcp-educ.sites.olt.ubc.ca/.

Discussion

It is not enough to have access to technologies in STEM teacher education. It is crucial that TCs, as well as teacher educators, have multiple opportunities to experience these technology-enhanced pedagogies both as learner and as educators [1-4]. These pedagogies have to be informed by educational research and supplemented with relevant educational materials [1, 4].

The TLEF-funded Mathematics and Science Teaching and Learning through Technology project provided such a support framework for UBC TCs and educators. The resources designed during the 3 years of the project were enhanced technology use in STEM methods courses. TCs and educators benefited greatly from the project [4]. Most importantly, TCs also became contributors and not only consumers of the resources. Thus, from the very beginning of their careers TCs became both beneficiaries and benefactors of the STEM education community at UBC and internationally.

Conclusions

It is important to encourage STEM Teacher-Candidates (TCs) to engage with new educational technologies during their practicum and after graduation. To support them in effective technology adoption, TCs have to be exposed to these technologies in their methods courses. They have to experience the benefits and challenges of technology-enhanced pedagogies in a non-threatening learning environment. To make the implementation of new technologies viable, TCs and their instructors also have to have access to research-based materials that support the implementation of these technologies into practice. The TLEF-supported resource: Mathematics and Science Teaching and Learning through Technology is such a database of K-12 research-based pedagogical resources for STEM teaching with technology. It has been used successfully with UBC mathematics and science methods and inquiry courses. The integration of the resource in these courses has made a positive impact on the TCs, expanding their pedagogical repertoire, while helping them acquire positive attitudes about active STEM learning.

Contact

Marina Milner-Bolotin Ph.D.
Assistant Professor | Faculty of Education | Department of Curriculum and Pedagogy
The University of British Columbia | Vancouver
Phone 604 822 4234 | e-mail: marina.milner-bolotin@ubc.ca
Web site | http://blogs.ubc.ca/mmilner/
MSTLTT Web site: http://scienceres-edcp-educ.sites.olt.ubc.ca/

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