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Developing Pre-service Teachers' Capacity in Teaching Science with Technology through Microteaching Lesson Study Approach

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ABSTRACT
In order to effectively use technology in teaching, teacher candidates need to develop technology related pedagogical content knowledge through being engaged in a process of discussion, modeling, practice, and reflection. Based on the examination of teacher candidates' lesson plan assignments, observations of their microteaching performance, and their reflective journals, our study found that Microteaching Lesson Study in methods courses provides teacher candidates a great opportunity to learn how to teach with technology. Its significance lies in the opportunity of practice, collaborative refection, instant feedback, and learning from each other.
Keywords: Technological pedagogical content knowledge; teaching with technology; science methods course; pre-service teacher education.

INTRODUCTION

Today's teachers are expected to use technology in their teaching. Responding to the expectation about teachers' technology proficiency, teacher education programs often offer a standalone technology course (Kleiner, Thomas, & Lewis, 2007). Unfortunately, such a quick fix approach has been argued to be not successful in preparing teachers to teach with technology (Flick & Bell, 2000; Moursund & Bielefeldt, 1999). A recent report from the U.S. National Center for Education Statistics (NCES, 2010) states that only 25% of school teachers report that pre-service teacher education programs had any influence on their ability to use technology in teaching. As a footnote for such low influence of teacher education programs on teachers' ability of using technology, literature has pointed out that teacher education programs often have a limited use of technology in teacher education courses, an emphasis on

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teaching about technology rather than teaching with technology, and a lack of faculty modeling of appropriate ways to integrate technology into school subject teaching (Capobianco & Lehman, 2006; Zhou, Zhang, & Li, 2011).

To address such shortcomings of teacher education in preparing future teachers to teach with technology, Tondeur et al (2012) suggested that pre-service teacher education shouldn't concentrate only on developing technological skills through educational technology courses, but should also focus on how technology can be used for teaching and learning. Technology skills will not automatically transfer to the ability of teaching with technology. The first two authors of this article have advocated the significant role of methods courses in developing future teachers' technology proficiency (Zhou & Xu, 2011). In practice, they have been using Microteaching Lesson Study (MLS) approach to provide teacher candidates opportunities to learn and practice the use of technology in science teaching. This paper reported the findings from a study that was designed to explore the effectiveness of using MLS approach in science methods courses to prepare teacher candidates for teaching science with technology.

LITERATURE REVIEW

Teacher candidates are a unique group on campus. On one hand, they are learners as the students from other majors on campus. On the other hand, they are different since they learn how to teach subjects rather than the subjects themselves. The picture gets even more complex when technology is brought into subject teaching. What type of knowledge teacher candidates actually need to develop? How should a teacher education program help with the development of such knowledge? Our study drew information from multiple areas of literature described below.

Pre-Service Teachers' Technology Related Knowledge

Shulman (1986) used Pedagogical Content Knowledge (PCK) to describe teachers' knowledge system. PCK refers to an overlap of subject knowledge and pedagogical knowledge. It includes an understanding of the ways of representing and formulating the subject that make it comprehensible to others: the most useful form of representations, the most powerful analogies, illustrations, examples, explanations, and demonstrations, etc. It also includes an understanding of what makes the learning of specific topics easy or difficult for certain age group of learners. Considering the significance of technology in teaching, Mishra and Koehler (2006) advocate the term Technological Pedagogical Content Knowledge (TPACK). Similar to the concept of PCK, TPACK refers to an integrated understanding of technology, pedagogy, and subject content. At the heart of the TPACK framework is the complex interplay of three primary forms of knowledge: content knowledge, pedagogy knowledge, and technological knowledge. This framework suggests that to develop the ability to teach a subject matter, one must not only grasp the content of the subject, learn essential principles that guide learning in this subject area, but also must learn to structure and enhance learning opportunities for students. In other words, capable teachers must know why certain concepts are important and be able to flexibly incorporate new resources including technology into their knowledge of subject pedagogy in ways that enhance learning.

Teaching with Technology

Today's technology makes it easier to access information in more than one format and also can generate information that is not available otherwise (e.g. simulations). However, the availability of information does not guarantee learning, just as access to nutrition does not necessarily lead to good health for everyone. Learners need to retrieve, filter, and make sense of information. A successful learner today knows how to use technology creatively in his or her process of knowledge construction, which can be best described using the term learning with technology. When students learn with technology, they use technologies as mind tools for analyzing the world, accessing information, interpreting and organizing their personal knowledge, and communicating what they know to others (Jonassen, 1996).

To facilitate students' learning with technology, teachers have to teach with technology. Instead of looking at technology only as a new way of delivering information, teachers need to take technology as an integral component of good pedagogy. Beyond content delivery, technology can be used to access information, provide innovative information that traditional teaching methods cannot provide, or as a useful tool to conduct inquiry activities or communicate with others. In order to build technology into their pedagogy, teachers should know why, when, and how to use technology to facilitate student inquiry. In other words, teachers need TPACK to be able to teach with technology. If teachers don't have such quality, they will hesitate to use technology or use technology ineffectively (Zhou, Brouwer, Nocente, &Martin, 2005), which leads to students' rejection to the use of technology in teaching (Charbonneau, 2012).

TPACK Development through Methods Courses

Since TPACK involves a hybrid understanding of technology, pedagogy, and subject, it is best developed through methods courses where pedagogical ideas and tools meet the subject content. These courses provide a meaningful context where learning to use technology can be pedagogically situated in the teaching of subject matters (Davis & Falba, 2002; Zhou & Xu, 2011). The Society for Information Technology and Teacher Education has purposely promoted this movement by awarding exemplar use of technology in methods courses. Among the award winners, Bodzin (2005) focused on pre-service science teachers' understanding of Web-based scientific inquiry; Schwarz (2005) helped pre-service teachers evaluate and use computer modeling and simulation software for science learning and teaching; Hoban (2007) used slow motion animation ("slowmation") to engage pre-service teachers in understanding science content knowledge.

Positive results have been reported for the integration of technology with methods courses. Through a peer coaching collaboration between instructional technology graduate students and pre-service teachers enrolled in mathematics methods course, Tryon and

Schwartz (2012) found that pre-service teachers became more aware of how technologies that are used in everyday interactions could eventually be incorporated into their classroom practices. Ye, Jim, and Selmer (2010) integrated pedometers into elementary science and mathematics methods courses. They found that the lesson plans developed by pre-service teachers showed that pedometers could be used as technology tools to teach many essential mathematics and science concepts. Polly, Mims, Shepherd, and Inan (2010) documented that pre-service teachers who took part in the technology integration activities in method courses appeared to report more technological knowledge, more positive attitude towards technology integration, and better implementation of technology-rich instructions during field placement. Jang (2008) found that the integration of technology and team-teaching into science teacher education methods courses was a way of constructing knowledge and theories and a way to increase the use of instructional technology in teaching for pre-service teachers.

Lesson Study as a Way of Professional Learning

Lesson study is a professional development process that engages teachers in collaboratively examining their practice with a goal of becoming more effective. It involves a cycle of planning, teaching, observing, critiquing, and revising of selected lessons with clear overarching goals and research questions pre-set up by participating teachers (Lewis, 2002). Lesson study is beneficial for its collaborative elements as it helps open up new perspectives to teaching and learning for teachers, aside from deepening their subject matter knowledge as well as their pedagogical content knowledge (Lim, Lee, Saito, & Syed-Haron, 2011; Puchner & Taylor, 2006). It could lead to instructional improvement (Lewis, Perry, & Murata, 2006) and allow teachers to develop and reaffirm their identities as professionals (Leiberman, 2009). These identities break traditional teaching norms such as individualism, presentism and conservatism, and assist teachers in their persistent efforts to support students (Lieberman, 2009). Puchner and Taylor (2006) reported that the impact of lesson study on teachers included the recognition of the advantages of collaboration, the awareness that they significantly impact their students' learning, and the belief that changes could occur in relation to student engagement and learning in ways they had not imagined.

Besides the benefit to in-service teachers' professional development, there are some study reports in the literature claiming that lesson study can be a useful tool for pre-service teachers' professional learning as well. For example, Burroughs and Luebeck (2010) explored the outcome of engaging pre-service teachers that were enrolled in a mathematics methods course in collaboration with in-service teachers in lesson study. They found that pre-service teachers can participate in and contribute to lesson study in meaningful ways and they gained new ideas about the ways lessons were developed and enacted, as well as insights into the ways lessons directly influence students' learning. As a requirement of an elementary science methods course, Marble (2007) asked pre-service teachers to conduct lesson study at schools. He found that through the three teaching occasions, pre-service teachers had remarkable improvements in lesson design and delivery, learning environment management, engagements with meaningful content, and assessments and data generation. Marble indicated that pre-service teachers repeatedly showed a strong propensity to perceive their teaching as an evolving practice that necessitates active attention and thoughtful reflection.

The benefits of lesson study to pre-service teachers reported by Burroughs and Luebeck (2010) and Marble (2007) are still connected with the school teaching context. When lesson study approach is used within methods courses, it carries a format of Microteaching Lesson Study (MLS), which draws elements from both lesson study and microteaching. MLS is a cooperative learning experience intended to challenge prospective teachers' thinking about teaching and learning, and encourage their connection between theory and practice. It provides prospective teachers enrolled in a methods course with hands-on teaching experiences that engage them in the cycle of planning, teaching, reflecting on, and revising lessons (Fernandez, 2005). There is little research about the effect of MLS on pre-service teachers' learning, except for Fernandez (2010) and Fernandez and Robinson (2007). These two studies revealed that teacher candidates enrolled in the secondary mathematics methods courses perceived MLS to be a worthwhile learning experience. In particular, they felt that the most important aspects about their learning through MLS were connecting theory to practice, collaboration, and reflection. No research is available on how MLS impacts pre-service science teachers' development of TPACK. To fill this literature gap, our study was designed to investigate how MLS enhances pre-service teachers' TPACK knowledge in the context of science methods courses.

STUDY CONTEXT

The study was carried out in an Ontario university when its pre-service teacher education took only two semesters. Students who enrolled in the teacher education program already had successfully finished a bachelor degree. The program took a format of interlock between university instruction and practice teaching. Three school placements for practice teaching were embedded in the program, each lasting 4 or 5 weeks.

Data for this study were collected from the physics and chemistry methods courses over three years with a total number of 65 participants. These courses were designed for pre-service secondary science teachers and ran through two semesters with a total of 48 hours. The use of technology in science teaching was one of 5 major modules, which was covered in approximately half way of these courses. Within this technology module, pre-service teachers were first engaged in six hours of lecture, modeling, and discussion about the use of technology in science teaching and then were required in groups of 3-5 to develop a technology mediated lesson plan on a self-selected science topic. Using the Technology Integration Plan model as a framework (Roblyer & Doering, 2011), we lead teacher candidates to think through what-, why-, how-, and when-questions about the use of technology. What-question refers to the identity of the technology teachers pick up, including its characteristics, nature, and function. Why-question answers why teachers choose this technology and how it is better than or complimentary to non-technology methods. How-question deals with the way teachers use the technology. When-question refers to at what point of their instructional process teachers use the technology. In our teaching, we emphasized that the effective way of using technology in teaching is to integrate it with non-technology methods. We didn't want teacher candidates to plan a lesson where the use of technology takes the whole class period, rather expected them to pick up and drop technology in a way that artists choose certain paints when working on a great art work. In other words, we required teacher candidates to teach with technology as described above. Specific technology examples were used to make sure the discussion meaningful and concrete to teacher candidates.

Four categories of technologies that are available to science teaching were mentioned in our courses, including visualization (images, visual illustration, simulations, and animations), probeware (sensors), web-based resources, and communication technologies. Since our discussion was focused on how to integrate technology into the process of classroom teaching, the last two categories that are more suitable for the after-class use were not explored in-depth. Simulation and probeware were emphasized since they have great potentials to help students' inquiry-based learning process (Zhou, Brouwer, Nocente, & Martin, 2005; Zucker, Tinker, Staudt, Mansfield, & Metcalf, 2008). Simulation examples from the MAP project (Zhou, Brouwer, Nocente, & Martin, 2005), PhET (http://phet.colorado.edu), and Gizmos (http://www.explorelearning.com), were used to discuss about how they could be integrated in classroom teaching to help students understand the difficult concepts or provide virtual inquiry-based learning process. The class discussion often resulted in more than one way to use a particular simulation in teaching and then the pros and cons of each way was analyzed. We agreed that hand-on activities and other non-technology methods should not be overlooked just because of the use of simulation. Probeware is significant since it allow learners to collect real time date over a period of time, which qualifies it an excellent inquiry tool. However, due to the availability issue of this technology, teacher candidates were not provided opportunity to practice it in class. Instead, a movie clip was used to show how PH probe can be used in titration and a motion probe be used in a hand-on activity that investigated the relationship between force and acceleration.

Unlike a usual assignment asking students to present lesson plans for class sharing, teacher candidates were asked to team-teach their planned lessons to the class. They were asked to treat their peer teacher candidates as school students, that is, perform like a real classroom teaching by asking question, probing response, arranging group activities, asking students to make conclusions, and so on. The teaching for each group was about 50 minutes long to cover the content that was equivalent to a regular 72 minute school class. At the end of teaching, peer teacher candidates were invited to ask questions and provide comments on any aspect of the lesson: planning, execution, and particularly the use of technology. Then the teaching group were asked to verbally respond to peers' comments and reflect on their own teaching. At the end, the instructor provided comments and suggestions about the lesson. In addition to the onsite discussion, teacher candidates were required to submit written reflective reports as one part of the lesson plan assignment.

STUDY DESIGN

This study took a qualitative authentic research design rather than manipulating any component of the subjects being studied. Data resources included teacher candidates' lesson plans, reflective journals, and researchers/instructors' observation notes of microteaching performance. In addition to those conventional components of a lesson plan, the lesson plan assignment particularly required teacher candidates to demonstrate how they built technology into their instructional activities and as well to include a paragraph to explain the rationale of their choices and integration of technology. In their reflective reports, teacher candidates were required to reflect on what worked in their use of technology and what could be done differently. They were also asked about how the MLS process helped them developing TPACK knowledge. Careful notes were taken by the researchers/instructors while observing teacher candidates' microteaching performance and class discussion.

We conducted both qualitative and quantitative analysis on research data as Berg (2009) suggested for analyzing content. Qualitative analysis deals with the themes and antecedent-consequent patterns of theme while quantitative analysis deals with duration and frequency of theme. Both types of analysis can greatly contribute to a comprehensive understanding of the data. To support this position, Abrahamson (1983) stated that content analysis can be fruitfully employed to examine any type of communication and it may focus on either qualitative or quantitative aspects of communication messages. For this study, Quantitative analysis was conducted to collect information about questions such as how many participants hold positive attitude toward MLS and how many raised concerns about it. Qualitative analysis answered questions such as how MLS helped participants to learn about teaching with technology and what concerns they raised. Quantitative analysis was simply to tally participants' responses embedded in their reflections. Qualitative analysis was more complex. It involved a process of coding and recoding. Berg (2009) discussed that the process of coding can employ both deductive and inductive approaches. In deductive approach, the researcher uses some categories suggested by a theoretical perspective, literature review, research questions or interview questions. Deductive coding creates analytical categories for the researcher to start assessing data. The inductive approach begins with the researcher immersing themselves in the documents in order to make sense of them. When analyzing this study, we were aware that we looked for evidence of participants' success and challenges in the process of microteaching with technology, which served as analytical categories. However, our coding was an open process (Strauss, 1987). That is, when we initially read over the data, we noted down any significant items along the documents without limiting our attention to any pre-set topics. In the later stage of data analysis, we merged initial coding into several significant themes including what technology being used, why technology being used, how technology being used, teacher candidates' perspectives about the benefits of MLS approach in a methods course, and their concerns with this approach. For each category, there are a few themes/subcategories to support the main concept. Such a structure can be seen in the next section of this paper. In order to make sure an accurate understanding of each group's work, all types of data sources for each group were cross read for the purpose of triangulation. To be more specific, the data gained from lesson plans and MLS observation notes were used to make sense what participated put in their reflections.

FINDINGS AND DISCUSSION

What Technology Participants Used

Among the 18 lesson plans, 17 involved the use of various types of simulation. Many used visual illustrations such as pictures, cartons, and charts retrieved from the internet. Only one group used probeware. This group asked students to use a motion sensor to produce real motions that represented by given d-t and v-t graphs. Considering what we covered in the class, there is no wonder for such a polarized choice of simulation over probeware. As mentioned earlier, we dedicated much more discussion to simulation over probeware. Participants felt safer and more comfort to use the technology they just learned rather than trying some that were not covered much in the class. For the group using motion sensor, one group member had just finished a graduate degree in physics before he entered the teacher education program. He had a great amount of experience using probewares in his undergraduate physics courses and when he served as a TA for university physics courses. In reflecting their choice of technology, this group member wrote: "I was the expert on this particular ICT and what can be done with it. I was able to help my group members learn how to use it." In addition to simulation and probeware, streamed YouTube videos were used by a few groups although they were not covered in our classes. We assumed that this was because they were so common and easy to get and use.

Why Participants Used Technology

In class, we ensured teacher candidates understand that technology is used not because it is new, but because it provides different and/or more effective learning experiences, which students may not be able to access without technology. Such understanding was demonstrated in their lesson plan and microteaching, and more explicitly worded in their reflection journals. In regards to their general understanding of the role of technology in teaching, the following typical quotation was taken from a participant's reflection:

It is extremely important not to forget that a science classroom needs to encompass hands-on labs so students can explore concepts with raw materials through inquiry. Technology in the classroom should not replace this laboratory component, but if properly used alongside traditional activities, ICT can greatly support the learning process of students… ICT can be used to visually show phenomena that students are unable to see in a classroom setting (i.e. solutions at the molecular level, the digestion of food inside of the stomach, etc.). Teachers need to be skeptical when freely bringing ICT into the science classroom though. If teachers can confidently agree that their incorporation of ICT will engage, enhance, enrich, support or facilitate the learning process that the traditional blackboard and chalk cannot accomplish, then I truly support it within the science classroom.

In this quotation, the participant explicitly pointed out that science teaching could not get rid of hands-on activities due to the use of technology. Technology should be used in ways that facility science teaching and learning. A teacher should leverage the advantages of both technology and non-technology approaches in order to achieve the maximum results of instruction. Similarly, another participant argued that technology should be used when it can provide a tool or resource that supplements the conventional instructional methods. This participant wrote:

> *I view the role of ICT in science teaching as being that of a facilitator. By this I mean that I feel ICT is best suited as a means of presenting or exploring information brought forth during a lesson in a different way, a way which may have a better chance of getting through to students who may struggle with strictly oral instruction. I also feel that ICT can play an important role in terms of helping to illustrate a concept, visually, that an instructor simply would not be able to illustrate using conventional methods. For example, showing a chemical reaction in real-time at a molecular level can realistically only be done with the aid of ICT. However, I feel that the use of ICT should be carefully considered and used only as an aid to supplement the instruction being given by the teacher [rather than replacing it]… That being said, I really do feel that ICT presents many exciting opportunities to offer multiple perspectives on a given concept or topic and the ability to cater to multiple learning style when delivering a lesson.*

Participants were asked to reflect on the rational of technology choices for their lesson plan. One participant from the group who used a motion sensor in their lesson wrote,

> *The use of ICT in our lesson plan to help students fully understand the concept of position-time and velocity-time graphs is a welcome change to traditional methods of learning p-t, v-t and a-t graphs due to the fact that the motion sensor gives immediate feedback on the motion produced by the student who is attempting to interpret and duplicate the graph. This immediate feedback shows the student right away whether their idea of the graph is right or wrong instead of waiting for teacher feedback.*

This quotation clearly demonstrated that the group chose a motion sensor in their lesson because the sensor could measure student actions immediately and display them in real-time. Such quick feedback is beyond the ability of any traditional lab. One group taught a lesson about atomic orbitals. In regards to the rationale of their technology choice, one of its members reflected on how they chose technology according to their instructional objectives. This participant wrote,

> *To find good relevant ICT for our topic took time and effort. We were all involved in the process of searching online for possible tools. Since our topic was quite abstract, we were looking for a simulation that could visually explain how electrons are laid out around the nucleus within their orbitals. We initially gathered any simulation related to our topic then choose the one that applied to our learning objective which was to have students understand the placement of electrons within orbitals at each quantum level. The background to this*

lesson was electron configuration. We found one simulation that tied in both topics. Students could see the configuration of electrons as well as the shapes of the orbitals involved, how electrons fit into the orbitals and how the orbitals lay upon each other.

How and When Participants Used Technology

From their lesson plans and microteaching exercises, it was easy to notice that participants use technologies in many different ways, at different instructional occasions, and for various purposes. They built technology into the process of inquiry even thought the actual use still needs improvement. This demonstrated their understanding about the priority role of pedagogy over technology. They used technology to achieve their instructional goals rather than included them in teaching for its novelty. Rather than bring technology to instruction as one time short action, teacher candidates deliberately referred to specific components of simulation software multiple times during their teaching when concepts needed to be clarified further.

One group used a Gizmos simulation to address students' misunderstanding of the concept about weak/strong acid and base, and use it as an inquiry tool to investigate acid and base equilibrium. A member from this group summarized their use of technologies as following,

While creating our lesson plan we were very conscientious with our implementation of technology as we did not just want to use technology to teach [original italics] the students., Our goal was to use technology to interact with [original italics] the students and allow them to independently discover through inquiry [original italics]. Each ICT utilized throughout the lesson had a specific purpose. The opening YouTube video was a review of previous knowledge of acids and bases, but more importantly was a hook to engage the students at the beginning of an early morning lesson and to get them excited for the hands-on lesson that lies ahead of them. The PowerPoint presentation was a visually appealing method to communicate the components of the lesson in an efficient manner, including a SmartBoard activity where students were asked to recall previously taught definitions about acids and bases and write them on the board. Lastly, the core component of the lesson was a simulation that depicted an important chemistry concept at the molecular level. Without this simulation, the concept could not have been explicitly taught with realistic visuals showing students why the scientific phenomenon is occurring. The entire lesson was inquiry-based rather than traditional, which created an excellent context for our specific technological simulation to be used. Students were able to manipulate different variables such as the strength of the acid/base as well as the concentration of the acid/base. They could use various methods of measurement to determine the conductivity or pH of the solution being observed, and could observe this as a magnified solution or as a bar graph that represented reactant and product concentrations. I think that our plan worked very well in creating a student-directed learning experience.

Another group used a simulation from the PhET website to teach a lesson about the conservation law of energy. Their lesson nicely started with non-technology teaching methods (demonstration and case analysis) to review the transformation between forms of energy, and then took the process of diving as an example to introduce the concept of energy conservation, using the mathematical language. The simulation was then brought up to illustrate how energy conserves in a more complex case of skateboarding on a v shape track with a visual presentation about each type of energy changes in the process. Worksheet was provided to guide student thinking over the case. The simulation was also use to compare two different situations: friction-on and friction-off. At the end, students were asked to construct their own skateboarding track using the simulation.

The use of steamed YouTube videos was witnessed in some lesson plans. Videos were used to introduce the lesson topic, illustrate the concept, and review previously taught content. Since many YouTube videos were not necessarily developed with an educational purpose and sound pedagogy, concerns arose with the use of videos by some groups. For example, one group played a video at the very beginning of their lesson on the VSEPR theory about molecular shapes. Their intention was to introduce the topic. However the video content was the theory which students would learn in the class. Although some teacher candidates thought that the video grab students' interest, we commented that it was not effective. Another group used a video to help students visualize atomic orbitals following non-technology lecturing (blackboard drawing and description). The video was very useful for its 3D and color effects. We believe that it would work better if the lecture and video blended together for each orbital rather than lecturing all orbitals first and then showing the whole video as a conclusion. In other words, the group could discuss one orbital with both traditional illustration and technology visualization before moving on to another.

Participants' Perceptions about the Significance of MLS

Participants were asked to reflect on how MLS helped them develop their understanding and skills of teaching with technology. Their reflective writings were required to address both components of MLS: the microteaching exercise and collaborative reflection. All participants reported that microteaching pushed them think through every detail about their lessons and provided them opportunities to "put into practice various teaching techniques, especially those dealing with ICT-based lessons." They realized that the microteaching experience was very important "because as prepared for a lesson as you strive to be, you can never completely predict the flaws that may exist or the troubles that may arise, such as student confusion or misunderstanding. Trialing the lesson out is what truly reveals its strengths and weaknesses." More particularly, the microteaching deepened participants' understanding of the use of ICT and further convinced them of the significance of using ICT in science teaching. In this regard, two participants wrote,

> *This specific microteaching experience truly showed the effectiveness of the PhET simulations and how pedagogically helpful they can be… Witnessing the students'*

reactions to the simulation and their findings through the activity, it was clear how important the simulation was to support the lesson's teaching. Microteaching allowed me to maintain a teacher role and experience any difficulties that may arise when incorporating ICT in the actual science classroom. More importantly, microteaching and incorporating technology into a lesson plan made me realize that it is definitely something that I want to encompass in my teaching philosophy and utilize when I am out in the field.

The microteaching exercise was not only a practical opportunity for the teaching group, but also provides an opportunity for the rest class to learn from peers. They could learn from others about what technologies were available and how they could be incorporated into teaching. At the end of the microteaching section, as teacher candidates suggested, the class collaboratively develop a list of ICT recourses for science teaching.

Collaborative discussion/reflection/feedback at the end of microteaching was designed to provide teacher candidates with opportunities to learn from each other's success and challenge, which was valuable to both the teaching group and the rest of class. It allowed teacher candidates to view the appraisal of their teaching performance from three different perspectives: peer comments, teaching group's self-reflection, and the instructor's onsite feedback. In the process of MLS, peer teacher candidates acted as a dual role: future teachers and school students. They could provide critiques from the point view of student learning and as well from their professional understanding of teaching. The teaching group's self-reflection was significant as well since they often could realize what was going well and what could be improved while they were teaching based on their own observation of the participation of their peer teacher candidates. The instructor's onsite feedback finally pushed the excise to another level. It opened teacher feedback to all class participants rather than being kept to the teaching group members only as in a traditional assignment. In regards to the significance of the collaborative reflection and instant feedback, one participant wrote in her reflection:

The discussion process is always helpful as it allows for many other viewpoints on the lesson, including constructive criticism. This portion of the lesson plan assignment allows us to see how others would have included the technology and possible activities that they would have done with the ICT, which opens my eyes to many other possibilities that I may not have thought of. Secondary opinions are very beneficial and I always learn so much during the discussion process as it allows me to see my lesson from other people's perspective and how I can alter it to fit students better.

The following rather long excerpt from a participant's reflection nicely outlines what she learned from the discussion.

The discussion process helped analyze what went well and what could have been improved with ICT in this chemistry lesson. Most of the feedback agreed with our group that the simulation was an effective way of conveying the concept of acid and base strength at the molecular level. The discussion showed that the inquiry-based method worked well within the context of the lesson. All preconceptions were put on paper before the simulation

> *activity began giving students a chance to reveal their original thoughts and compare with the reality found during the simulation. Some feedback requested that an activity sheet per student would have been more effective so that all students were interactive and had a role. If I were to do this lesson again with a Grade 12 class, I would likely put the students in pairs so that one student could manipulate the simulation while the other student recorded the findings on the activity sheet. This would serve as an efficient way to have all students involved in the inquiry process. Based on feedback given, I would also have changed the amount of simulation usage. As Dr. Zhou mentioned, the simulation should not be a one-time activity and then never referred to again. It can be an ongoing learning technique so that when questions arise or concepts require clarification, the simulation is there to bring back a visual representation to the class. The simulation should also be revisited in the lessons to come that would deal with the same concepts of acids and bases. Clearly through this experience of teaching an ICT lesson plan, I have been convinced that these online simulations are great [original italics] in being able to convey scientific concepts. I cannot wait to incorporate them into my lesson plans for my April placement.*

In this quotation, the participant detailed how the collaborative discussion recognized her group's use of simulation in teaching an inquiry-based lesson about acid/base strength and informed her possible changes to her group lesson. Two major changes she summarized were: letting students work in pairs with a provided worksheet and referring to the simulation more than one time when necessary. She reported that the MLS exercise raised her love of technology and motivated her to use ICT in future teaching.

Participants' Concerns and Difficulty with MLS

Among the 65 participants, there were only three (Joshua, Erin, and Nancy) who raised some concerns about MLS in their reflections. Although he highly commented on the microteaching exercise, Joshua felt the time could be much different between teaching a class to peer teacher candidates and to a school class. He wrote, "The only negative I see with this approach is for timing of the lesson. It is hard to get a feel for how long these activities would take in a real class since our levels are much higher and we get through the material much quicker than they would." He was right. The audience of microteaching was different from that of school teaching. Teacher candidates had learned the subjects before although many of them actually forgot the details. Therefore, the pace of MLS may be different from teaching in a real school classroom.

Erin reported the challenge of treating adult teacher candidates as school students. She wrote, "It's difficult to micro-teach as if you are in a classroom filled with adolescents when really there is a room full of adults because we would normally communicate with the adolescents in a manner different from how we would communicate with adults." It seems that the rapport between teacher candidates set up obstacles for this participant to enjoy and exercise the power or authority a teacher has in a real school classroom. Her belief in the difference between adult and adolescents became a great obstacle for the MLS exercise. She admitted that "I felt silly to ask my peers so simple questions. They are not sixteen years old kids." During MLS, she sometime slipped back into presenting from teaching. We had to remind her to teach instead of presenting at such occasions. Erin also reported that "teaching a lesson for the first time in front of your peers is nerve-racking." For her, practice teaching to school children would be more comfortable than microteaching in front of her peers. Comparing microteaching with conventional lesson plan presentation, Erin wrote "When micro-teaching, you don't have the opportunity to explain your reasoning for picking to do certain tasks or activities." Therefore, from her points of view, the MLS exercise missed the opportunity of describing the rationales of lesson choices.

Nancy, from a group of whose MLS received the most critical comments, actually preferred traditional way of presentation over microteaching. She justified her position in her reflection like this:

> *I would prefer to present our lesson to our peers instead to treating them as high school students because our peers are educated enough to know the answers to our lessons and they also know how to use ChemDraw. I also feel that I would get more out of others' presentations if I did not have to play the role of a high school student and could just see the lesson plan and how they would teach it. In regards to the discussion session, I would find it easier to participate in giving feedback if the lesson was just explained to me… I also like to hear how my group members felt the microteaching went. I think it's important to collaborate and reflect together as a group to see the variety of opinions within my group. I do wish that our group would be given time privately to reflect amongst ourselves before doing so in front of the class because I feel that we would be more honest with ourselves as group members.*

Nancy thought that microteaching was not practical since her peer teacher candidates already knew the content. Similar to Erin, Nancy believed she would learn more from the presenting groups who described their lesson rationales and instructional plans. She argued that she would be in a better position to provide feedback if they were asked to present their lesson plans instead of microteaching them. It seems that she was not used to the open learning opportunity MLS provided. She felt that the group should be given an opportunity to reflect their lesson in a more private space rather than in front of the class right after their microteaching. This may link to her personal characteristics that generally set up a person's learning preference.

One thing needs to mention is that the microteaching of technology-mediated lessons was the 2nd time of MLS exercise in the methods course. It took place after teacher candidates came back from the first teaching placement. Before they took on the first teaching placement, they had one MLS exercise on inquiry-based teaching approach. Based on our observation, more teacher candidates had a stronger resistance to treat their peers as school students at this second MLS practice. They more often slipped back to presentation from teaching compared with the first MLS experience. This might be because the practice teaching experience made them consider more about the difference between the peers and school kids or might be due to their tiredness of such exercise that took place for a second time.

CONCLUSION AND IMPLICATIONS

In order to prepare future teachers to teach with technology, teacher education programs need to help teacher candidates develop TPACK (Dilworth et al., 2012), which is believed to be best done in the context of methods courses (Davis & Falba, 2002; Zhou & Xu, 2011). Fine and Fleener (1994) caution teacher educators about haphazard efforts to integrate technology into methods courses. Their study found that the mentions of pros and cons of calculator use and the brief demonstration of lesson plans given in mathematics methods courses left pre-service teachers with at best a superficial understanding of technology. Teacher candidates appeared to be inadequately prepared to employ calculators in the classrooms of their own. In our study, teacher candidates were engaged in the discussion of the rationales and approaches of integrating technology (mainly simulation) in science teaching during the lecture section, and particularly were provided with opportunities to practice what they learned about the use of technology through microteaching. The collaborative reflection and instant feedback turned to be very informative and beneficial to teacher candidates' professional learning. Our study findings confirmed Ertmer' statement (2003) that teacher educators need to become very specific and explicit about which technology is being infused to support learning. Research has indicated that it takes a great deal of education and experience to achieve a comfortable level of expertise in the use of technology as a teaching tool for helping students learn (Lynblinskaya & Zhou, 2008; Thomas & Cooper, 2000). MLS should be considered as the earliest useful step prospective teachers can take to learn and practice how to use technology in teaching.

Learning to teach with technology requires understanding, modeling, and practice (Bell, Maeng, & Binns, 2013; Gill, Dalgarno, & Carlson, 2015). It involves teacher candidates' appreciation of the power of technology and learning of technical skills to use technology. More important, it requires teacher candidates to develop habit and ability to take technology as a "mind tool" for instruction. Our study indicates that MLS within the context of methods courses is a promising way to develop teacher candidates' TPACK knowledge and skills. Their use of technology revealed their appropriate understanding the role of technology in science teaching. In most cases, participants demonstrated effective way to integrate technology with non-technology methods, although with space for improvement. The significance of MLS lies in the opportunity of practice, collaborative and instant reflection, and learning from each other, as our participants reported.

MLS encountered some teacher candidates' concerns. A few participants reported their discomfort with teaching peers as school students and thought presentation format might provide them better opportunity to explain their lesson plans and provide feedback to peers. While we appreciate these concerns, we want to point out that like any teaching method, we cannot expect MLS to be perfect for every learner. The instructor should take advantage of each method and supplement it with other methods for those things such method is not good at.

It is fair to conclude that MLS is a promising approach to develop teacher candidates' ability to teach with technology. Unfortunately, it has not been widely used in other methods courses. At one debriefing section, one participant explicitly commented, "we should have this in other courses as well." It is recommended that a teacher education program should seriously consider applying MLS approach to all methods courses so that all teacher candidates can have the opportunities to develop their TPACK for teaching their certified subjects with technology.

Hooper and Rieber (1999) described five stages of teachers' use of technology: familiarization, utilization, integration, reorientation, and evolution. At the stage of familiarization, teachers become aware of new technology and its abilities and learn the "how-tos" of using it. At the stage of utilization, teachers begin to use them both privately and at school, but will not miss it if taken away. At the stage of integration, teachers use technology for certain tasks. Technology becomes an integral part of the curriculum and pedagogy. Reorientation stage features the restructuring of teaching in new ways that are enabled by technology. The purpose of using technology has a focus on student learning rather than for delivery of content. At the final stage of evolution, teachers continue to evolve, adapting and integrating technology. This five stage model reveals the significance of technological knowledge before they can use it in teaching.

The five-stage model of technology adoption provides a good explanation for one of our study findings that most participants only used the technologies discussed in the methods course due to unfamiliarity with other potential technologies. More recently, Buabeng-Andoh (2012) reviewed the literature in regards to the factors that influence teachers' use of technology and found teachers' computer efficacy plays a significant role in their decision to use technology. Unfortunately, the time limitation and their mandates do not allow methods courses' instructors to cover all technologies. This raises a need for coordination between the technology course and methods courses. Ideally, the technology course helps teacher candidates learn many types of technologies, and the methods course develop teacher candidates' pedagogical knowledge and skills to apply these technologies in subject teaching.

This study was explorative in nature. Its evidence came from observation and reflection. Future research may develop some quantitative instruments to measure teacher candidates' TPACK knowledge and skills at the stages of pre and post the MLS process. Such research will set up further evidence to claim the effectiveness of MLS. Our study also suggests that future research needs to look into the questions associated with curriculum continuity between the technology course and methods courses so that the development of teacher candidates' capacity to teach with technology becomes a consistent effort through the teacher education program.

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