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Math and Science Teacher Candidates' Use of Technology to Facilitate Teaching and Learning During Student Teaching

Janet Tassell, Rebecca Ruth Stobaugh, and Michael McDonald
Western Kentucky University

Abstract

The goal of this study is to determine how effectively student teachers from a large comprehensive institution have used technology to complement their teaching in mathematics and science. The researchers reviewed the required Teacher Work Sample (TWS) capstone projects of student teachers. The TWS is an assessment instrument designed to guide student teachers in designing, implementing, reviewing, and adjusting instruction. Student teachers document in the TWS narratives their use of technology, and this use was compared to the 2008 U.S. Department of Education (USDE): Measures of Teacher and Student Technology Use. Data gathered in the study revealed both strengths and weaknesses regarding the student teachers' use of technology to enhance their teaching goals. Implications are derived about effective use of technology by mathematics and science teacher candidate preparation.

Introduction

How do educators facilitate learning in light of the plethora of technology expectations and options available? One repeatedly hears of a school district purchasing interactive boards to replace the old chalkboards or the dry-erase boards in the classroom. However, are teachers truly making classrooms more interactive through the effective use of technology? What is becoming common is that teachers turn to technology to energize their presentations or lectures to the class, receive assignments from students, enter and communicate grades, complete required schools reports, and develop assignments and assessments. Teachers have confidence that this helps them claim to be "technology literate" and have an interactive classroom. However, a barrier tends to be revealed when looking at the "teacher use of technology" in comparison to "student use of technology for learning" where students learn the content through the use of technology. While teachers often feel confident utilizing some technologies in presenting content, they feel uncomfortable planning instructional tasks with students.

A great deal of technology is available for teacher use. One method to encourage the use of technology tools could be to incorporate their use in teacher preparation programs. Teachers may believe that they must use technology to a capture the interest of the students rather than viewing technology as the vehicle for authentic and engaged learning. One thing is certain -- technology is rapidly changing and growing in availability. The notion of a "static set of skills" does not describe the finesse it takes for teachers to interface with students in the classroom. In many ways, the use of technology for presentation in the classroom has become the chalkboard of twenty years ago.

In teacher preparation programs, teacher candidates should integrate technology to engage students in critical thinking, decision-making, and real world problem-solving. In mathematics and science fields, technology is an integral part of the jobs in these areas and therefore technology should be a seamless focus of instruction to replicate the real-world applications of the content. However, the question must be asked: Are today's mathematics and science teacher candidates using technology effectively to enhance learning? In addition, are culminating performances in teacher preparation programs requiring teacher candidates to design instruction and assessment engaging K-12 students in using technology to achieve higher levels of learning?

The Study

Teachers need to be as effective as possible -- every child needs to be learning to his or her fullest each and every day. Without the incorporation of technology, today's teachers run the risk of not connecting students to higher levels of learning. A time to incorporate teaching and learning technologies for teachers is during their teacher preparation program before they are in the trenches of the classroom. Programs need to prepare the teacher candidates to know what technology is currently available, to understand how to use technology as a tool for student learning, and to prepare the new teacher and their students to continue learning as technology evolves. Teachers need to have a clear understanding that technology should facilitate student learning, and this is often best achieved through student use of technology as part of their own learning. The National Council for Accreditation of Teacher Education (NCATE) has given an "unacceptable" rating to programs that do not technologically prepare their teachers. In the "Pedagogical Content Knowledge for Teacher Candidates," the "unacceptable" rating includes,

"Teacher candidates do not understand the relationship of content and content-specific pedagogy delineated in professional, state, and institutional standards in a way that helps them develop learning experiences that integrate technology and build on students' cultural backgrounds and knowledge of content so that students learn" (National Council for Accreditation of Teacher Education, 2008).

Teacher education programs are faced with a two-part challenge: (1) What technologies should teacher candidates understand and be able to incorporate in their teaching? (2) How can the teacher candidates be assessed for their knowledge and use of technology? NCATE supports the requirement that effective teachers are "able users" of technology in the following statement:

> COMMITMENT TO TECHNOLOGY: The unit's conceptual framework reflects the unit's commitment to preparing candidates who are able to use educational technology to help all students learn; it also provides a conceptual understanding of how knowledge, skills, and dispositions related to educational and information technology are integrated throughout the curriculum, instruction, field experiences, clinical practice, assessments, and evaluations (National Council for Accreditation of Teacher Education,2008).

Consequently, this study was designed to determine if teacher candidates of mathematics and science at a large comprehensive institution's teacher education program effectively integrate technology into math and science instruction. The concern that surfaced from preliminary informal conversations with education faculty that coursework expectations of math and science teacher candidates did not consistently prepare them comprehensively to plan learning experiences using technology. The framework that provided the vehicle for studying this was the Teacher Work Sample (TWS), a robust tool that assesses teacher candidates' ability to embed technology in their instruction.

Purpose of the Study

The International Society of Technology in Education (ISTE) organization created technology standards for teachers and students in 1998; the most recent version of these standards, the National Educational Technology Standards (NETS) for Students, were released in 2007 (International Society for Technology in Education). These standards support and promote a higher level of student use of technology where students are engaged in authentic learning to design products and improve problem-solving skills (Kentucky Department of Education, 2008).

The state teaching standards for this institution provide a list for initial expectations for teachers to demonstrate their skills and knowledge about technology. According to Standard 6, "The Teacher Demonstrates the Implementation of Technology":

6.1 Uses available technology to design and plan instruction
6.2 Uses available technology to implement instruction that facilitates student learning
6.3 Integrates student use of available technology into instruction
6.4 Uses available technology to assess and communicate student learning
6.5 Demonstrates ethical and legal use of technology

(Kentucky Department of Education, 2008)

In light of these standards' mandates, this study was designed to investigate whether teacher candidates at the institution are effective users of technology.

Research Questions and Assumptions

The research questions addressed two specific questions:

1. Are math and science teacher candidates from a state institution using technology to facilitate teaching and learning in the Teacher Work Sample during the student teaching experience?
2. What are the differences between and among mathematics and science content areas in the type of technology used in the Teacher Work Sample at this institution during the student teaching experience?

The researchers made the following assumptions: that the United States Department of Education (USDE): Measures of Teacher and Student Technology Use (U.S. Department of Education, 2008) is an appropriate framework for evaluating the technology needed by student teachers to be effective, and that student teachers described their full use of technology in their Teacher Work Sample.

Review of Related Literature

Universities are responsible for preparing teacher candidates for the state and national teaching standards. However, NCATE goes a step further to push the mastery of technology standards: NCATE expects that schools of education incorporate technology skill instruction within the methods courses, field experiences, and content courses of education students. Vanetta and Beyerbach (2000) noted the importance of the seamless use of technology in the teacher education curriculum to equip the teacher candidates during their experiences as a student and in preparing them to be a teacher. Within field experiences, 79% of teacher education programs stated teacher candidates utilized technology to some extent within the field experiences. Around 51% of all teacher education programs for initial licensure stated that they offered a course on educational technology within their programs (Kleiner, Thomas, & Lewis, 2007). Teacher education accreditation agencies, state teaching standards, and federal agencies have advocated for the integration of technology into instruction. Whether this is happening is the question.

The National Center for Education Statistics 2007 report on education technology used in teacher education programs stated the following statistics about the programs (Kleiner, Thomas, & Lewis, 2007):

- Utilized Internet resources and communication tools in all or some of their teacher education programs (100%).
- Taught about ways to integrate technology into lesson planning (99%).
- Stated utilizing content specific software tools while teaching (97%).
- Noted multimedia digital content was used for instruction (95%).
- Reported technology was used for retrieving or organizing data to enhance teaching (90%).
- Instructed pre-service teachers on using technology for student assessment that aligned to state curriculum standards in all or some of their programs (88%).
- Used digital portfolios in all or some of their programs (82%).
- Instructed on the utilizing technology for student assessment in all or some programs (79%).

However, a word of caution with these statistics: "…report of topics taught within programs should not be taken to mean that the topics were taught in any depth or breadth across

the curriculum. Rather the estimates only indicated that the topic was taught at least to a minimal degree" (Kleiner, Thomas, & Lewis, 2007). When questioned to a "major" extent about how teacher education programs incorporated technology instruction, the percentages dramatically declined:

- Fifty-seven percent taught pre-service teachers about how to use technology to enhance classroom instruction.
- Seventeen percent instructed pre-service teachers on using technology to assess student achievement.
- Seventeen percent trained pre-service teachers on designing instructional interventions to individualize instruction.
- Fifteen percent addressed how to utilize technology to accommodate for various student learning styles (Kleiner, Thomas, & Lewis, 2007).

Incorporating technology was reported as problematic for teacher education programs. According to the U.S. Department of Education report on teacher education's use of educational technology, one barrier was that 93% colleges of education report that the schools for field experiences and student teaching experiences do not have the appropriate technology needed. Furthermore, pre-service teachers often lacked time to experiment with technology (93%) due to P-12 teachers facing pressures to pass state tests, and felt concerned about using a product without full knowledge of it in front of students who are savvy users of technology. Another set of barriers includes that the classroom teachers had concerns about effectively implementing technological resources in their classroom due to their own lack of training (22%) or were unwilling to integrate technology (12%), in turn making it a difficult situation for the teacher candidate to integrate technology into the lessons they taught. Other barriers included college of education faculty who lacked technology training (83%), lack of faculty time to use technology tools (87%), lack of willingness of faculty to incorporate technology (73%), and lack of infrastructure (6%). Only 2% of teacher education programs stated that teacher candidates lacked technology skills as a major barrier to integrating technology. However, institutions affirmed that only 48% of the teacher candidates were able to practice their technology skills at a medium to high range (Kleiner, Thomas, & Lewis, 2007).

From a more optimistic angle, according to a U.S. Department of Education survey, a large majority of teacher education programs (67%) strongly agreed that their graduates possessed the knowledge and skills to effectively employ technology resources in their instruction. Furthermore, 44% strongly agreed and 52% agreed somewhat that their graduates can design project-based lessons enhanced with technology. When asked about whether experiences include technology in lessons, 35% strongly agreed and 54% agreed somewhat. Fewer programs reported that graduates would effectively integrate assistive/adaptive technology to assist special needs (18% agreed strongly; 61% agreed somewhat) (Kleiner, Thomas, & Lewis, 2007). Even though teacher candidates had a generally positive attitude toward technology, nationally a large number stated that they are unprepared to effectively incorporate technology into instruction (Beckett, Wetzel, Buss, Chisholm, Misdoubted, & Padgett, 2001). Some of the challenges for integrating technology into undergraduate programs are training, technical support, lack of funding, and limited technology resources (Duhaney, 2001). However, due to all of the competing interests in an undergraduate program of course requirements, technology integration was and is still a challenge.

Teacher Work Sample

A consortium of 11 universities gathered to create a tool to measure and assess the growth of teacher candidates -- hence the Renaissance Teacher Work Sample (TWS) was developed by the Renaissance Partnership (The Renaissance Partnership for Improving Teacher Quality, 2001). This initiative was designed to affect "a paradigm shift from a focus on the teaching process to learning results and connecting teacher performance to student learning" that would in turn lead institutions to "implement programs and practices that build their capacity to be accountable for the impact of their teacher candidates and graduates on student learning" (Pankratz, 1999). To validate the TWS as an authentic tool to measure candidate growth and impact on student learning, the group developed TWS exemplars, and shared information, materials, expertise, and research across institutions related to the TWS.

The resulting TWS instrument (Schalock, Schalock, & Girod, 1997) documents teacher candidates' preparation on seven teaching processes or components believed critical to improving P-12 instruction and student learning (Denner, Norman, Salzman, Pankratz, & Evans, 2004): Contextual Factors, Learning Goals, Assessment Plan, Design for Instruction, Instructional Decision-Making, Analysis of Student Learning, and Reflection and Self-Evaluation. All teacher candidates complete the Teacher Work Sample during their student teaching semester and are scored on a common rubric that addresses the seven required sections. Teacher candidates are given descriptive prompts and rubrics to guide their development of the capstone project. Within each TWS component, there are three to six indicators clarifying the expectations in each section. There is one indicator assessing students' technology abilities in the Design for Instruction section of the TWS. To be proficient in this area, a pre-service teacher must describe the incorporation of technology in their unit or offer a strong rationale for not using technology.

Methodology

This study reviewed a random selection of Teacher Work Sample (TWS) capstone projects produced by mathematics and science student teachers. Due to the design and credibility of the U.S. Department of Education (USDE) (2008) research study, a framework was available to examine student teacher technology use at this institution via the TWS projects. Specifically, the study narrowed the focus to the indicators from the USDE study to form a checklist by which to analyze the TWS samples. This study reviewed the area(s) of the TWS portfolios that dealt specifically with the ways student teachers described their use of technology to enhance their teaching effectiveness. The teacher candidates are required to describe the ways they use technology in their student teaching semester of instruction in their narrative.

Two initial teacher certification programs were selected for the study: Math K-12 and Science K-12. The TWS projects of ten students in each major were randomly selected. For each student teacher submission, a score of one (1) was recorded if the student teacher revealed evidence of satisfying a USDE technology standard on the checklist. A zero (0) was recorded if no evidence was offered satisfying a USDE technology standard on the checklist. The student teacher TWS projects were reviewed by three researchers and the results were compiled for this study. The administration of the study was conducted during the Spring 2009 semester at this institution.

The following provides evidence from a randomly selected TWS used in the study:

Technology has been a huge part of my unit. It has helped me create my lesson plans. I have also incorporated on-line activities in my lessons. There are two days of my unit where I will pull up internet sites and model or reinforce skills…. I have also incorporated United Streaming into my unit. I chose to show a short video about how to subtract fractions. I also used the internet to challenge students who finished their work early. I have found several websites that reinforce skills... so that the students can work independently. In addition, my class visits the computer lab… using the fraction websites and fraction software to reinforce skills (Teacher Work Sample #4600, 2006).

For an example of coding, this sample was coded as a one (1), for each of the following indicators:

- Teacher's Use of Technology in Instruction
  - o Develop curricula or assignments
  - o Do research and lesson planning using the Internet
  - o Present concepts to students
- Students' Use of Technology in Learning
  - o Practice or review content
  - o Extend learning with enrichment activities

All other indicators were not present in the sample including the third category of indicators, "Students' Use of Technology for the Critical Thinking and Decision-Making Skills Related to Technology Literacy."

Findings

The sample for the case study included 20 student teachers from the following initial teacher certification majors at this institution: 10 from Math K-12 and 10 from Science Education (SCI K-12). Table One shows the checklist including the cumulative scores of each content area major. This table also reports the total obtained from all groups for each checklist item, the maximum score possible and the percentage of the codes received by each major in relation to each checklist item.

Table One
Checklist and Codes Calculated on a Comparison of TWS Samples and USDE Indicators.

	Math K-12	SCI K-12	Both Groups Total	Total Indicators Present	% of Codes Received
Teacher's Use of Technology in Instruction					
Develop curricula or assignments	8	7	15	20	75%
Create tests or quizzes	2	2	4	20	20%
Do research and lesson planning using the Internet	5	8	13	20	65%
Present concepts to students	9	10	19	20	95%

Test students	1	2	3	20	15%
Adapt instructional activities to student's individual needs	1	1	2	20	10%
Collaborate with experts to teachers in other locations	0	0	0	20	0%
Students' Use of Technology in Learning					
Practice or review content	5	3	8	20	40%
Extend learning with enrichment activities	1	1	2	20	10%
Take tests or quizzes using a computer	1	2	3	20	15%
Conduct online research	1	0	1	20	5%
Prepare for standardized tests	0	0	0	20	0%
Produce media, Web, or presentation products	1	1	2	20	10%
Students' Use of Technology for the Critical Thinking and Decision-Making Skills Related to Technology Literacy					
Work cooperatively or collaboratively with other students	0	0	0	20	0%
Communicate electronically about academic content with experts, peers, or others	0	0	0	20	0%
Visually represent or investigate concepts	2	0	2	20	10%
Take tests or quizzes using a computer	0	0	0	20	0%
Use inquiry-based strategies	0	1	1	20	5%
Solve real-world problems	0	1	1	20	5%
Work in content in multiple disciplines	0	0	0	20	0%
Use authentic tools	0	1	1	20	5%
Create products that had real-world audiences	0	0	0	20	0%
Codes Received (20max/sample)	37	40	77		
Codes Possible (10 TWS samples)	220	220			
Percentage Received	16.81%	18.18%			

The findings show mathematics and science K-12 teacher candidates utilizing technology most prominently in the "Teacher's Use of Technology in Instruction" category. Both mathematics and science teacher candidates used technology to "Present concepts to students" in 95% of the cases. Two other checklist items received more than 50% of the possible codes

indicating student achievement in the content area: "Develop curricula or assignments" in 75% of the cases, and "Do research and lesson planning using the Internet," in 65% of the cases.

In the Teacher Work Samples examined, neither content major studied received 20% or more of the codes possible on the scoring checklist. Science Education K-12 received the highest percentage with 18.18% occurrences of the possible codes on the checklist. Math K-12 received the lowest percentage with 16.81% occurrences of the possible codes on the checklist. All other indicators received less than 50% occurrences of the possible codes on the checklist. Seven items received no codes on the checklist, indicating no achievement in these areas by the teacher candidates; most of these items fell within the categories that tracked student use of technology and student learning with technology:

1. Collaborate with experts to teachers in other locations
2. Prepare for standardized tests
3. Work cooperatively or collaboratively with other students
4. Communicate electronically about academic content with experts, peers, or others
5. Work in content in multiple disciplines
6. Create products that had real-world audiences
7. Take tests or quizzes using a computer (in the "Students' Use of Technology for the Critical Thinking and Decision-Making Skills Related to Technology Literacy" category)

There were various ranges among the three categories: "Teacher Use of Technology in Instruction" (which ranged from 0 to 95% of the students indicating achievement in the content area), "Student Use of Technology in Learning" (which ranged from 0 to 40% of the students indicating achievement in the content area), and "Students' Use of Technology for the Critical Thinking and Decision-Making Skills Related to Technology Literacy" (which ranged from 0 to 10% of the students indicating achievement in the content area). As the percentages indicate, the data reveals a lower rate of technology use when referring to students' use of technology of critical thinking and decision-making skills compared to the other categories.

Conclusions

Based on the findings of this study, the following conclusions are drawn:
1. The math and science TWS documents studied show that the undergraduate program is preparing student teachers in the category of "Present concepts to students."
2. Math Education K-12 is preparing student teachers in the category of "Develop curricula or assignments."
3. Science Education K-12 is preparing student teachers in the category of "Do research and lesson planning using the Internet."
4. Concerning the remainder of the items detailed by the USDE (2008), math and science content areas included in the study are deficient in preparing student teachers to use technology to accomplish the goals of "Students' Use of Technology in Learning" and "Students' Use of Technology for the Critical Thinking and Decision-Making Skills Related to Technology Literacy."

Implications
Most of the math and science student teachers in the study reported using technology for delivering instruction. Teachers indicated the technology they used most included PowerPoint

presentations, electronic whiteboards, and online videos. The technology mentioned second most were used to develop curricula or assignments, including word processing technology to create documents such as handouts and tests. The third most prevalent result indicates that math and science student teachers use the Internet for conducting research for lesson planning. Even though these were the second- and third-strongest findings from the data, since only 75% of student teachers were developing curricula or assignments and 65% were conducting research and lesson planning using the Internet with technology, more attention should be paid to this part of their training by teacher education programs.

The study revealed that very little technology was reported in the area of student use in completing work or assessments, or engaging in higher-level thinking. No math and science student teacher reported using technology to have students prepare for standardized tests; work cooperatively or collaboratively with other students; communicate electronically about academic content with experts, peers, or others; work in content in multiple disciplines; or create products that had real-world audiences. All of the areas dealing with the ways students used technology as addressed in the USDE (2008) needed attention by teacher education programs in preparing student teachers.

During student teaching, many teacher candidates did not have the opportunity to incorporate the level of technology they wished to due to constraints imposed by the school or due to limited technology access in their schools. This stifling of the student teaching experience itself was unfortunate but could be overcome by improving an understanding of what technology integration means and how to troubleshoot difficult situations. The students in K-12 classrooms should not be going without technology experiences.

The findings of this study are being woven back into the mathematics and science methods coursework and TWS design to strengthen its technological components. The TWS technology indicator was itself not written in such a way that provided a detailed expectation within the technology indicator, whereas the USDOE holds a much higher standard for what should be achieved. Math Education K-12 and Science Education K-12 reported virtually equal use of technology by their student teachers. This study indicated that the content areas should invest more time and resources in preparing student teachers to use technology when planning instructional experiences where students engage technology for real-world tasks.

Limitations

The study had the several limitations. The sample reviewed was limited to student teachers enrolled in this institution during Spring 2009. The study reviewed only two content area majors: Math K-12 and Science K-12. The dichotomous checklist was used to code each technology indicator (which limited the degree that each indicator was actually met).

Recommendations for Further Study

This study involved student teachers at one university. Future studies should investigate whether the results from other universities in other regions report similar results. Further research should investigate if discrepancies exist between elementary, middle school, and secondary grade teacher education programs to discover if teacher education programs are preparing student teachers in the most effective and most recent technologies. Finally, future investigations should focus on the knowledge and skills of faculty in teacher education programs and their readiness to prepare future educators in the most effective use of technology.

The math and science teacher candidates' effective use of technology should and can be utilized to develop strong lessons that engage students in higher levels of learning. Teacher candidates are at a stage of learning the importance of strong lesson planning, and teacher programs have been expecting them to be masters in the area of "Teacher Use" more so than in the area of "Student Use" of technology. Further study should be conducted to determine how to incorporate and encourage "Student Use" of technology to promote critical thinking, collaboration, and achievement in mathematics and science classes.

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