CAN PRESERVICE TEACHERS LEARN TO USE MULTIPLE INSTRUCTIONAL TECHNOLOGIES IN ONE SEMESTER?

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Abstract

Knowledge of instructional software programs that can meet mathematical curricula objectives, motivate and engage students in problem-based learning/inquiry is essential for teachers. This is the second of a series of studies tracking the implementation of instructional technology in a mathematics methods course. The first report was presented at the Congress of Educational Research in Mathematics Education10, Dublin, Ireland, February 2017. Data were collected from surveys, power point presentations of an instructional technology lesson, and the reflections written post lesson presentations. The data were used to classify where preservice teachers were on the five steps Apple Classroom of Tomorrow ([1]) inclusion of instructional technology in the classroom. Of the 24 preservice teachers, 21 were solidly on Step 2 – limited use of technology. There were 3 who stood at Step 3 creating their lesson plans to use technology on a daily basis.

Keywords: Instructional technology, preservice teachers, mathematics education.

1 INTRODUCTION

Teaching mathematics in 2017 requires far more than a deep understanding of mathematics. Multiple pedagogical methods and strategies are needed to be able to address student learning needs. Today, teachers need to use instructional technology that applies scientific processes and stored knowledge to solve practical tasks ([2]). Knowledge of computer software that can meet curricula objectives, motivate students, and engage students in problem-based learning and inquiry is essential ([3]). The ground work for knowing how to apply technology with intent and purpose for producing knowledge products should now be part of the responsibility of teacher preparation programs.

This case study report is an expansion of a first presentation of the results to the Congress of Educational Research in Mathematics Education10, Dublin, Ireland, February 2017. This report augments the details of the results of the second study, the issues that arose in the implementation of technology in the classrooms, and the related effects at the university level.

Defining instructional technology in education has been evolving since the American Educational Communications and Technology group produced a broad definition in 1963 that matched the elements of pedagogical courses of the time ([4]).

While the technology sections of learned societies grappled with refining the definition of instructional technology, the Association of Mathematics Teacher Educators (AMTE) created standards for the preparation of preservice mathematics teachers for grades Pre-Kindergarten to grade 12 (PK-12). These standards devoted a section of the Adolescence to Young Adult (AYA) grades (C.1.6. Using Mathematical tools and technology) to identifying the types of mathematical software preservice teachers should master. AMTE explained C.1.6. with the following statement:

Well-prepared beginning teachers of secondary mathematics must be proficient with tools and technology designed to support mathematical reasoning and sense making, both in doing mathematics themselves and in supporting student learning of mathematics. In particular, they should develop expertise with spreadsheets, computer algebra systems, dynamic geometry software, statistical simulation and analysis software, and other mathematical action technologies, as well as other tools such as physical manipulatives. [Elaboration of C.1.6] ([5]).

The AMTE elaboration of mathematical instructional technology aligns with the goals of this research to help mathematics preservice teachers become competent and frequent users of instructional technology.
1.1 Integration of instructional technology into curricula issues

Ertmer, Conklin, Lewandowski, Osika, Selo, and Wignal ([6]) found that preservice teachers needed specific ideas and examples of how to put instructional technology into their mathematics instruction. Wang’s (2004) research noted that goal setting increased self-efficacy. Dexter and Riedel ([7]) identified the importance of clinical educators use of instructional technology as a key to helping preservice teachers increase their self-efficacy using classroom technology. For this research, instructional technology was practiced in the methods course giving teaching ideas to the preservice teachers. A teaching assignment goal to use a software program was required of following Wang’s ([8]) finding.

1.2 Introduction of technology to pre-kindergarten to grade 12

In the 1970’s, Apple created the Apple®II for classroom work ([9]). By the 1980s ([10]), computers became part of some PK-12 classrooms. School districts developed technology plans to implement the use of computers at each grade level. However, the districts were missing a vision for computer curricula with measurable objectives that could be tracked to identify the educational impact of computer use by the teachers and students ([3]). By the 1990s, many schools had a computer on every teacher’s desk and computer laboratories. The 2000s students worked with personal devices such as Chromebooks and iPads. Graphing calculators span the decades since Demana and Waits ([11]) noted the importance of creating multiple graphs to grasp a mathematical concept.

1.3 Pre-service teachers using technology for knowledge production

Preservice teachers are well versed in the use of electronic devices as are today’s PK-12 students. Applying that understanding beyond word processing, communications, and gaming to using technology for knowledge production should be part of every teacher preparation program. Doering, Hughes, and Huffman ([12]) did a five-year study that provided the hardware and software for their preservice teachers and content faculty at the University of Minnesota. Initially, they found that preservice teachers had a solid knowledge of technology use, but integrating technology into daily instruction and problem-based learning was not a skill they had. By the end of the study with the integration of instructional technology into content and pedagogical classes, the preservice teachers became productive users of instructional technology in their field experiences.

Franklin ([13]) reported on the attitudes of Curry School of Education at the University of Virginia elementary level teacher graduates. The participants noted a clear understanding of the importance of using computers in the classroom to foster student curiosity and to construct ideas. These teachers had a deep comprehension of electronic pedagogical content knowledge as the reason for their smooth transition to classroom implementation.

The use of Web 2.0 tools in the classroom by preservice teachers was examined by Sadaf, Newby, and Ertmer ([14]). To think of Web 2.0 devices as tools to increase learning, preservice teachers needed the support from their clinical educator, needed easy access to those tools, and had to hold a high level of self-efficacy regarding their ability to help student learning. Only when these elements were met did the preservice teachers act on using instructional technology in their classrooms.

1.4 Assessment scales for instructional technology

Pre-Service teachers are well versed in the use of electronic devices as are today’s PK-12 students. Applying that understanding beyond word processing, communications, and gaming to using instructional technology for knowledge production should be part of every teacher preparation program. Some schools of education do include instructional technology as an element in their teacher preparation programs. Doering, Hughes, and Huffman ([12]) did a five-year study that provided the hardware and software for their pre-service teachers and content faculty at the University of Minnesota. Initially, they found that pre-service teachers had a solid knowledge of how to use technology, but integrating instructional technology into daily instruction, how to plan lessons and problem-based learning was not a skill they had considered nor could they come up with ideas on how to do so. These results confirmed Ertmer et al.’s ([6]) research that pre-service teachers did not know how to integrate technology into mathematics classes. By the end of the study with the integration of instructional technology into content and pedagogical university classes, the pre-service teachers were able to become productive users of instructional technology in their field experiences.
Franklin ([13]) reported on the attitudes of Curry School of Education at the University of Virginia elementary level teacher graduates. In her study, the participants noted a clear understanding of the importance of using computers in the classroom to foster student curiosity and to construct ideas. Franklin observed that these teachers had a deep comprehension of electronic pedagogical content knowledge as the reason for their smooth transition to classroom implementation.

According to Darling-Hammond and Richardson ([15]), all teachers need to learn how to help students cultivate thinking skills and performance abilities at Bloom’s analysis and synthesis levels. One means of helping students learn those upper level skills would be to use Web 2.0 tools – instructional technology in the classroom.

The use of Web 2.0 tools in the classroom by pre-service teachers was examined by Sadaf, Newby, and Ertmer ([14]). They found that pre-service teachers held neutral perceptions regarding the value of such tools. To think of Web 2.0 devices as tools to increase learning, pre-service teachers needed the support from their clinical educator, needed easy access to those tools, and had to hold a high level of self-efficacy regarding their ability to help student learning by using Web 2.0 tools. Only when these elements were met did the pre-service teachers act on using instructional technology in their classrooms. This research examines that pre-service teacher transition to using technology in the classroom given a course requirement.

1.4.1 Implementation of instructional technology assessment

Being able to evaluate pre-service teachers’ instructional technology use that impacts student learning needs to go beyond collections of participants’ comments. At the start of the 1990’s, education researchers observed teachers using instructional technology. The results were lists of hierarchies that defined how much the lessons depended on the use of technology and how the collected data impacted problem solving.

A long term study by, Dwyer, Ringstaff, Haymore, and Sandholtz ([1]) working with Apple Classroom of Tomorrow (ACOT) examined how teachers adapted their classrooms and pedagogy to using technology when provided with multiple computers, an abundance of software, technical support, and technology training. The researchers identified a five step progression of how teachers developed technology-based pedagogy identifying it as the ACOT stages of classroom change. Step 1 – Entry. The teachers are acquainted with the basic tools of the computer and classroom programs. Step 2 – Adoption, the teachers adopted the computer programs for limited use (defined as practice not knowledge building). Step 3 – Adaptation, the teacher thoroughly integrated the use of computers into the curriculum. This step resulted in students learning more, being engaged with the content, and producing better knowledge products. Step 4 – Approbation, teachers who cannot teach without computers. Step 5 – Invention, teachers created their own programming that enhanced student learning. The ACOT (1994) study noted that teachers’ development was not done in leaps, but moved forward in increments over time. As the teachers embraced technology, their pedagogical strategies shifted from being teacher-centered to student-centered.

Other evaluation tools were examined but found to be too broad or focused on the technology rather than the teacher. These studies included the work of the Cognition and Technology Group at Vanderbilt ([16]) that developed a progression of expertise scale of five levels. While these five levels were similar to the ACOT stages, they did not define the teacher change as well. Heick ([17]) described four growth stages of students and teachers when using technology. However, this scale focused on school protocol rather than teacher development. Thus, the researcher worked with the ACOT five stage scale to define preservice teacher development for using technology in the classroom.

1.5 Theoretical framework

The researcher selected the ACOT ([1]) steps to serve as the theoretical framework for this study to judge how preservice teachers developed using technology. The ACOT instrument focused on the changes in teacher practice whereas, other instruments focused on the partnership of the teacher and the students. The case study descriptive quality lends itself to using the ACOT descriptions to define advancement on these steps. This research is to learn how far preservice teachers can grow using instructional technology in one semester.
2 METHODOLOGY

This article is the second report of a long term descriptive case study as it follows preservice mathematics teachers in a mathematics methods course that required a lesson using instructional technology to be taught during a 90 hour field experience. A case study format fits this research as it describes the conditions necessary to produce knowledgeable preservice teachers' regarding instructional technology. The research question is: How far can preservice teachers' develop using instructional technology on the ACOT Steps in one semester?

2.1 Participants

The preservice teachers in this study consisted of N=24. All preservice teachers were in a course titled Secondary Mathematics Methods which was required for state licensure to teach. Eleven were majoring in Adolescence to Young Adult Mathematics Education (AYA) with a second degree or major in mathematics. Thirteen preservice teachers selected mathematics as one of their two concentration fields for Middle Childhood Education (MC). There was one male in each licensure group with 10 females in the AYA group and 12 females in the MC group.

2.2 Setting

The university is a private, non-profit school located in the south-western, urban section of a Midwestern state. There are approximately 8,529 undergraduates and 3,117 graduate students. The department of Teacher Education conducts classes at the undergraduate and graduate levels.

2.3 Procedure

At the start of the methods course, a survey was given asking students how frequently they used: 1) word processing; 2) spreadsheets; 3) power point presentations; 4) photomath; 5) Wolfram Alpha; 6) DESMOS; 7) GoogleSketchUp; 8) Polling apps; 9) GeoGebra; 10) Kahoot? Likert scales from 0-never used to 5-all the time used were the levels of selection. This study introduced preservice teachers to free-source mathematical software programs. The methods course demonstrated the programs and provided practice teaching mathematics concepts and procedures with them. During the clinical experience of the methods course, the preservice teachers were required to create and teach an instructional technology lesson.

2.3.1 Study history: Equipment survey of partnership schools

One of the elements found by Sadaf et al. ([14]) that was needed for preservice teachers to use instructional technology was easy access to Web 2.0 tools in the classrooms. This study interviewed the university's partnership school districts to learn what technology was in place in those classrooms. The school districts reported that they had invested in computers for all teachers and individual laptops, iPads, or Chromebooks for the students. The more frugal districts had multiple computer carts with 30 individual devices for classroom use. Regarding educational software programs, freeware was the programming of choice. The availability of Web 2.0 tools and software programs allowed the researcher to create an assignment goal requiring the use of instructional technology that Wang ([8]) recommended.

2.3.2 The search for mathematics freeware and program criteria

The criteria that were used to evaluate the appropriateness of the instructional technology were the eight Common Core State Standards Mathematical Practices (CCSSM) ([18]) and the eight National Council of Teachers of Mathematics (NCTM) Teaching Practices ([19]). Any mathematical program had to require students to perform six of the eight Mathematical Practices and allow the teacher use all eight NCTM Teaching Practices.

While attending the annual Detroit Area Council of Teachers of Mathematics meeting, the researcher attended one presentation over Skype with the founder/creator of DESMOS, Eli Luberoff. He had the session attendees solving problems using the DESMOS Calculator which was an intuitive, dynamic, graphing program. At the NCTM Interactive Institute 2015, the program focused on free computer programs for geometry and algebra instruction: GeoGebra and DESMOS and polling programs to engage students in discourse while evaluating the solutions of other students. These polling programs required that students use their smart phones rather than clickers. Wolfram Alpha a program that could be used for higher levels of mathematics. The program had many more options with which
teachers could integrate other content areas. This search for instructional technology was not
exhaustive. Once three major programs were found and noted in the AMTE Preservice Teacher
Standards ([5]), the researcher stopped the search. The programs included: DESMOS, GeoGebra,
Wolfram Alpha, PollEverywhere.

2.4 Data Collection
The data collection began with a survey conducted at the start of the mathematics methods class
asking preservice teachers how frequently they used the software programs: word processing,
spreadsheets, power point, PhotoMath, Wolfram Alpha, DESMOS, Google Sketchup, Polling
programs, and GeoGebra. The instructional technology lesson plan with preservice teacher reflections
were collected after the six weeks of field experience. The reflections served as a record of the
preservice teachers’ comfort level, frequency, and self-efficacy using technology. The preservice
teachers presented their instructional technology lesson in a power point presentation that included
video clips illustrating their teaching with instructional technology, their classes discussing and
completing the mathematical work, and the classes voting on the most elegant solutions. The video
tape clips were to verify what was stated in the lesson plans and reflections. From the reflections,
implementation issues were discussed. Data was recorded regarding the frequencies that the
preservice teacher used: the instructional technology; had the students use that software; and the
issues that arose while teaching a technology-based lesson.

2.5 Data analysis
2.5.1 Analysis of surveys
The Survey of Classroom Technology for Knowledge Production was conducted to learn how familiar
the preservice teachers were with use of instructional technology. The Likert scale scores were totaled
and measures of central tendency were calculated.

2.5.2 Assessment of class assignment
An assignment was created by the researcher with a goal matching the findings of Wang (2004) to
learn what level the preservice teachers reached on the ACOT scale of proficiency – could they use
and integrate technology smoothly into their teaching? Each preservice teacher created and video-
taped an instructional technology lesson plan using a real world problem for their classes to solve by
using a mathematical software program. Once the students had solutions, they were grouped and
each student explained their solution to the group. The student group debated the approaches and
modified their work to create their best solution. Each group presented their solution to the whole class
and PollEverywhere.com was used to have students vote on for the elegant solution. The projects
were graded using the rubric found in Figure 1.

<table>
<thead>
<tr>
<th>Technology and mathematics project rubric</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 points of the total possible of 21 points is the minimum passing grade</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Elements</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Completed UD lesson plan format</td>
<td>Hard copy of the lesson passed in with the incomplete reflection. The lesson plan lacks the sections and requirements of the AYA/MC UD Lesson Plan format.</td>
<td>Hard copy of the lesson passed in with the completed reflection. The lesson plan follows most of the section requirements of the AYA/MC UD Lesson Plan form</td>
<td>Hard copy of lesson passed in with written reflection. The lesson plan format follows all the requirements of the AYA/MC UD Lesson Plan format. The reflection provides clear and thoughtful responses.</td>
<td></td>
</tr>
<tr>
<td>2. Use of DESMOS, GeoGebra, or GoogleSketch-Up</td>
<td>Your presentation shows your attempt to use DESMOS, GeoGebra, Google-Sketch-Up to present the problem</td>
<td>Your presentation clearly shows your use of DESMOS, GeoGebra, Google-Sketch-Up posing the problem</td>
<td>Your presentation clearly shows your mastery of DESMOS, GeoGebra, or GoogleSketch-Up as the presentation mode for posing your problem</td>
<td></td>
</tr>
</tbody>
</table>
3. Problem solving with engaging real world problem

<table>
<thead>
<tr>
<th>Evidence of the students solving a mathematical problem.</th>
<th>Evidence of the students solving a real world math problem.</th>
<th>Evidence of the students solving an engaging, real world problem. The problem is posted and easily read.</th>
</tr>
</thead>
</table>

4. Math discourse: students explain, defend, challenge the ideas of others

<table>
<thead>
<tr>
<th>Evidence of students engaged in classroom discourse. but not on topic.</th>
<th>Evidence of the students engaged in classroom discourse. Types of discourse are not clear.</th>
<th>Evidence of the students engaged in classroom discourse that includes explaining, defending, and challenging the solutions/ideas of others.</th>
</tr>
</thead>
</table>

5. Student presentations

<table>
<thead>
<tr>
<th>Evidence of students presenting their solutions with no clear reasoning.</th>
<th>Evidence of students presenting their solutions with little explanations.</th>
<th>Evidence of several student presentations explaining/defending their solution.</th>
</tr>
</thead>
</table>

6. Student use of polling

<table>
<thead>
<tr>
<th>No use of polling devices</th>
<th>Some students use polling devices.</th>
<th>Evidence of the students using electronic polling</th>
</tr>
</thead>
</table>

7. Clear video of the voted solution.

<table>
<thead>
<tr>
<th>No clear result to the voting. Or the solution is not clear.</th>
<th>Problem solution is correct, but not the voting.</th>
<th>Evidence of the problem solution selected by the class can clearly be read.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Total Score</th>
<th>_______/21</th>
</tr>
</thead>
</table>

Figure 1. Technology and mathematics unit Rubric.

During the power point presentations, notes were taken by the methods instructor regarding the frequency of use and the issues that the preservice teachers had when implementing this technology-based lesson. Lesson reflections were reviewed for common themes and attitudes.

3 RESULTS

The results of the Survey of Classroom Technology for Knowledge Production revealed that the AYA preservice teachers used mathematics instructional technology more than the MC preservice teachers prior to the methods course. All 24 preservice teachers used word processing, 11 used spreadsheets, and 19 used power point presentations. When the preservice teachers reached the specific mathematical instructional technology questions, many scores were zero. See Table 1 for median scores, standard deviation and standard error measure.

<table>
<thead>
<tr>
<th>Question</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>S.D.</td>
<td>0</td>
<td>0.65</td>
<td>0.79</td>
<td>0.2</td>
<td>1.57</td>
<td>1.31</td>
<td>0</td>
<td>0</td>
<td>1.4</td>
<td>0</td>
</tr>
<tr>
<td>S.E.M.</td>
<td>0</td>
<td>0.13</td>
<td>0.16</td>
<td>0.04</td>
<td>0.32</td>
<td>0.27</td>
<td>0</td>
<td>0</td>
<td>0.29</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 1. Survey of Classroom Technology for Knowledge Production, N=24.

The preservice teachers were able to implement the instructional technology lesson to varying degrees. The AYA preservice teachers were able to create a real world problem around which they built their lesson using instructional technology. The preservice teachers taught the students how to use their selected computer program on one day and the lesson the next day.

The MC preservice teachers created their real world problems, but those who taught in grades 4 and 5 were not able to use DESMOS, GeoGebra, nor Wolfram Alpha. Their cooperating teachers believed that this technology was not developmentally appropriate for the students. Since a majority the students in these grades did not own smart phones, many of the preservice teachers used Kahoot, a
Norwegian University of Science and Technology program. The preservice teachers used this software program to project questions and collect voting results.

The scores from the project rubric were gathered into the following data:

**Table 2.** Data Results from Technology + Mathematics Methods Project Rubric Scores.

<table>
<thead>
<tr>
<th>Rubric #</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>N=24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>S.D.</td>
<td>0.64</td>
<td>0.63</td>
<td>0.51</td>
<td>0.52</td>
<td>0.51</td>
<td>0.26</td>
<td>0.74</td>
<td></td>
</tr>
<tr>
<td>S.E.M.</td>
<td>0.17</td>
<td>0.16</td>
<td>0.13</td>
<td>0.13</td>
<td>0.13</td>
<td>0.07</td>
<td>0.19</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2a:** 2016 Survey of Classroom Technology for Knowledge Production Pre-Field, N=15.

<table>
<thead>
<tr>
<th>Question</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>S.D.</td>
<td>0.52</td>
<td>1.26</td>
<td>1.39</td>
<td>0.60</td>
<td>1.21</td>
<td>0.85</td>
<td>0.28</td>
<td>1.72</td>
<td>1.34</td>
<td>1.59</td>
</tr>
<tr>
<td>S.E.M.</td>
<td>0.14</td>
<td>0.35</td>
<td>0.39</td>
<td>0.17</td>
<td>0.34</td>
<td>0.24</td>
<td>0.08</td>
<td>0.48</td>
<td>0.37</td>
<td>0.44</td>
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</tbody>
</table>

**Table 2b:** 2016 Survey of Classroom Technology for Knowledge Production Post Field, N=15.

<table>
<thead>
<tr>
<th>Question</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>S.D.</td>
<td>1.3</td>
<td>1.35</td>
<td>1.06</td>
<td>0.52</td>
<td>1.10</td>
<td>1.22</td>
<td>0.74</td>
<td>1.20</td>
<td>1.10</td>
<td>1.46</td>
</tr>
<tr>
<td>S.E.M.</td>
<td>0.34</td>
<td>0.35</td>
<td>0.27</td>
<td>0.13</td>
<td>0.28</td>
<td>0.32</td>
<td>0.19</td>
<td>0.31</td>
<td>0.27</td>
<td>0.38</td>
</tr>
</tbody>
</table>

The 2015 scores from the project rubric were reported in the following data for Year 1:

**Table 3a:** 2015-Data Results from Technology + Mathematics Methods Project Rubric Scores.

<table>
<thead>
<tr>
<th>Rubric #</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>N=24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>S.D.</td>
<td>0.64</td>
<td>0.63</td>
<td>0.51</td>
<td>0.52</td>
<td>0.51</td>
<td>0.26</td>
<td>0.74</td>
<td></td>
</tr>
<tr>
<td>S.E.M.</td>
<td>0.17</td>
<td>0.16</td>
<td>0.13</td>
<td>0.13</td>
<td>0.13</td>
<td>0.07</td>
<td>0.19</td>
<td></td>
</tr>
</tbody>
</table>
The preservice teachers were successful having the students vote on the elegant solution to their problem. The high mean score with the lowest standard deviation and standard error measure confirm the attention the preservice teachers paid to this element of the assignment.

The power point presentations with video clips demonstrated the ease with which the preservice teachers acquainted their classes with instructional technology. This assignment matched the attributes needed for success by preservice teachers learning instructional technology found by Ertmer et al., ([6]) specific ideas, Sadaf et al., ([14]) available Web 2.0 tools, and Wang ([8]) providing goals.

The reflections noted issues that the preservice teachers faced when implementing their instructional technology lessons. Two of the AYA preservice teachers had issues using the polling app as the wireless connections were not consistent where they taught. A MC preservice teacher was not able to reserve the cart of laptops for her lesson. She put her questions and the polling in the Kahoot program and projecting from the cooperating teacher's desktop computer.

The overall theme in the preservice teachers' reflections found that using instructional technology was a positive experience. The preservice teachers solved technology issues that included: the internet working only on laptops in half of the classroom; no internet accessible; one preservice teacher reserved the cart of tablets then found another teacher took the cart without regard for the reservation list.

Observing the power point presentations and reading the lesson reflections where the preservice teachers noted the number of times they used instructional technology beyond the assignment. Given the one preservice teacher who did not do the assignment, 20 preservice teachers were solidly on ACOT Step 2 – limited use of technology. Three of the 24 used some version of instructional technology almost every day placing them on Step 3 – Adaptation where they built more lessons implementing instructional technology.

### DISCUSSION

Mentor teachers for preservice mathematics teachers need to know: mathematics well beyond what they teach ([20]), pedagogical content knowledge that contributes to student learning and achievement ([21]); and how to mentor preservice teachers ([22]). With the information learned in this study, having a mentor whose classroom is student-focused, a problem-based learning environment, and uses the NCTM Teaching Practices ([19]) would be ideal for the 21st century generation of mathematics teachers.

Many in-service teachers volunteer to work with a pre-service teacher in order to learn the current research and new methods being developed. In a conversation with one high school educator, she reported that she felt this exchange of current, research-based practice and how to use new instructional technology in the classroom put the in-service and pre-service teachers on a level playing field for professional conversations and learning opportunities (personal communication, 2011). Carlson and Gooden ([23]) noted that having mentor teachers who knew how to implement technology software in mathematics classrooms were few. These researchers found an insufficient number of opportunities for pre-service teachers to see technology used or modeled in their college mathematics or education classes, or in their field placements.

### Table 3b: 2016-Data Results from Technology + Mathematics Methods Project Rubric Scores.

<table>
<thead>
<tr>
<th>Rubric #</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>N=9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>S.D.</td>
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<td>0.0</td>
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<td>0.44</td>
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<td></td>
</tr>
<tr>
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<td>0.0</td>
<td>0.24</td>
<td>0.15</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td></td>
</tr>
</tbody>
</table>

Over all, the scores on the rubric were 2 or 3. There was one student who did not do the assignment. There is no ability on this scale to score a zero for no work done.
While the Carlson and Gooden article was from 1999, changes in education take time. Using instructional technology is not what many universities believe is part of teacher preparation (personal conversation with School of Education Technology Director, 9/9/16). At the university level, the head of technology at this university was amazed to learn that local PK-12 schools were paperless, had online textbooks, and were using tablets for all classwork (personal communication with the university technology director, 9/26/16). Universities need to accept that PK-12 schools are in the forefront of instructional technology implementation. It is university teacher preparation programs that need to provide technology training to pre-service teachers. If Teacher Education Departments wish to prepare teachers who are able to teach 21st century skills, instructional technology needs to be embedded and modeled in the pedagogical methods used by university faculty.

4.1 Implications and connections to mathematics teacher education

Adding program elements for instructional technology into the curriculum for preservice teachers is not a simple fix. Instructional technology needs time to present, model, practice. If preservice teachers practiced with mathematical instructional technology in college mathematics classes, they would witness the benefits to student achievement. The research by Carlson and Gooden ([23]) suggests that the responsibility for teaching preservice teachers how to integrate technology into the classroom be done not only in education courses, but also in mathematics classes. If these two departments can collaborate sharing this responsibility, the preservice teachers would witness the power of teaching with technology.

There is an assumption here on the part of the researcher that the mathematics faculty would be using the CCSSM Mathematical Practices by applying the NCTM Teaching Practices ([10]). Knowledge of these two sets of standards by faculty in two departments allows the pre-service teachers to examine teaching as a two-pronged experience: the role of students in the mathematics courses performing the eight CCSSM Mathematical Practices; and in their education courses examining how faculty activate the CCSSM Mathematical Practices by applying the eight NCTM Teaching Practices, connections between the two standards systems would provide the pre-service teachers with guidelines as to how they will approach the teaching of mathematics.

Collaborations between two departments sounds like a simple issue. However, most faculty are very protective of their academic freedom regarding what is included in their courses. Mathematics educators would like all mathematics faculty to use the NCTM Teaching Practices ([10]), but many see this request as downgrading their courses to high school standards. Conversations need to be open between these departments negotiating what might be fostered in both departments. Once a plan is created, the university will produce pre-service teachers who implement standards in a student-focused class using instructional technology.

With the speed of technological change and innovation more than doubling every 1.5 years according to Moore’s Law is just one indicator that all technological change happens at an exponential rate ([24]). Preservice teachers need to learn how to use instructional technology in order to create student-focused classrooms that engage their students in the learning process from their first day of teaching mathematics.

REFERENCES


