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Using TI-Nspire to Engage Preservice Mathematics Teachers in an Exploratory Geometry Module

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Using TI-Nspire to Engage Preservice Mathematics Teachers in an Exploratory Geometry Module

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In the mathematics classroom, most preservice mathematics teachers possess basic skills to use technology as an instructional strategy in communicating content standards. However, today's demands for preservice teachers to engage in a variety of "best teaching practices" in their preservice teaching and edTPA requirements can oftentimes place the acquisition of technical skills and integration of new technology in content curriculum far from the forefront of their minds. Ertmer, Conklin, Lewandowski, Osika, Selo, and Wignall (2003) acknowledged preservice teachers' desires to gain the adequate technical skills necessary to use technology in teachers' daily tasks of facilitating and managing their classrooms. They suggested that "in order to translate these skills into practice, teachers need specific ideas about how to use these skills to achieve meaningful learning outcomes under normal classroom conditions" (p. 96). Preservice teachers need guidance and information about "*how*, as well as *why*, to use technology in meaningful ways" so they can "develop their own visions for, or ideas about, meaningful technology use" (p. 96). Thus, the instructional aid of technology integration in the mathematics classroom must look to address specific uses of technology to help preservice mathematics teachers build awareness and confidence to implement innovative teaching approaches to enhance student learning.

One example of new technology that is currently used in high school mathematics classrooms is the TI-Nspire CX CAS handheld calculator. In an effort to demonstrate the use of this particular device and receive reflective feedback, preservice secondary school mathematics (PSSM) teachers engaged in an exploratory geometry module to manipulate and discover different mathematical concepts used to assist with writing geometry proofs. In the module, PSSM teachers bridged previously acquired technical skills with that of new skills to incorporate TI-Nspire technology in the teaching and learning of mathematics. The mathematics teacher educators compiled PSSM teachers' reflections from a small cohort of five PSSM teachers at a southeastern, urban institution in hopes to provide teacher educators with a reflective insight into PSSM teachers' experiences as they worked through a TI-Nspire incorporated geometry module. In particular, the focus of this reflection (1) analyzes the PSSM teachers' content enhancement in writing geometry proofs with the use of TI-Nspire technology and (2) looks at the effect of the integration of TI-Nspire technology on PSSM teachers' ability to implement and enrich the teaching and learning of mathematics, such as the observed benefits and challenges.

Significance

It is without a doubt that technology influences, for better or for worse, both the teaching and learning of mathematics. For example, Thomas and Hong (2013) performed a study that analyzed teachers' integration of calculator technology in the mathematics classroom. Some teachers and students identified calculator use as a "procedural, button-pushing emphasis in the lesson, rather than an emphasis on the mathematics" (p. 75). Those not familiar with the calculator technology had to focus on the operational facets, which hindered their concentration on the mathematics. On the contrary, others viewed calculators as interactive, time-saving tools that allowed teachers to cover more material and help students build conceptual understandings of mathematics through its visuals. To reap the benefits and limit the challenges of teachers and students using technology in the mathematics classroom, it is necessary to critically analyze research addressing technology use. Additionally, it is imperative that time and space is reserved to reflect on the exploratory experiences of integrating technology in the teaching and learning of mathematics.

The National Council of Teachers of Mathematics (NCTM) supports the use of appropriate technology in the mathematics classroom when it serves as a tool to teach and learn mathematics. As described in NCTM's *Principles and Standards for School Mathematics* (2000), technology can assist with visualizing mathematical ideas, organizing and analyzing data, and communicating results by applying mathematical reasoning and problem-solving skills. The graphical power of calculators and computers provides students with opportunities to explore mathematical content in several different representational forms that might be otherwise too challenging and time consuming to perform by hand. As a result, technology tools provide students with affordable access to visual models that can aid in students' conceptualization of mathematical ideas.

To effectively make use of technology in the mathematics classroom, teachers need to be equipped with adequate training and on-going instructional assistance. Teachers need to have an understanding of the technology's capabilities and how it can be used to advance student learning. This means that "teachers should use technology to enhance their students' learning opportunities by selecting or creating mathematical tasks that take advantage of what technology can do efficiently [through graphing], visualizing, and computing" (NCTM, 2000, pp. 25-26).

Several education companies offer exceptional technology resources that have found their way into the hands of teacher educators and students. Since the integration of TI-Nspire CX CAS in a geometry module is the main focus of this reflection, it is essential to comment on the research supporting this technology of interest. As addressed by Texas Instruments (2015), TI-

Nspire technology offers functionality and innovative visual content representations to advance students' understandings of mathematics concepts by means of exploration. TI-Nspire supports its technology products with research that indicates a need for supportive teaching tools to accelerate the understanding process by highlighting visualized geometric, algebraic, and graphical representations. The technology is also designed to allow for dynamically linked multiple representations such that users can observe cause and effect relationships of different representations.

More specifically, a geometry application is offered in the TI-Nspire CX CAS handheld that provides users with a setting to construct and manipulate geometric figures and animations. In addition, the calculator offers applications to explore graphs of functions, analyze data through statistical operations, build graphical representations, and much more. As Ozgun-Koca and Edwards (2009) observed in their research on mathematics teachers' views of using TI-Nspire, the calculator "allows students to dynamically manipulate the graph and observe the immediate effects of that manipulation on the symbolic form" (p. 1). To further examine the influence and significance of using TI-Nspire, the mathematics teacher educators observed the benefits, challenges, and overall experiences of the PSSM teachers working with this technology.

Participants

Participants in this study included two mathematics teacher educators and a cohort of five PSSM teachers. The PSSM teachers were enrolled in an initial teacher preparation program with a concentration in secondary mathematics education at a large, urban university in the southeastern region of the United States. One of the PSSM teachers returned to school for a second career, while the other four PSSM teachers completed their first degree in mathematics-related fields and went straight to work on their masters in secondary mathematics education.

Overall, the participants can be described as a diverse group that varies in gender, race, culture, socioeconomic backgrounds, and ideas of technology (see Table 1).

Table 1

PSSM Teachers' Gender, Race, and Academic Background

	Gender	*Race*	*Career Experience*
Abbey	Female	White	Student
Chelsea	Female	White	Student
Monica	Female	African American	Student
Tamesha	Female	African American	Student
Kyle	Male	White	Career Changer

After receiving IRB approval to perform the research, all five PSSM teachers in the cohort volunteered to participate in the summer of 2015. The research took place over the course of one summer semester methods course with a pretest and a posttest occurring the first and last day of class, respectively. Throughout the semester, the mathematics teacher educators collected coursework and reflections, which served as part of the data collection. Once the semester ended, a graduate research assistant organized the data and performed interviews with the participants. Data analysis did not begin until the start of the following semester to not interfere with the PSSM teachers' and the mathematics teacher educators' evaluations.

Identifying PSSM Teachers' Needs

As the PSSM teachers engaged with mathematical content and teaching pedagogy in their methods course, the mathematics teacher educators exposed the PSSM teachers to teaching and learning modules that were reflective of their future experiences in the mathematics classroom. Zhao and Bryant (2007) found that to effectively infuse technology in the classroom, teachers needed to participate in intensive curriculum-based technology training that addressed more than just the development of basic technology skills. Thus, it was the goal of the mathematics teacher educators to model and teach the PSSM teachers how to incorporate calculator technology into a geometry module. By designing a geometry module that incorporated a technology component, the mathematics teacher educators were able to gather insights into the PSSM teachers' successes and challenges as they engaged in learning situations similar to those of their future students.

Since the PSSM teachers were preparing to teach in geometry classrooms for their student teaching experiences, the mathematics teacher educators wanted to review key geometry concepts along with teaching pedagogy in the mathematics methods course. The mathematics teacher educators also knew from teaching previous methods courses that some PSSM teachers experienced trouble in recalling geometry content, especially skills involved with geometric proof writing. As a result, the mathematics teacher educators assigned a brief pretest (see Appendix Curriculum Content Pre/Posttest) that assessed the writing of right triangle and rectangle proofs at the beginning of the semester.

In the pretest (see Table 2), only two out of five participants were able to correctly prove the first problem addressing a right triangle. The participants who attempted the proof used mathematical concepts like negative reciprocal slopes, right angle, the distance formula, the Pythagorean Theorem, and plotting points on a graph. In the second problem that asked to prove a rectangle, only one out of five participants was successful at providing a correct proof. The participants who attempted the proof used mathematical concepts like four right angles, two sets of parallel lines, two slopes of negative reciprocals, plotting points on a graph, and equal opposite side lengths and angles.

Table 2

PSSM Teachers' Pretest Results

	Question 1	*Right Triangle Proof Concepts*	*Question 2*	*Rectangle Proof Concepts*
Abbey	Correct	Negative reciprocal slopes; right angle	Correct	Four right angles; two sets of parallel lines; two slopes of negative reciprocals
Chelsea	Incorrect	Plotting points	Incorrect	Opposite side lengths equal; opposite sides parallel; right angles
Monica	Correct	Distance formal; Pythagorean theorem	Incorrect	Plotting points
Tamesha	Incorrect	Plotting points; Pythagorean theorem	Incorrect	Opposite side lengths equal; opposite angles equal
Kyle	Incorrect	Plotting points	Incorrect	Opposite side lengths equal

The mathematics teacher educators collected the pretest and analyzed the findings. The PSSM teachers did not review their pretest until after the posttest given at the end of the semester. The mathematics teacher educators did not want to influence the PSSM teachers' performance by reviewing the pretest before the posttest. Given the PSSM teachers' performance and previous knowledge observed in the pretest, the mathematics teacher educators designed an exploratory geometry module to engage the PSSM teachers in review of the mathematical content addressed in the pretest and additional problem-solving strategies that would aid in content conceptualization.

Right after administering the pretest, the mathematics teacher educators also assigned a learning style inventory assessment for the PSSM teachers to complete. The learning style inventory assessment (see Appendix B) was administered to provide the mathematics teacher educators with information pertaining to how the PSSM teachers learn. The learning style inventory assessment also served as a modeled activity for the PSSM teachers to complete with their future students. Based on the PSSM teachers' results on the learning style inventory assessment (see Table 3), the mathematics teacher educators found that all five PSSM teachers were classified as visual learners.

Table 3

PSSM Teachers' Learning Style Inventory Analysis

	Visual Score	*Auditory Score*	*Tactile Score*
Abbey	34	16	18
Chelsea	32	17	28
Monica	36	30	21
Tamesha	28	24	13
Kyle	32	22	18

Using the PSSM teachers' learning style inventory analysis, the mathematics teacher educators knew that there was also a need to provide the PSSM teachers with situated-learning tasks that appealed to their visual learning needs. Additionally, the PSSM teachers commented that they learned best by working with material through collaboration and hands-on activities. Thus, it was imperative that the PSSM teachers were exposed to teaching and learning experiences that encompassed techno-kinesthetic, visually-based learning activities. The first instructional tool that came to mind was a TI-Nspire calculator activity to address this need.

Since geometry is very visual, it only makes sense to integrate technology that enriches reasoning, problem-solving, and visual awareness. As noted by Tabor (2014) in an article addressing the benefits of calculator use, "there is a place in mathematics classrooms for activities and lessons that have a curricular basis and that emphasize the kinesthetic and visual learning styles" (p. 626). The specific technology integrated into the geometry module used the TI-Nspire CX CAS handheld. Texas Instruments (2015) indicated that this graphing handheld was equipped with a powerful Computer Algebra System that offered users a system to build a deeper understanding of abstract concepts found in mathematics.

The mathematics teacher educators discussed the design and implementation of a geometry module with TI-Nspire. The geometry module utilized two technological advances of TI-Nspire: the document application and the device mechanism to manipulate multiple representations of the material. By using TI-Nspire technology, PSSM teachers were able to create a geometrical diagram by manipulating sliders that revealed measurements used to conjecture cause and effect relationships. Explorations in the new applications of TI-Nspire calculators enabled the mathematics teacher educators to not only address the pedagogy of calculator use but also observe its impact when used in the mathematics classroom.

Designing and Implementing a Geometry Module with TI-Nspire

To engage PSSM teachers in an exploratory geometry activity that helped with the recollection of geometric concepts and used new technology in an unfamiliar way, the mathematics teacher educators selected two geometry tasks (see Appendix C) that utilized TI-Nspire CX CAS technology from Texas Instruments' classroom activities. The tasks, along with several other classroom activities that can be used in the K-12 and college setting, were open to the public and free to download. The mathematics teacher educators integrated the TI-Nspire activity because several PSSM teachers had never used the technology. Although most PSSM teachers have used and owned TI-83/84 calculators, none of the PSSM teachers had personal experience using TI-Nspire technology. The mathematics teacher educators capitalized on this inexperience and lack of exposure to this device to model a learning situation that was reflective of the PSSM teachers' future teaching experiences.

The PSSM teachers were assigned the geometry module's Task 1 and Task 2 midway through the summer semester methods course. Task 1: Proving Right Triangles took place over one class session, while Task 2: Proving Rectangles was administered the next class session.

Prior to the geometry modules, the PSSM teachers learned about different co-teaching methods and how the emersion of strengths from two or more teachers can work together to better meet students' learning needs (Bauwens, Hourcade, & Friend, 1989; Walsh, 1992). Despite the variety of approaches used in co-teaching methods, the PSSM teachers studied specific co-teaching models like team teaching, station teaching, supplemental teaching, and parallel teaching. The mathematics teacher educators strategically incorporated the geometry module's Task 1 and Task 2 as possible activities to integrate in a co-taught classroom. With extra hands to distribute, facilitate, and assist with the TI-Nspire technology, the mathematics teacher educators took advantage of modeling innovative instructional strategies to enhance PSSM teachers' teaching and learning experiences.

Both tasks in the geometry module addressed the Georgia Standards of Excellence (GSE) Analytic Geometry content standard of MGSE9-12.G.GPE.4, which referred to using coordinates to prove simple geometric theorems algebraically. In Task 1: Proving Right Triangles, the mathematics teacher educators used parallel teaching to instruct the PSSM teachers how to write a geometry proof addressing a right triangle. Thus, the PSSM teachers were split into two groups (back-to-back) as the mathematics teacher educators taught the same lesson. The lesson addressed an example proof that was designed after the first question in the pretest. Mathematical concepts like perpendicular slopes, the distance formula, and the Pythagorean theorem were reviewed. The latter half of the lesson incorporated a technology extension that required the PSSM teachers to complete an adapted lesson from Texas Instrument's (2011) *The Pythagorean Theorem-and More* (see Appendix C). In this activity, the PSSM teachers used the document application of the TI-Nspire CX CAS calculator to construct triangles to explore the relationship between angles and side measures to classify different types of triangles, such as acute, obtuse, and right. To successfully manipulate the triangles, it was necessary for the PSSM teachers to have the technological skills to drag the vertices of each triangle to observe the change in the triangles' measurements.

The last part of the task's technology extension required the PSSM teachers to observe the areas of three squares whose vertices met to form a right triangle. Upon increasing or decreasing one square's area, the other squares changed accordingly to demonstrate one visual proof of the Pythagorean Theorem. These multiple representations of mathematical concepts provided the PSSM teachers with opportunities to develop further insights in writing proofs.

In Task 2: Proving Rectangles, the mathematics teacher educators designed a rotating stations activity that aligned with the Georgia Standards of Excellence (GSE) Analytic Geometry content standards of MGSE9-12.G.CO.11, which referred to proving theorems about parallelograms. Station 1 addressed writing a geometry proof using concepts of slope and the distance formula to prove a rectangle. Station 2 approached a geometry proof using mathematical concepts like diagonals and midpoints. In station 3, the PSSM teachers worked through application problems that required content knowledge of properties of rectangles. Lastly, station 4 required the PSSM teachers to complete a technology extension that was adapted from Texas Instrument's (2014) *Exploring Diagonals of Quadrilaterals* (see Appendix C).

To complete the task's technology extension station, the PSSM teachers had to know how to manipulate and drag endpoints and intersection points of two diagonals. The first part of the task provided a visual representation to observe what quadrilateral resulted when diagonals bisected each other (or one was the perpendicular bisector of the other), bisected vertical angles, or were congruent in length. The last part of the task determined whether special quadrilaterals could be formed given knowledge about the diagonals. Throughout the task, the up arrow could be used within the document to add more information on the screen, such as the angle or side measurements. This tool provided users with an opportunity to justify their conclusions with the aid of measurements. It was important to note that there were "tech tips" embedded throughout the instructor's guide to help teachers and students tackle the unfamiliarity of the device.

In both tasks' technology extensions, the PSSM teachers had to know how to access, download, and perform technical functions to complete requirements of the task. An understanding of the calculator's applications and keys were necessary to manipulate the visual models. Additionally, manipulating the geometric figures in both tasks allowed for the PSSM teachers to review characteristics of each figure in a kinesthetic and visual manner.

Results

At the end of the semester, the mathematics teacher educators presented the PSSM teachers with a posttest assessment (the same as the pretest assessment) to track advancements made in the PSSM teachers' geometry content understanding (see Appendix Curriculum Content Pre/Posttest). The mathematics teacher educators also asked the PSSM teachers to reflect on a prompt that asked for the PSSM teachers to identify the observed benefits and challenges of integrating TI-Nspire technology in a geometry module. The PSSM teachers' reflections served as a way for teacher educators to understand the PSSM teachers' struggles and successes using technology to advance grades 6-12 students' content knowledge and learning experiences in the classroom. Gaining these understandings can enable teacher educators to guide PSSM teachers' experiences as they explore, reflect, and adopt this form of technology in their teaching.

Impact on Content Knowledge

The posttest analysis (see Table 4) revealed improvement in the PSSM teachers' content knowledge in their ability to write geometric proofs addressing right triangles and rectangles. All five participants were able to correctly prove the first problem addressing a right triangle. Participants either used methods of slopes or distances to prove the right triangle. In the second problem that addressed proving a rectangle, three out of five participants were successful in correctly completing the proof. The two who did not complete the proof correctly made calculation errors in finding the length of the rectangle's diagonals. However, all participants commented on the properties of rectangles, including information about the rectangle's diagonals.

Table 4

PSSM Teachers' Posttest Results

	Question 1	*Right Triangle Proof Concepts*	*Question 2*	*Rectangle Proof Concepts*
Abbey	Correct	Negative reciprocal slopes; right angle	Correct	Diagonals of equal length
Chelsea	Correct	Perpendicular lines; negative reciprocal slopes; right angle	Correct	Opposite sides lengths equal; opposite sides parallel; perpendicular slopes; right angles
Monica	Correct	Distance formal; Pythagorean theorem; negative reciprocal slopes	Incorrect	Diagonals bisect at midpoint; two slopes of negative reciprocals; right angles
Tamesha	Correct	Negative reciprocal slopes; right angle	Incorrect	Opposite sides parallel; diagonals of equal length
Kyle	Correct	Negative reciprocal slopes; right angle	Correct	Diagonals of equal length; diagonals bisect at midpoint

Unlike the pretest (see Table 2), the posttest (see Table 4) indicated the PSSM teachers' content understanding of diagonals of rectangles. The PSSM teachers recalled observations reviewed in the Texas Instrument's (2014) *Exploring Diagonals of Quadrilaterals* task to accurately construct a geometric proof. For example, Kyle was successful at writing about the rectangle's diagonals of equal length and the fact that they bisected each other at the same midpoint, concepts never mentioned in any of the PSSM teachers' pretest. Although the mathematics teacher educators would have liked for all of the PSSM teachers to complete the second question correctly, the minor miscalculations of Monica and Tamesha indicated computational errors that may have been caught by the PSSM teachers if they reviewed their work. Overall, the PSSM teachers' exploration in the geometry module's tasks and technology extensions contributed to the advancement in the PSSM teachers' content knowledge of writing right triangle and rectangle geometric proofs. The TI-Nspire challenged the PSSM teachers to form conjectures, experiment with manipulating geometric figures, and engage in problem-solving activities.

Preservice Mathematics Teachers' Reflections

Methods courses should provide PSSM teachers with opportunities to work with technology and see how it can be used in their teaching. It is essential for PSSM teachers to reflect on their beliefs, views, and experiences working with technology (Zhao & Bryant, 2007). The mathematics teacher educators asked the PSSM teachers to respond to an open-ended reflection prompt that followed the TI-Nspire geometry module. The guiding question for reflection was, 'What benefits and/or challenges did you encounter in the geometry module when using the TI-Nspire?'

After the PSSM teachers reflected on their experiences, the mathematics teacher educators compiled a list of the PSSM teachers' responses (see Table 5). Overall, it was noted that incorporating the TI-Nspire was beneficial for visual learners and enhanced the learning experience. The PSSM teachers additionally observed the value of teaching a concept in multiple ways in a co-teaching learning environment. Despite observed benefits to using TI-Nspire in the geometry module, there were some concerns and challenges. Some of the PSSM teachers encountered technological challenges with not having enough experience working with the calculator.

Table 5

PSSM Teachers' Reflections

	Benefits	*Challenges*	*Other*
Abbey	-"The TI-Nspire was interesting."	-"The TI-Nspire worksheet took too long and I felt I learned about the calculator instead of the math." -"I felt the TI-Nspire slowed the lesson down and we could have gotten more done by simply drawing."	-"Technology is great in the classroom as long as it doesn't keep you from covering everything." -"It was helpful to learn about co-teaching because I will use it during my preservice." -"I liked having experiences from multiple instructors."
Chelsea	-"Using the TI-Nspire was nothing but helpful for me."	-"I got a little frustrated at times."	-"The co-teaching models demonstrated through the geometry lesson were very instructional and helpful."
Monica	-"I liked having different ways of completing the same type of problem." -"The benefit of using TI-Nspire is that it shows the student the image that he or she is working on."	-"Challenges I encountered would be not having enough experience with the TI-Nspire."	-"Having the different mathematics educators gave me different viewpoints."
Tamesha	-"Using the TI-Nspire enhanced the learning experience. It was a great tool to be included in the module."	-"I struggled with moving the cursor around and getting it to go where I wanted it to go."	-"Provided us with a great example on how to co-teach a lesson."
Kyle	-"Incorporating the TI-Nspire was a nice addition for visual learners." -"The main benefits were that it (a) helped	-"I had never used the TI-Nspire technology before, so learning to operate the program was a challenge."	-"The parallel teaching approach to right triangles helped by lowering the student/teacher ratio." -"The station teaching approach was helpful

	me visualize the concepts at issue, and (2) added a fun new aspect to the lesson to keep it fresh and hook the students." -"Learning two different ways to prove that a polygon is a right triangle is helpful."		because it allowed us to learn the same concept from multiple different instructors through different activities." -"I would definitely use parallel and station teaching to help students with different learning styles."

In the mathematics teacher educators' observations of the PSSM teachers' experiences, most of the PSSM teachers appeared motivated and excited to engage with the technology. Initially PSSM teachers had trouble maneuvering around the document and manipulating the geometric figures by dragging their vertices. However, there was observed improvement in using the technology between the first and second task. PSSM teachers were also impressed when they learned about the interactive features and applications of the TI-Nspire. Some of the PSSM teachers even expressed their wish to have had this instructional tool when they first learned about triangles and rectangles in geometry. Overall, the PSSM teachers acknowledged the benefit of the TI-Nspire's visual and kinesthetic approach to increasing their engagement and conceptualization of geometric concepts to aid in writing proofs.

Conclusive Remarks

In conclusion, the lessons learned through the exploratory experiences of the PSSM teachers were eye-opening and encouraging in that the mathematics teacher educators' plans for preparing the PSSM teachers with more conceptual and procedural understanding appeared to make a difference. When the PSSM teachers were faced with the routine problems in the geometry module, the mathematics teacher educators learned that their memory recall was sparse. Despite having the qualifications to enroll in a secondary teacher education program, the recent graduates and career changer seemed to have limited recall of some mathematics concepts and procedures. Therefore, the mathematics teacher educators employed an exploratory approach using the TI-Nspire CX CAS on some of the same concepts within the routine problems, asking the questions in different ways. By providing a collaborative learning space for the PSSM teachers to use the TI-Nspire calculators, the PSSM teachers enriched their conceptual understanding of writing geometric proofs addressing right triangles and rectangles. The advancement of the PSSM teachers' mathematics knowledge was evident in the pretest and posttest comparisons and confirmed with the research literature (Ertmer et al., 2003; Ozgun-Koca & Edwards, 2009; Thomas & Hong, 2013).

The PSSM teachers were provided with a geometry model that incorporated the TI-Nspire CX CAS that aligned with the Georgia Standards of Excellence (GSE) efforts to initiate technology integration across the curriculum. Based on the PSSM teachers' feedback, the mathematics teacher educators quickly realized that many of the PSSM teachers believed that single-handily using a Promethean or SMART Board would suffice as a sufficient form of technology integration needed within the curriculum. However, technology must include tools, such as handheld calculators, where students have direct access to technology. This realization of the PSSM teachers' thinking was clear to the mathematics teacher educators that technology integration must be intentional from the beginning to the end of the preparation program with appropriate mentorship to effectively use the technology.

Implications for Future Exploration

As new technology fills the classrooms, teachers of all experience levels can be overwhelmed with finding time and resources to learn about new technology devices and how the devices' capabilities can be tied to teaching and learning content curriculum (Thomas &

Hong, 2013). The mathematics teacher educators focused on two tasks in a geometry module that used different aspects of the TI-Nspire device to model and bridge technology and curriculum content. PSSM teachers were able to explore downloading TI-Nspire documents and manipulating geometric figures. The geometry module's tasks served as an activity to expose PSSM teachers to the TI-Nspire CX CAS technology.

The mathematics teacher educators plan to continue the integration of technology as a component of the PSSM teachers' methods courses. The mathematics teacher educators wish to continue researching the benefits and challenges of using technology in the mathematics classroom. A proactive approach to working with PSSM teachers will provide opportunities for PSSM teachers to learn how to efficiently and effectively use technology to meet the needs of mathematics' learners.

Mathematics teacher educators must think about how to promote continued advocacy for the advancement in the application and mentorship of technology integration in the mathematics classroom. Based on what the mathematics teacher educators have observed and experienced, the following are critical issues to address.

Mathematics teacher educators should:

1. Reflect on their beliefs, views, and experiences working with technology;
2. Be proactive and intentional in providing their students (PSSM teachers) with opportunities for appropriate use of handheld technologies, such as the TI-Nspire CX CAS and/or others;
3. Consistently discuss the rationales for utilizing the technology;
4. Use the technological tools to enhance PSSM teachers' mathematics knowledge and understanding of concepts and procedures in their teaching

practices and for their future careers.

Cooperating mathematics teachers (clinical practice) should:

1. Have access to the handheld technology to assist their assigned PSSM teachers;
2. Engage in professional development to enhance their knowledge of handheld technology;
3. Be willing to share their experiences and/or allow PSSM teachers to explore with the integration of technology.

Overall, mathematics teacher educators need a system of horizontal expertise across not only content but in the reinforcement of technology use across college and school campuses, which includes the mathematics teacher educators, university supervisors, and the PSSM teachers. Teacher education programs should invest time in incorporating technology integration opportunities that strongly encourage and inspire PSSM teachers to continue to expand their use of new technology in the mathematics classroom.

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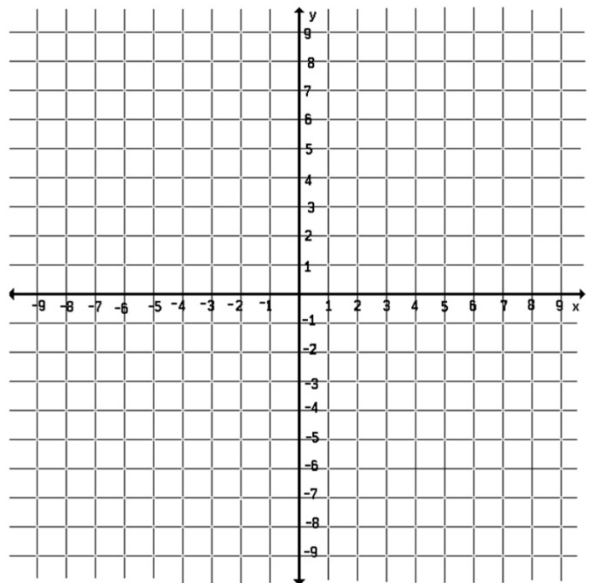
Appendix A

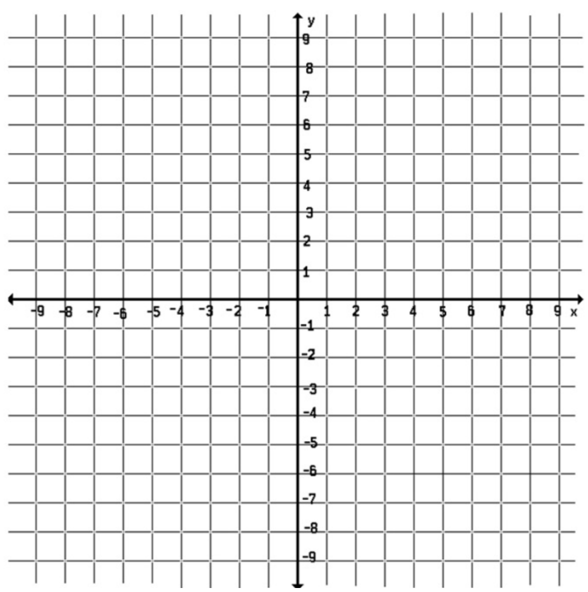
Curriculum Content Pre/Posttest

Please complete the following questions to the best of your ability. Remember to justify your mathematical reasoning process.

1. Prove (or disprove) that the polygon with vertices A(5, 6), B(8, 5), and C(2, -3) is a right triangle.



2. Prove (or disprove) that the quadrilateral with vertices W(2, 1), X(1, 3), Y(-5, 0), and Z(-4, -2) is a rectangle.



Appendix B

Learning Style Inventory

Assessment

What is your learning style? Everyone learns differently. Knowing your individual combination of strengths will help you to study and succeed academically.

To better understand how you prefer to learn and process information, place a check in the appropriate space after each statement below: Often (**O**), Sometimes (**S**), Rarely (**R**).

	O	S	R
1. I can remember best about a subject by listening to a lecture that includes information, explanations and discussion.			
2. I prefer to see information written on a chalkboard and supplemented by visual aids and assigned readings.			
3. I like to write things down or to take notes for visual review.			
4. I prefer to use posters, models, or actual practice and other activities in class.			
5. I require explanations of diagrams, graphs, or visual directions.			
6. I enjoy working with my hands or making things.			
7. I am skillful with and enjoy developing and making graphs and charts.			
8. I can tell if sounds match when presented with pairs of sounds.			
9. I can remember best by writing things down several times.			
10. I can easily understand and follow directions on a map.			
11. I do best in academic subjects by listening to lectures and tapes.			
12. I play with coins or keys in my pocket.			
13. I learn to spell better by repeating words out loud than by writing the words on paper.			
14. I can understand a news article better by reading about it in the newspaper than by listening to a report about it on the radio.			
15. I chew gum or snack while studying.			
16. I think the best way to remember something is to picture it in your head.			
17. I learn the spelling of words by "finger spelling" them.			
18. I would rather listen to a good lecture or speech than read about the same material in a textbook.			

19. I am good at working and solving jigsaw puzzles and mazes.			
20. I grip objects in my hands during learning periods.			
21. I prefer listening to the news on the radio rather than reading about it in the newspaper.			
22. I prefer obtaining information about an interesting subject by reading about it.			
23. I feel very comfortable touching others, hugging, handshaking, etc.			
24. I follow oral directions better than written ones.			

Scoring Procedures

Now place the point value for your selections on the line next to the corresponding item below. Add the points in each column to obtain the preference score under each heading.

OFTEN = 5 points SOMETIMES = 3 points RARELY = 1 point

VISUAL		AUDITORY		TACTILE	
NO.	PTS.	NO.	PTS.	NO.	PTS.
2	____	1	____	4	____
3	____	5	____	6	____
7	____	8	____	9	____
10	____	11	____	12	____
14	____	13	____	15	____
16	____	18	____	17	____
19	____	21	____	20	____
22	____	24	____	23	____
Visual Preference		Auditory Preference		Tactile Preference	
=	____	=	____	=	____

If you are primarily a VISUAL learner, by all means be sure that you look at all study materials. Use charts, maps, filmstrips, notes, videos, and flash cards. Practice visualizing or picturing words and concepts in your head. Write out everything for frequent and quick visual review.

If you are primarily an AUDITORY learner, you may wish to use tapes. Tape lectures to help fill in gaps in your notes. But do listen and take notes - and review your notes frequently. Sit in the lecture hall or classroom where you can hear well. After you have read something, summarize it and recite it aloud. Talk to other students about class material.

If you are primarily a TACTILE learner, trace words as you are saying them. Facts that must be learned should be written several times. Keep a supply of scratch paper on hand for this purpose. Taking and keeping lecture notes is very important. Make study sheets. Associate class material with real-world things or occurrences. When appropriate, practice role playing.

Adapted from http://www.reading.ac.uk/ssc/resource-packs/UbosDvd/Module_6/M6_Session_01+02/Learning_Style_Inventory.doc

Appendix C

Geometry Module Task 1: Technology Extension

The Pythagorean Theorem—and More
PythagoreanTheorem.tns

Name ______________
Class ______________

Problem 1 – Investigating side lengths

Use page 1.2 to explore the following questions.

What is the relationship between c^2 and $a^2 + b^2$ when $\triangle ABC$ is a right triangle?

What is the relationship between c^2 and $a^2 + b^2$ when $\triangle ABC$ is an acute triangle?

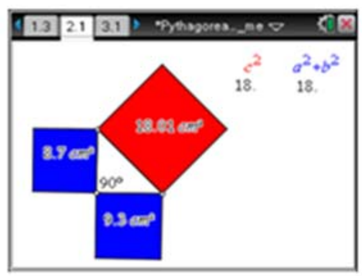
What is the relationship between c^2 and $a^2 + b^2$ when $\triangle ABC$ is an obtuse triangle?

Use page 1.3 to determine whether a triangle with the given side lengths is acute, right, or obtuse.

1. 3 in., 7 in., 8 in. ______________
2. 3 ft, 5 ft, 5 ft ______________
3. 8 cm, 15 cm, 17 cm ______________
4. 7.9 m, 11.5 m, 15.4 m ______________
5. 26.2 in., 36 in., 48.1 in. ______________

Problem 2 – Using squares

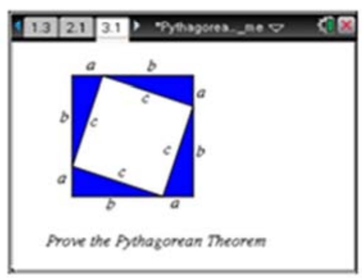
Explain how the diagram on page 2.1 demonstrates the Pythagorean Theorem.



Problem 3 – Extension

Use the diagram on page 3.1 to prove the Pythagorean Theorem by substituting expressions into the following equation. Then simplify each side.

$$A_{outer\ square} = A_{four\ triangles} + A_{center\ square}$$



Adapted from https://education.ti.com/en/us/activity/detail?id=7AB8721F3E294FC68AA002D5291F5421&ref=/en/us/activity/search/advanced

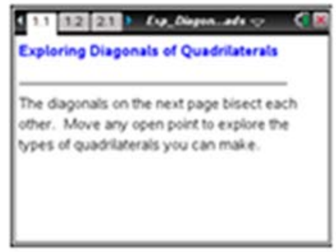
Geometry Module Task 2: Technology Extension

Exploring Diagonals of Quadrilaterals
Student Activity

Name ______________

Class ______________

Open the TI-Nspire document *Exp_Diagonals_of_Quads.tns*.



What type of quadrilateral can you create if you know the diagonals are perpendicular bisectors of each other? What if the diagonals were mutually bisecting? What if they were perpendicular? In this activity, you will investigate these different possibilities to determine the characteristics of diagonals of various quadrilaterals.

Move to page 1.2.

1. The two diagonals on this page are special because they always bisect each other. Drag any open point to make a quadrilateral. To see the quadrilateral, select ▲ on the screen. Drag a point. To see angle measurements or side lengths, select ▲. Then drag a point.

   a. Can you create each of the quadrilaterals in the table below? Record your findings in the table.

	Parallelogram (not rectangle, not rhombus)	Rectangle (not square)	Rhombus (not square)	Kite (not rhombus)	Square	Trapezoid	Quadrilateral with four different side lengths
Yes or No?							
Why or Why not?							

   b. What special quadrilaterals can be formed with bisected diagonals?

Exploring Diagonals of Quadrilaterals
Student Activity

Name ______________
Class ______________

Each of the remaining problems in the file contains two diagonals that have some special property. Move through pages 2.1, 2.2, 3.1, 3.2, 4.1, 4.2, 5.1, and 5.2.

2. What special quadrilaterals can be formed? Record your findings in the table below.

Pg	Diagonal Properties	Parallelogram (not rectangle, not rhombus)	Rectangle (not square)	Rhombus (not square)	Kite (not rhombus)	Square	Trapezoid	Quadrilateral with four different side lengths
1.2	*Diagonals bisect each other*							
2.2	*One diagonal is a perpendicular bisector of the other*							
3.2	*Diagonals bisect vertex angles*							
4.2	*Diagonals are congruent*							
5.2	*Diagonals are perpendicular*							

Return to page 1.2.

3. a. If the diagonals bisect each other, then the quadrilateral *must* be what type of figure?

b. Justify your answer.

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