

6-2009

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Sherry Herron

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Recommended Citation

Hartsell, Taralynn; Herron, Sherry; Fang, Houbin; and Rathod, Avinash (2009) "Effectiveness of Professional Development in Teaching Mathematics and Technology Applications," *Journal of Educational Technology Development and Exchange (JETDE)*: Vol. 2 : Iss. 1 , Article 4.

DOI: 10.18785/jetde.0201.04

Available at: <https://aquila.usm.edu/jetde/vol2/iss1/4>

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Effectiveness of Professional Development in Teaching Mathematics and Technology Applications

Taralynn Hartsell
Sherry Herron
Houbin Fang
Avinash Rathod

The University of Southern Mississippi, USA

Abstract: *This study investigated whether a four-week professional development workshop for math teachers helped improve their ability to integrate technology into instruction and teach math concepts. Instruments for data collection included four different types of surveys that asked questions concerning their technology skills and confidence in teaching various math topics. Results of the study revealed that the professional development workshop did improve their technology skills in using graphing calculators and different software programs, as well as increasing their overall confidence in teaching different math topics such as fractions, percentages, real numbers, etc.*

Keywords: professional development, math education, technology integration

1. Introduction

Effectiveness of classroom instruction originates from the teacher. If the teacher is well-prepared, well-versed, and thoroughly supported, then changes in the curriculum and instructional strategies can occur. Confidence is a source for teachers to accept and test different instructional strategies. In math education, using various strategies to motivate students to learn math concepts is important. Nonetheless, many math teachers are not proficient or confident enough when teaching certain math principles, let alone applying technology tools into math lessons (MT21, 2007). In a recent report from the Massachusetts's Department of Elementary and Secondary Education (2009), members of the state board believe that teacher quality is a key determinant of student achievement and having a strong content knowledge is crucial to effective teaching. In order to reach the state's high

standards of mathematics and science learning, the members say that this "requires a depth of content knowledge, conceptual understanding, and facility with core skills that exceeds the level of many current elementary and middle school teachers" (p. 2). In addition, they realize that professional development is important for upgrading the skills of the existing faculty, particularly for teachers who are not highly qualified. Hence, professional development is required in order for instructional effectiveness to occur within the mathematics curriculum. This study investigates whether a four-week summer math workshop targeted for K-12 teachers can help strengthen the participants' knowledge, skills, and instructional applications of technology into math education. Findings reveal that progress has been made through the course of study and a heightened confidence in the participants' ability to transfer what has been learned into the classroom environment is evident. Thus, professional development is the

key for initiating and securing change in math instruction.

2. Literature Review

The use of technology in K-12 education has grown steadily since the inception of classroom computers in the 1970s (Puma, Chaplin, & Pape, 2000). Nowadays, we see many exciting technologies available for classrooms, some of which could dramatically improve educational outcomes (Dede, 1998). However, even with the abundance of technologies available at schools, many teachers do not have the knowledge necessary to effectively integrate these technologies into their lessons (Davis, 2002). Additionally, the U.S. Department of Education found that the manner in which teachers teach has not changed dramatically, despite the dramatic increase in available educational technology (Smerdon et al., 2000). Furthermore, only 50% of public school teachers with computers and/or Internet access available in their schools have made use of these technologies during classroom instruction (National Center for Education Statistics, 2000). Schools have clearly spent money to purchase new technologies, but teachers are clearly not making full use of their technological options, particularly math teachers. According to Powers and Blubaugh (2005), the “future mathematics teachers need to be well versed in the issues and applications of technology” (p. 254). If not, then the way mathematics has been traditionally taught will not meet the current needs and demands of students today.

Becoming a math teacher is not that problematic, but teaching math well is a complex endeavor (National Council of Teachers of Mathematics, 2000). Mathematics education research has already shown us that too few students have adequate math comprehension or problem-solving skills (National Research Council, 2001). To make

up for this lapse in student outcomes, math teachers should be among the most enthusiastic in seeking to maximize technologies’ potential to develop student understanding, stimulate student interest, and increase student mathematic proficiency (National Center for Education Statistics, 2000). Ultimately, the responsibility is left to the math teachers to integrate technology into classrooms; the tool simply being present in the classroom is not enough (National Council of Teachers of Mathematics, 2000). This is a very complex and difficult task for math teachers to learn to use new technologies appropriately, especially without support. But, the knowledge and skill of integrating technology into math lessons is vital (Mergendoller, 1994).

In regards to stages of technology adoption, teachers begin at the entry or knowledge level as they seek information concerning the technology innovation because of general interest, and eventually move toward full adoption and implementation. With increased contact to the technology innovation along with collaboration of other teachers, teachers move up toward the path to becoming innovators themselves as they redefine classroom environments to create innovative learning experiences that truly engage the power of technology to involve students in higher-order thinking tasks. In a sense, teachers at the innovator level are willing to take risks and try different instructional approaches to achieve desired learning outcomes (Christensen & Knezek, 2002; Rogers, 1995). Several studies that investigated how professional development has improved teachers’ attitudes toward using graphing calculators in the math classroom revealed such transitional stage from beginner to adaptation and implementation. In a study on the usage of graphing calculators in mathematics classrooms, researchers found that a shift of mathematical focus to a broader perspective of the implications of the

technology for the learning of mathematics occurred among the teacher participants during the workshop (Thomas & Hong, 2005). Hence, their original focus on the calculator's technical aspects moved toward a more general focus on the application of the calculators to teach math concepts. In a secondary math education program, similar effects also occurred as the pre-service teachers changed their philosophies and attitudes toward the use of calculators in pedagogy toward the positive (Kastberg & Leatham, 2005). Furthermore, pre-service teachers experienced a transformation from frustration over the introduction of calculators in a middle-school teacher education program toward acceptance and excitement once they observed its use in a regular classroom setting (Walmsley, 2003). Hence, training to become comfortable and familiar with any single new technology can help improve math teachers' confidence level towards using that technology in their classroom. According to Kiraz and Ozdemir (2006), technology acceptance is related to four main factors: (1) the perceived ease of use of technology, (2) the perceived usefulness of technology, (3) the attitudes toward the use of technology, and (4) the frequency of use of technology. If teachers perceive that the technology is easy to use and effective in teaching math concepts, this perception can lead toward positive attitudes toward the use of that technology. With the development of these positive attitudes toward the use of technology, behavioral intentions to use the technology will transpire. Thus, constructive attitude and perception, along with self-confidence, will lead teachers to apply technology in the math classroom.

3. Problem Overview

Teachers are key agents toward initiating changes in education. They are the individuals who teach, mentor, and support learning in the classroom. An effective teacher can motivate, stimulate, and help students acquire

academic and professional skills to become successful. But, if the teacher does not have the background knowledge, proper skill sets, and professional support, then instructional change cannot occur. Thus, professional development is critical toward helping these key agents become successful in instruction, particularly in math education.

This study tried to assess whether teachers who participated in an intensive, four-week in-service training workshop concerning skills development to teach mathematics using technology as instructional tools enhanced their knowledge and ability to apply what was learned into instruction. To examine this research problem, four research questions were developed:

1. Does participating in an in-service training session develop skills acquisition in using software programs, scientific calculators, and solving mathematical problems?
2. Does participating in an in-service training session assist teachers to apply their knowledge and skills in teaching math and technology concepts?
3. Do teachers who complete an in-service training session have a better ability to apply what they have learned into the math curriculum?

4. Methodology

4.1. Participants

The goals of the Summer Mathematics Institute (SMI) were to improve the mathematics knowledge and instructional technology skills of mathematics teachers and the achievement of students in mathematics in grades six through eight by enabling participating teachers to: (a) understand the mathematics concepts presented, (b) integrate mathematics topics directly related

to content standards into classroom instruction, (c) utilize technologies such as graphing calculators, computer applications, Web-based resources, and interactive white boards in classroom instruction to foster the learning of mathematical concepts, (d) compile, interpret, and utilize real world data using relevant technology and software, (e) locate, analyze, understand, and interpret appropriate student test data, (f) use data to build spreadsheets, bar graphs, and pie charts that demonstrate trends and mathematics concepts, (g) develop and use lessons plans, class objectives, and activities that will foster student mastery of concepts within the content standards, and (h) understand action planning and its connection to mathematics content standards and student achievement.

These main goals were addressed through a comprehensive, twenty-day summer mathematics institute with two follow-up days during the subsequent fall. Instruction was provided by a mathematics professor and a practicing middle school master teacher with support from a graduate student. Daily instruction occurred at a school district computer laboratory with each teacher working at a desk-top computer and the primary instructor working from with an interactive white board positioned in front of the room.

Middle school mathematics teachers from surrounding public school districts were invited to apply. Priority was given to teachers from high-needs school districts and those who had their principal's endorsement. The number of teacher participants for the SMI over the four year span included: 24 teachers (2005), 24 teachers (2006), 26 teachers (2007), and 27 teachers (2008). Teacher participants had to submit an application packet to the SMI coordinators to be selected for participation in the professional development workshop.

Typically, each day focused on learning the basics of and working mathematics problems

using the TI 84 graphing calculator, Microsoft Excel, Microsoft PowerPoint, or combination of both. Using the calculator, teachers learned to input and graph data, how to use function tables, and generate random number. Excel topics included building a grade book spreadsheet emphasizing weighted average, median, and mode, to using Excel to create visual comparisons between various charts as a way to analyze data and teach proportions and percentages. Teachers also learned how to produce tessalations with the software program Paint. Finally, they learned how to build mathematics lessons with PowerPoint and create math problems using Equation Editor in Word. Teachers were eager to share their experiences and help each other as they tried to incorporate technology into their teaching.

4. 2. Procedures and Instruments

The Technology Assessment Test (TAT) and Final Composite Evaluation Survey (FCES) have both been used to assess the effectiveness of this four-week workshop for all the past four years of 2005, 2006, 2007 and 2008. Researchers especially used the Frequency of Use of Technology in Solving Mathematical Problem Survey (FTMS) and Confidence in Use of Technology in Solving Mathematical Problem Survey (CTMS) in 2008 to determine whether the participants used technology more frequently and confidently than before they attended the training sessions.

Both survey questionnaires were based on 4 point Likert scale with 1 scored as strongly disagree to 4 scored as strongly agree. In addition, the TAT consisted of 25 items concerning Excel spreadsheets, PowerPoint, the T1-T4 calculator, and mathematical concepts. The FCES consisted of 16 items regarding the evaluation of effectiveness of in-service training workshop by participants. Both of the FTMS and CTMS included 14 items regarding how frequently participants

used the technology in solving mathematical problems and how confident they were while using the technology. The TAT, FTMS, and CTMS surveys were distributed to participants at the beginning of the four-week workshop and also at the end of the training session to assess their current knowledge regarding the use of technology in solving mathematical problems and the effectiveness of the training sessions. The FCES was only used at the end of the training workshop to allow participants to assess the effectiveness of the training session.

The software program SPSS was used to analyze the data collected from the four kinds of questionnaires of TAT, FCES, FTMS, and CTMS. The TAT, FTMS and CTMS surveys were analyzed by using two-tailed paired t-test with an α set at .05. Descriptive statistics were used for analyzing the FCES survey questionnaire.

5. Findings

Findings analyzed from the various surveys used in the study revealed some interesting insights into the effectiveness of professional development upon promoting teachers' confidence, attitudes, and skills in using technology to teach mathematical concepts. The findings are presented based upon the different surveys used (TAT, FTMS, CTMS, and FCES). Each is accompanied with a narrative of the data analysis and information learned.

5.1. Technology Assessment Test Results

To answer the research question, Does participating in an in-service training session develop skills acquisition in using software programs, scientific calculators, and solving mathematical problems?, the *Technology Assessment Test* was used to document changes in knowledge acquisition. The TAT included 25 questions concerning the four areas (Excel, PowerPoint, T1-T4 calculator, and mathematical concepts) covered in each training session across the four years from 2005 to 2008 of the Summer Mathematics Institute. The participants were asked rate their knowledge in all four areas listed above at both the beginning and end of the training session. The researchers wanted to determine the effectiveness of the Summer Mathematics Institute through comparing the scores of the pre- and post-tests. Paired t-test was used to analyze all the data and the results were revealed in Table 1. Significant differences ($p=.000$) were found in all four areas of Excel, PowerPoint, T1-T4 calculator, and mathematical concepts meaning that participants increased their knowledge in these areas. Teachers not only knew more about how to use those technologies, but also gained more knowledge in math concepts upon completing the Summer Mathematics Institute. The same results are displayed in Figure 1 in graphical form.

Table 1. Test Scores of Participants (TAT, 2005-08)

Variables	Pre-test $M \pm SD$ %	Post-test $M \pm SD$ %	df	t	p^1
Excel Sheet (11)	0.43±0.21	0.83±0.13	91	-16.350	.000
Power Point (2)	0.23±0.32	0.62±0.33	91	-8.838	.000
T1-84 Calculator (3)	0.12±0.25	0.88±0.22	91	-23.166	.000
Mathematics (9)	0.52±0.29	0.71±0.25	91	-6.174	.000
Total (25)	0.40±0.16	0.79±0.14	95	-20.145	.000

Note: ¹ by paired t test; All mean scores are proportions

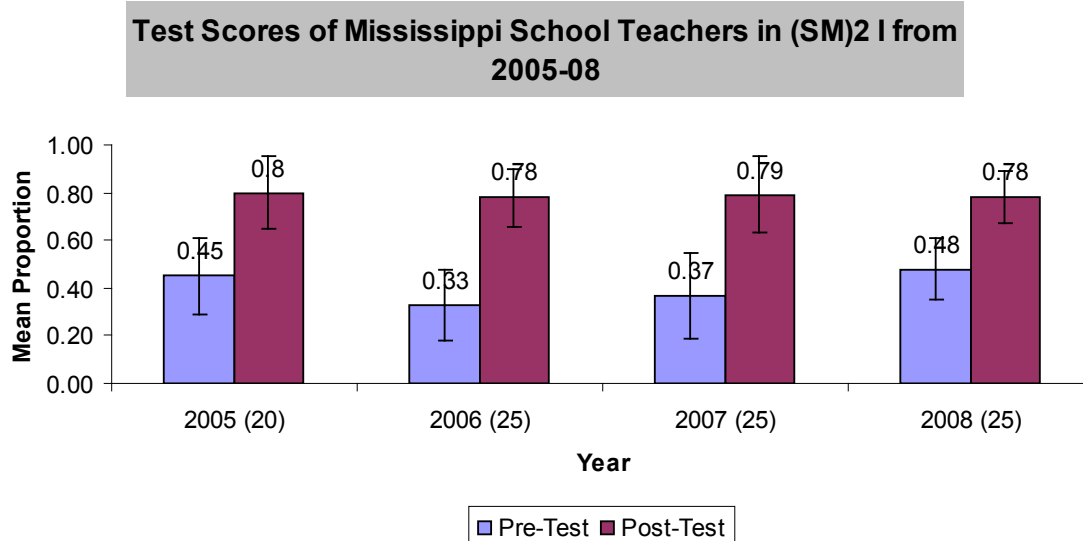


Figure 1. Math Test Scores of Mississippi School Teachers from (SM²)I 2005-2008

5.2. Frequency of Use of Technology Results

To answer the research question, Does participating in an in-service training session assist teachers to apply their knowledge and skills in teaching math and technology concepts?, the researchers used the *Frequency of Use of Technology in Solving Mathematical Problem Survey (FTMS)* in 2008. This instrument was

used to obtain more information about the participants’ professional development and the usage of technology in solving mathematical problems. The participants were asked to rate how frequently they used technology to solve mathematical problems in 14 subdivisions in math (see Table 2). A paired t-test was used to analyze all the data in both pre- and post-tests.

Table 2. Frequency of Use of Technology in Solving Mathematical Problems Survey Results (2008)

Variables	Pre-test <i>M</i> ± <i>SD</i>	Post-test <i>M</i> ± <i>SD</i>	<i>df</i>	<i>t</i>	<i>p</i> ¹
Number Patterns	1.43±0.84	2.57±1.12	22	-4.754	.000
Operations with Decimals	1.92±1.04	2.96±1.02	24	-4.437	.000
Percent	1.76±1.05	3.08±0.95	24	-5.959	.000
Interest, Discount and TASx	1.84±1.07	2.76±1.13	24	-3.130	.005
Mean, Median and Mode	2.13±1.08	3.17±1.01	23	-4.139	.000
Operations with Integers	2.04±1.11	2.96±0.93	22	-3.339	.003
Area, Perimeter and Circumference	2.25±1.15	3.04±1.04	23	-2.580	.017
Ratios, Rates and Proportions	1.83±1.03	3.04±1.07	22	-4.230	.000
Model DaTAS Using Charts and Graphs	1.88±1.01	3.08±1.15	24	-3.795	.001
Solve 1- and 2-Step Equations	1.79±1.06	2.63±1.10	23	-2.733	.012
Functions	1.68±1.04	2.91±0.97	21	-4.077	.001
Tessellations	1.45±0.76	2.75±1.21	19	-4.333	.000
Probability	1.79±1.02	2.75±1.11	23	-3.922	.001
Linear Relationships	1.83±1.19	2.83±0.94	22	-4.251	.000

Note: ¹ by paired *t* test; Likert scale 1 to 4 with 4 as high

Researchers found a significant improvement between the pre-test to the post-test regarding the frequency of use of technology in all fourteen subdivisions of high math. These results meant that the participants would use technology significantly more often in solving math problems than before attending the Summer Mathematics Institute. From the results, researchers also determined that more the participants learned about the various forms of technology, the more inclined they would be to use them in their classrooms.

5.3. Confidence in Use of Technology Results

To answer the research question, Does participating in an in-service training session assist teachers to apply their knowledge and skills in teaching math and technology concepts?, the researchers conducted the *Confidence in Use of Technology in Solving Mathematical*

Problem Survey (CTMS) to determine if there was an improvement of confidence regarding the usage of technology in teaching math in 2008. Participants were asked to rate their confidence when using technologies in solving mathematical problems before and after attending the Summer Mathematics Institute. The CTMS contained 14 questions which were the same as the FTMS questionnaire concerning main subdivisions of mathematics in high school. From the results described in Table 3, researchers found that all the mean scores of the 14 questions improved when comparing the scores from the pre- and post-tests, and 10 of the 14 improvements were significant. The four non-significant improvements were those involving Number Patterns, Operations with Integers, Ratios, Rates and Proportions, and Solving 1- and 2-Step Equations (*p* values were in bolded in Table 3).

Table 3. Confidence in Use of Technology in Solving Mathematical Problems (CTMS, 2008)

Variables	Pre-test <i>M±SD</i>	Post-test <i>M±SD</i>	<i>df</i>	<i>t</i>	<i>p</i> ¹
Number Patterns	3.42±0.78	3.71±0.55	23	-1.772	.090
Operations with Decimals	3.54±0.72	3.88±0.34	23	-2.892	.008
Percent	3.50±0.78	3.83±0.38	23	-2.892	.008
Interest, Discount and TASx	3.29±0.81	3.67±0.48	23	-2.229	.036
Mean, Median and Mode	3.54±0.78	3.88±0.34	23	-2.145	.043
Operations with Integers	3.50±0.78	3.75±0.44	23	-1.661	.110
Area, Perimeter and Circumference	3.50±0.78	3.88±0.34	23	-2.584	.017
Ratios, Rates and Proportions	3.33±0.76	3.63±0.65	23	-1.904	.070
Model DaTAS Using Charts and Graphs	3.50±0.66	3.83±0.48	23	-2.326	.029
Solve 1- and 2-Step Equations	3.54±0.78	3.67±0.70	23	-0.681	.503
Functions	2.82±0.91	3.50±0.60	21	-4.948	.000
Tessellations	2.90±0.85	3.65±0.49	19	-4.265	.000
Probability	3.04±0.71	3.57±0.51	22	-2.787	.011
Linear Relationships	2.59±1.14	3.32±0.78	21	-3.167	.005

Note: ¹ by paired *t* test; Likert scale 1 to 4 with 4 as high

5.4. Final Composite Evaluation Survey Results

To answer the research question, Do teachers who complete an in-service training

session have a better ability to apply what they have learned into the math curriculum?, the *Final Composite Evaluation Survey (FCES)* was used. This instrument was designed to

assess the effectiveness of training from the participants' viewpoint and to help the workshop instructors improve teaching efficiency. The FCES have been used for four years since 2005 and contains 16 questions, 6 of which concern the knowledge that participants gained from each Summer Mathematics Institute (see Table 4). The participants were asked to rate their views toward the learning effectiveness from the Summer Mathematics Institute from 1 (Strongly Disagree) to 4 (Strongly Agree). All the results for the four years were shown in Table 4. From these results, researchers

found that 100% of the participants in all four years agreed or strongly agreed that they gained knowledge from the four week training session. No one selected strongly disagreed or disagreed in this questionnaire, signifying that all participants gained knowledge upon completing the Summer Mathematics Institute across the past 4 years. In addition, among all the results, the strongly agreement for each question across all four years were around 80%, which indicated that the math teachers have had a very successful experience from the Summer Mathematics Institute.

Table 4. Final Composite Evaluation Survey (FCES 2005-2008)

Variables	Strongly Disagree	Disagree	Agree	Strongly Agree
	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)
I gained additional understanding of mathematics content	0	0	15 (16.0)	79 (84.0)
Mathematics content was associated with the Mississippi mathematics Framework for grades 5-8	0	0	10 (10.6)	84 (89.4)
My skills to use technology to aid in teaching mathematics content have improved considerably as a result of the institute	0	0	9 (9.6)	85 (90.4)
The institute has increased my ability to interpret data	0	0	15 (16.0)	78 (83.0)
Expertise gained as a result of the institute will help improve student achievement	0	0	9 (9.6)	85 (90.4)
The institute will help me formulate strategies to help students improve their score on the Mississippi Mathematics Curriculum Test	0	0	11 (11.7)	82 (87.2)

Note: Likert scale 1 to 4

6. Conclusion and Discussion

This study did answer the original research questions. First, a four-week intensive in-service training session can help teachers

develop the necessary skills to teach math in the classroom. By learning various software programs, calculator functions, and tools that may be available in the classroom, the teacher participants increased their skills

toward effective integration. In addition, because the samples used in the workshop to demonstrate the functions of various software programs (e.g., using spreadsheets to solve discount problems, and monthly income and expense accounts) and calculator applications (e.g., input and graph data, how to use function tables, and how to generate random numbers) were relevant to math concepts that would be taught in the actual classroom, this demonstration helped increase the teachers' knowledge of solving mathematical equations. Second, by participating in the in-service training session, teachers were able to apply their knowledge and skills to teach math and technology concepts. For instance, participants' knowledge concerning different math topics (e.g., number patterns, functions, percents, and probability) increased, especially when related to technology use. Finally, participants from the workshop did improve their confidence and ability to apply what they learned into the math curriculum. The workshop provided participants with a better understanding of how math can be taught in different ways. In a sense, the SMI workshop provided participants with different instructional strategies that they would have considered using before.

There were some inconsistencies in the research findings that lead to further discussion. Researchers found that confidence levels of using technology to teach number patterns, ratios, rates and proportions, and to solve 1- and 2- step equations were not significant. However, the frequencies of using technology to teach these content areas were significant (see Table 2 and Table 3). One of the reasons attributed to this inconsistency could be that the participants could see possible uses of technology when teaching math content, but that actual classroom experiences may discourage them from using technology. Teachers may have limited accessibility to technology or technical support may not exist

at the school. Another possibility could be that teachers may question their own abilities to teach this concept, or traditional paper-pencil methods could be used just as effectively. Yet another possibility could be that participants knew how to use available technologies, but had a difficult time incorporating their use in teaching certain concepts. In other words, there is a difference between possessing technology skills and knowing technology application. This brings forward the issue that it is not enough for teachers to learn the technology skills, but they have to know how to integrate technologies into math instruction.

Actually, technologies do not have to be used to teach all math concepts. According to the National Council of Teacher of Mathematics' Standard 2 (1998), mathematics instructional programs should include attention to number patterns at all levels. Students are supposed to (a) understand various types of patterns and functional relationships, (b) use symbolic forms to represent and analyze mathematical situations and structures, and (c) use mathematical models and analyze change in both real and abstract contexts. Because the paper-and-pencil method is just as useful to teach such concepts, advanced technologies are not always needed, especially when teaching lower grade students. This may explain why the participants still did not feel as confident in teaching number patterns after completing the workshop. For the same reason, researchers also attribute the same conditions for solving step 1- and 2- equations in algebra.

Comparing Table 3 and Table 4, researchers found that the more technology skills the participants learned, the more likely they were to use the technology in their classrooms. For example, in Table 3, all of the results were significant which meant that participants would use technology frequently in their classrooms. In Table 4 on the other hand, three of the results were not significant. This meant that

participants had tried to use technology in their classrooms, even though they may not have had the confidence or ability to do so. Thus, teachers needed to be taught not only technology skills, but also how to incorporate technology into math instruction. Of course, one workshop cannot solve all the problems relating to the integration of technology into math instruction. However, future workshops should pay more attention toward the incorporation of technology into the math curriculum.

This research study had limitations. First, the sample population was not representative of all teachers in South Mississippi. They were selectively chosen by the researchers to participate in the Institute through an application process. Second, the instruments of data collection were not always administered consistently. The CTMS was only used in 2008 which could affect the results. Nonetheless, the findings from this study did address the effectiveness of conducting an intensive, four-week professional development workshop and how this could enhance teachers' confidence, knowledge, and ability to integrate technology into the math curriculum.

Future studies need to be performed in order to examine the effectiveness of professional development in improving teachers' ability to teach math concepts and technology skills in the classroom. To support quantitative findings, a more qualitative approach should be considered to document changes among participants across a longer period of time. This type of examination would offer an in-depth perspective of how professional development could affect the environmental culture and perspectives of classroom teachers. As key agents for change within the classroom culture, providing teachers with professional development opportunities across a longer period of time is necessary. Teachers do learn from one another, and allowing teachers to interact within a professional setting that

permits them to observe, communicate, and share ideas and concerns are important for change to occur.

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Acknowledgements

Special acknowledgments are given to the staff members behind the delivery of the Summer Math Institute. For without their efforts, data collection would not have occurred. These individuals are Ms. Michelle Green, Mr. Tom Richards, Dr. Myron Henry, and Dr. Haiyan Tian.

Contact the Authors

Taralynn Hartsell, Ph.D.

The University of Southern Mississippi, USA
E-mail: Taralynn.Hartsell@usm.edu

Sherry Herron, Ph.D.

The University of Southern Mississippi, USA
E-mail: Sherry.Herron@usm.edu

Houbin Fang

The University of Southern Mississippi, USA
E-mail: houbinfang@yahoo.com

Avinash Rathod

The University of Southern Mississippi, USA
E-mail: avinash.rathod10@yahoo.com