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Going Against the Grain: Should Differentiated Instruction be a Normal Component of Professional Development

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This study investigated whether a four-week intensive professional development workshop for math teachers was effective in improving their knowledge and skills of mathematics concepts and technology, as well as improving their attitudes toward integrating technology into teaching math. Instruments for data collection included a pre- and post- test for math concepts and technology and four different surveys: concerns, proficiency, frequency of use of use, and confidence. Data also included participants' background information and their weekly reflections. The results revealed that this workshop was effective overall, but not for all teachers. We conclude that the trainer should implement differentiated instruction in order to maximize the learning experience for all teachers.

Keywords: educational technology, professional development, differentiated instruction, math education, technology integration

INTRODUCTION

The effectiveness of teaching and learning activities in the classroom requires teachers to equip solid subject content knowledge, rich pedagogical knowledge, and modern technology integration abilities. The changes and technological developments in the world require teachers to update their knowledge and skills in order to meet students' needs in the changing environment. This means that high quality education needs high quality teachers. How do we produce high quality teachers? "Expanding effective support to teachers and principals and reforming and improving teacher preparation" is an important way to accomplish this (Fact Sheet, 2011. p.2). Thus, teachers' professional development has become an important way to enhance the quality of teachers. However, not all professional development programs are effective; and not all effective professional programs may be effective for every participant (Blocher, Armfield, Sujo-Montes, Tucker, & Willis, 2011; Mason, 2007). What should the educator trainers consider in order to ensure that all participants experience effective training in the defined training domain? To

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achieve this goal, trainers must consider the differences among teacher learners. The argument that individuals do not learn in the same way has been demonstrated by research (Fischer & Rose, 2001; Green, 1999; Mulroy & Eddinger, 2003).

Differentiated instruction is considered an effective teaching component in current K-12 classrooms in order to meet students of diverse abilities, interests and learning profiles (Pearl, 2006). According to Tomlinson (2005), differentiated instruction is a teaching philosophy that is based on the premise that students learn best when their teachers accommodate the differences in their readiness level, interests and learning profile. For in-service teacher learners, the differences among them may be the level of their pre-existing knowledge and skills within the training context and the degree of their confidence and beliefs of using the knowledge and skills in their classroom already present. The differences among them may also be their potential learning interests and motions, learning style, and learning skills. Hartsell, Herron, Fang, and Rathod (2009) demonstrated that a four-week professional development workshop did improve math teachers' technology skills and their overall confidence in integrating technology into classroom and teaching different math topics over a four year span (2005, 2006, 2007, & 2008). The current study investigated whether differentiated instruction should be included as a normal component of professional development in this four-week professional development workshop for in-service math teachers to improve their teaching of math with educational technology tools. In the workshop, the educational technology tools are defined as computer- and calculator-based electronic devices: TI-84 graphing calculator, Microsoft® Excel, Microsoft® PowerPoint, Microsoft® Equation Editor, Geometer's Sketchpad®, and web resources for teaching math.

LITERATURE REVIEW

Contemporary classrooms have gone beyond the image of a teacher, a chalkboard and bored students since the nation's first educational technology plan was initiated. *Getting America's Students Ready for the 21st Century: Meeting the Technology Literacy Challenge* was released by the U.S. Secretary of Education, Richard Riley in 1996 (U.S. Department of Education [USDOE], 1996). "All teachers in the nation will have the training and support they need to help students learn using computers and the information superhighway" was one of the technology goals established in this plan. Four years later, a new set of goals was identified by USDOE (2000) included the following: "all teachers will use technology effectively to help students achieve high academic standards." Has this goal been achieved? Many researchers and educators had high expectations for technology integration into secondary mathematics classroom, but in fact, things do not always progress according to our wishes. Technology integration lags behind the high expectations that were set (Lagrange, Artigue, Laborde, & Trouche, 2003). Harris (2008) provided the results of a national survey of U.S. K-12 teachers:

- More than half of the teachers surveyed reported that using digital technologies has strongly influenced the ways they teach.
- Approximately 80% see computer use as very or somewhat important to the success of their professional work-for administration, communication, planning, and instruction.
- Yet only 37% of the same sample reported using computers with their students daily. (p. 18).

Regardless of the effective use of educational technology in the classroom, the reported results indicate that although many teachers have acknowledged the importance and usefulness of educational technology, many of the respondents used it infrequently in their teaching. One of the reasons for infrequent use is the lack of professional development

in educational technology for the teachers (Harries, 2008). To achieve the goals set by U.S. Department of Education in 1996 and again in 2000, the teachers must have access to, know how to, and would be willing to use technology. It is no more a big issue for teachers and students to access technology in schools. The high need for teachers developing the knowledge and skills for technology use still calls for educational technology professional development, which has played, is playing, and will play a significant role in the past, current, and future time.

Research has demonstrated that the effective use of technology in the classroom can change students' thinking ways and learning behaviors. Roschelle, Pea, Hoadley, Gordin, and Means (2000) provided examples of how technology use benefits students' four fundamental characteristics of learning: active engagement, participation in groups, frequent interaction and feedback, and connections to real-world contexts. Pinkham (1996) also illustrated that modern technology helps students address questions and answers fruitfully. In mathematics classroom, the appropriate use of technology benefits students' conceptual and procedural understanding of mathematics content, and it influences the ways of thinking about and identifying with the subject (Hodges & Conner, 2011). However, the availability of technology (advanced calculators and computer software) challenges math teachers thinking about technology integration in the classroom. Although technology use for drill and practice is very common in math classroom, more sound technology integration should promote students' mathematical thinking and conceptual understanding.

Sometimes, it is not easy for teachers to make decisions about what type of technology can be appropriately used for a specific mathematics topic (Hodges & Conner, 2011). Teachers struggle to conduct effective technology integration that positively influences student learning (Lawless & Pellegrino, 2007). This requires increased opportunities for teachers to learn how to use the technology (Roschelle, et al. 2000). However, providing technology knowledge and skill instruction for teachers does not assure that it will necessarily increase their understanding of how to integrate technology into their teaching practice and does not necessarily change teachers' attitude and beliefs on technology use (Blocher, Armfield, Sujo-Montes, Tucker, & Willis, 2011). Mason (2007) claimed that technology professional development, attitude toward technology, and computer experience are significantly related to the secondary school teacher's ability to use technology. Moreover, the complexity of teachers' technology integration relates to three types of knowledge: technology knowledge, pedagogical knowledge, and content knowledge referred to as TPACK and the understanding of the intersection of these categories (Koehler & Mishra, 2009). In other words, educational technology professional development should focus on enhancing the understanding of TPACK that will support their success of technology integration and the recognition of the value of technology integration in the classroom. Research provides evidence that effective technology professional development improves teachers' attitudes toward using graphing calculators and computer software in math classroom (Hartsell, et al., 2009; Kastberg & Leatham, 2005; Walmsley, 2003). Once math teachers have positive attitudes toward the use of technology and the confidence in integrating technology for teaching math concepts, they must be willing to apply technology in the classroom.

However, little research has reported how technology professional development helps each participant successfully build confidence in technology integration rather than overall effectiveness of the training. An effective teacher-training program may not be effective for each individual because teachers' TPACK backgrounds and needs, interests, and motivations were not considered and addressed. According to Darling-Hammond and Snyder (2000), a seminal challenge for teachers, and thus, teacher educators, is that their teaching needs to meet human diversity. To be a learner-centered learning environment,

differentiated instruction should be applied (Tomlinson, 2005). Tomlinson's (2005) comprehensive model suggests that teachers' knowledge of students' readiness, interests, and learning profile characteristics should be used to appropriately differentiate content, process, product, and learning environment.

Many teacher educators advocate their teacher learners to use progressive and responsive instructional practices (such as differentiation) in K-12 classrooms, but they do not make congruence in their own teaching (Santangelo & Tomlinson, 2012). The majority of teacher educators who were surveyed reported that they never used various strategies to support differentiation in professional training (Santangelo & Tomlinson, 2012). Indeed, Grierson (2011) illustrated how differentiated professional learning in content, process, and expected outcomes supported teachers' diverse needs and interest in a particular initiative. Differentiated instruction can help teachers respond to the needs of different learners, engage learners, and cater to learners' interest, learning profile, readiness (Pearl, 2006). Thus, the idea that 'one size does not fit all' should also be applied to teacher education so that every participant receives maximum effectiveness from the training program.

RESEARCH QUESTIONS

An effective classroom never occurs without an effective teacher (National Council for Accreditation of Teacher Education [NCATE], n.d.). An effective teacher needs to be fully equipped and work continuously to improve professional skills. Becoming an effective teacher is a learning process that goes beyond teachers' certification. Professional development plays a crucial role in supporting teachers' professional growth. However, ineffective professional development costs teachers' time end energy, and may have negative impacts in their own classrooms. Providing effective professional training is critical to pass on positive energy to teacher learners.

This study follows up on the study of Hartsell, Herron, Fang, & Rathod (2009 which showed an overall increase math and technology content knowledge, proficiency, frequency of use, and confidence in technology integration after participating in a four-week institute. In the current study, we tried to assess whether a recent institute based on the similar content and technologies would have positive influence on each individual as well as an overall increase. To examine the research problems, the following questions were formed.

1. Is the four-week professional development workshop effective overall in reducing teachers' concerns of integrating mathematics and technology?
2. Is the four-week professional development workshop effective overall in improving teachers' math and technology content knowledge, the proficiency, frequency of use, and confidence in technology integration in their classroom?
3. Is the four-week professional development workshop effective for each teacher in reducing teachers' concerns of integrating mathematics and technology?
4. Is the four-week professional development workshop effective for each teacher in improving his or her math and technology content knowledge, the proficiency, frequency of use, and confidence in technology integration in the classroom?
5. How can the four-week professional development workshop be effective for each teacher?

METHOD

The Summer Math Institute (SMI) aimed at improving participating teachers' content knowledge in mathematics and their technology proficiency and students' achievements in grades five through ten in the area of mathematics by accomplishing the following goals:

(a) to integrate mathematics topics directly related to content standards into daily instruction, (b) to integrate and utilize technology into daily instruction (e.g. graphing calculators, computer applications, web-based resources, and visual technology) to foster the learning concepts of mathematics, (c) to be able to compile, interpret, and utilize real world data using appropriate technology and software, (d) to be able to use data to build spreadsheets, bar graphs, and pie charts that demonstrate trends and mathematics concepts, (e) to be able to develop and implement lesson plans featuring mathematics content areas, and (f) understand action planning and its connection to mathematics content standards and student achievement. The above goals were addressed through a twenty-day summer session and two follow-up sessions during the subsequent fall and spring semesters. Approval for the study was sought and obtained from the university's Human Subjects Review Board.

THE CONTENT DOMAIN

The selection of the SMI topics was based on the Common Core State Standards for Mathematics and the professional needs of participants. The SMI featured entertaining and challenging activities that would motivate teachers to design their own creative lessons that aimed for high achievements. Typically, daily instruction focused on strengthening the understanding of math concepts and working mathematics problems using TI-84 graphing calculator, Microsoft® Excel, Microsoft® PowerPoint, Microsoft® Equation Editor, Geometer's Sketchpad®, or combination of the above. Teachers learned how to use Excel for building a grade system, presenting data, analyzing data, graphing data, and teaching math concepts such as proportions and percentages. The basic use of calculators focused on how to input and graph data, how to make a function table, and how to generate a random number. The learning of Geometer's Sketchpad focused on how to construct dynamic geometric graphs and how to use them to address geometry concepts. Participating teachers also learned how to use PowerPoint to build mathematics lessons and use Equation Editor to create math problem.

PARTICIPANTS

Instruction of the topics was provided by a mathematics professor and a National Board Certified practicing middle school master teacher with a support from two graduate students. A school district computer laboratory equipped with 27 computers and an interactive white board was reserved for daily instruction. Each participant work at a desktop computer and the primary instructor worked in front of the room with a computer and the interactive board. Three round tables were centered in the middle of the room for group activities.

Participants were classroom teachers of mathematics, grades 5-10, from surrounding public school districts. The participants had to submit an application packet to the director of the SMI in order to be selected for participation in the professional development workshop. The 22 selected participants were the mathematics teachers from high-needs school districts and those who had their principle's endorsement. Each participant agreed to participate in the study.

INSTRUMENTS

Multiple dimensions of assessing the effectiveness of this four-week workshop were administered: the Mathematical Content and Technology Assessment Test (MT), the

Surveys of Concerns, Proficiency, Frequency of Use, and Confidence regarding the integration of mathematics and technology. These assessments have been used for 10 years of the project with validity well established and reliability reported at .88 (Hartsell et al, 2009). The MT was used to determine whether the participants improved their knowledge of mathematics and technology before and after the workshop (see Appendix A). The Survey of Concerns and Proficiency was used to determine whether participation of the workshop decreased teachers' concerns of integrating technology into their mathematics teaching and increased their perceived proficiency in using these tools (see Appendix B). The Survey of Frequency of Use and Confidence was used to examine whether the participants would use technology more frequently and with more confidence than before they attended the workshop (see Appendix C).

The MT consisted of 26 items relating to the knowledge of Microsoft Excel and PowerPoint, TI-83 or TI-84 graphing calculator, Geometer's Sketchpad®, and the mathematical concepts. Twenty-five questions are multiple-choice items. One item asks participants to draw a picture to reflect the relationship among various number sets. A perfect score would be 100.

The Survey of Concerns was based on a 4-point Likert scale with 1 representing 'completely disagree' to 4 representing 'completely agree'. With 17 items, a score of 17 would represent no concerns and a score of 68 would represent extreme concerns. The Survey of Proficiency was based on a 4-point Likert scale with 1 representing 'completely disagree' to 4 representing 'completely agree'. With 7 items, a score of 7 would represent no proficiency and 28 would represent complete proficiency.

Both the Survey of Frequency of Use and Survey of Confidence included items associated with 14 math concepts: number patters; operations with decimals; percent; interest, discount, and mathematics; mean, median, and mode; operations with integers; area, perimeter, and circumference; ratios, rates, and proportions; modeling data using charts and graphs; solving one and two-step equations; functions; tessellations; probability; and linear relationships. In the Survey of Frequency of Use, 1 represented 'very rarely' and 4 represented 'frequently'. A score of 14 would represent no intended technology use in teaching any of these topics in the classroom and 56 would represent frequent use of technology in teaching all of these topics. In the Survey of Confidence, 1 represented 'not at all confident' and 4 represented 'completely confident' in teaching these math concepts. A score of 14 would represent no confidence in teaching any of these topics in the classroom and 56 would represent complete confidence in teaching all of these topics.

Data collection also included participants' demographic information and weekly reflections in order to analyze the differences among the participants. The participants' background information (certification, the grade level they taught, and years of teaching math) and weekly reflections were used to discover their different backgrounds, needs, and interests, and how we might need to accommodate our training methods in order to meet their needs. Weekly reflections began with the same five prompts: "I got…; I expected…; a thing of value…; I wish…; next I will or next I need…" (see Appendix D). Demographic information and reflections relevant only to the discussion of differentiated instruction will be presented in the results section.

PROCEDURES

On the first day of the four-week workshop, participants completed the MT, each of the surveys, and provided demographic information. Participants were given as much time as they needed to complete the MT without the use of a calculator. Participants completed all of the MT and surveys and again on the final day of the workshop and without the use of a calculator.

Weekly reflections were completed on the last day of each week. The participants were given about 20 minutes to complete them.

RESULTS

To answer the research questions, results were analyzed from the various data sources: the MT test, four different surveys, teachers' background information, and teachers' weekly reflections. First, the paired-t test of SPSS software was used to investigate whether the four-week in-service teachers' training workshop had an effect on their math and technology knowledge, concerns, proficiency, frequency of use, and confidence in the integration of technology and mathematics teaching. Table 1 displayed the results of the paired-t tests.

Table 1. The paired t-test results (*N*=22)

	Pre		*Post*					
	M	*SD*	*M*	*SD*	*t*	*df*	**p*	***d*
MathTech	48.24	13.68	73.77	8.11	-8.93	21	<0.001	1.903
Concerns	51.82	8.43	44.64	9.39	2.75	21	0.012	0.587
Proficiency	16.36	3.71	23.50	3.02	-7.95	21	<0.001	1.694
Frequency of use	29.77	13.83	39.82	11.43	-2.98	21	0.007	0.636
Confidence	40.73	11.52	49.41	5.56	-3.42	21	0.003	0.728

**p*, the alpha was set as 0.05.
***d*, if $0 < d \leq 0.3$, a small effect size; if $0.3 < d \leq 0.6$, a moderate effect size; if $d > 0.6$, a larger effect size.

OVERALL MT AND SURVEY RESULTS

Did the four-week workshop improve in-service teachers' knowledge of mathematics and technology? Twenty-two participants completed the MT test at the beginning and end of the workshop. The MT test included 26 problems covering five areas (Excel, PowerPoint, Geometers' Sketchpad, TI-83/84 Calculator, and Math Concepts). For each participant, the number of correct answers was totaled and the sum divided by 26. The percent of correct answers was the score. The pretest mean was 48.24 with a standard deviation of 13.67. The posttest mean was 73.77 with a standard deviation of 8.11. Results of the t-test showed that $t(21) = -8.926$, $p < 0.001$. The Cohen's $d = 1.903$ (greater than 0.6, which is a larger effect size). From both the statistics of p value and the effect size d, the differences of the MT tests between pre- and post- tests were statistically significant. The twenty-two teachers knew more knowledge in technology and math concepts upon completing the Summer Math Institute.

The Survey of Concerns was used to investigate whether the four-week workshop helped in-service teachers decrease their concerns in integrating technology in math classroom. With 68 representing extreme concerns and 17 representing none, the pretest mean was 51.82 with a standard deviation of 8.43, and the posttest mean was 44.64 with a standard deviation of 9.39. T-test results follow: $t(21) = 2.754$, $p= 0.012$. The Cohen's $d = 0.587$ (greater than 0.3, but less than 0.6, which is a moderate effect size). The statistics of p value and effect size *d* illustrated that the four-week workshop statistically made a significant difference between the pre- and post- test. These teachers decreased their concerns in math teaching using technology.

The Survey of Proficiency was used to investigate whether teachers increased their perception of proficiency in using various technology tools in math classrooms. With a

score of 28 representing extreme proficiency and 7 representing none, the pretest mean was 16.36 with a standard deviation of 3.71, and the posttest mean was 23.50 with a standard deviation of 3.02. In addition, the statistics results of proficiency, $t(21) = -7.947$, $p < 0.001$, and the Cohen's $d = 1.694$, showed that these teachers made a significant increase in their perception of proficiency.

To determine teachers' intended frequency in the use of technology in teaching the fourteen specific areas of math concepts after attending the workshop, the Survey of Frequency of use was administered. With a score of 56 representing the highest expected use and 14 representing the lowest, the pretest mean was 29.77 with a standard deviation of 13.83, and the posttest mean was 39.82 with a standard deviation of 11.43. The statistical results of frequency of use were $t(21) = -2.981$, p =0.007. The corresponding Cohen's d was 0.636. This workshop did made significant changes in the teachers' intended frequency of use of using technology in math classroom.

Did the workshop help teachers build more confidence in teaching the fourteen specific areas of math concepts with the use of technology With a score of 56 representing the highest level of confidence and 14 representing the lowest, the pretest mean was 40.73 with a standard deviation of 11.52, and the posttest mean was 49.41 with a standard deviation of 5.56. The statistical results were t (21) = -3.415, p = 0.003, and the Cohen's $d = 0.728$. Again, these results showed that the workshop significantly enhanced teachers' level of confidence in teaching selected math concepts using technology.

From all the results of the four different surveys and the MT test, the 2013 workshop produced overall significant effects on in-service math teachers' math and technology knowledge and skills and their attitude toward the integration of technology and math teaching. The above statistical results gave positive answers to the first two questions. These results demonstrated that the Summer Math Institute could help teachers develop necessary skills and equip them with the necessary knowledge to teach math in their classrooms using technology. However, did this program have positive effects on each participant? In order to answer this question, the comparisons of individual scores between pre- and post- tests and surveys were used to find who experienced non-positive effects during the workshop.

INDIVIDUAL MT AND SURVEY RESULTS

Unexpected results in each test and survey are now presented. In the MT test scores, T10's score decreased from pre-test to post-test (61.54 to 57.69). All of the other teachers' MT test scores increased from pre to post. Two teachers' concerns scores increased from pre to post T10's concerns scores increased from 23 to 53; T19's concerns scores increased from 54 to 62. All of the other teachers' concerns scores decreased from pre to post. Nineteen teachers' proficiency scores increased, but the scores of T4, T20, and T8 did not: T4's and T20's scores remained the same, and T8's scores decreased from 23 to 20. The scores of frequency of use showed that T6's score remained the same and five teachers' scores (T4, T5, T8, T12, and T15) decreased from pre- to post- test. Among those teachers whose scores decreased, T4 and T5 had a large decrease: from 42 to 34 and from 28 to 14, respectively. The scores of confidence revealed that two teacher's scores remained the same and two teacher's scores decreased: T5 has decreased from 49 to 42.

We found that five teachers had only one unexpected score, four teachers had two, and one teacher had three. The five teachers with only one were T12, T13, T15, T19, and T20 - in the area of frequency of use, confidence, and frequency of use, concerns, and proficiency, respectively. T5 had two unexpected scores: both frequency of use and confidence decreased from pre to post. T6 had two unexpected scores: frequency of use and confidence remained the same from pre to post; T8 had two unexpected scores:

proficiency and frequency of use decreased from pre to post; T10 also had two: MT test score decreased and concerns increased from pre to post; but T4 had three unexpected scores: proficiency, frequency of use, and confidence. Therefore, not every teacher experienced effective training even if the overall MT and survey results were positive. To understand why these individuals failed to get the expected scores in some aspects, it was important to review their background information and reflections. Next, those who had more than one unexpected score were chosen to be analyzed in order to find out why they did not demonstrate the typical pattern.

REFLECTIONS RESULTS AND RELEVANT BACKGROUND INFORMATION

The reasons that T5, T6, T8, T10, and T4 were atypical emerged from their background information and reflections. These results can be classified into several categories: grade level, years of teaching math, prior knowledge, desire to learn, and speed of learning.

Grade level. We found that four of the five atypical teachers taught 5th and 6th grade math, which is at the lower range of the targeted grade level. T5 and T6 were certified to teach K-6. The majority of the teachers (12 of the 22) were teaching above the 6th grade. The diverse teaching grade levels (grades 5 through 10) challenged the trainers to meet each teacher at her own level. See the evidence below:

> T5 in week 2: "It gets nerve wrecking to not know, so I find myself just sitting and that isn't helping. The 7th and 8th grade content is very unfamiliar to me, so it's going to take time to grasp all of the information."
>
> T6 in week 2: "I expected more information relevant to teaching 5th grade math."
>
> T10 in week 3: "Some of things we are doing are way above the level that I am teaching."

The above evidence implied that the instructional level needed to be adjusted for those teachers who were teaching lower grade levels, or that differentiated instruction needed to be used in order to meet their needs.

Years of teaching math. Even though T10 was an experienced computer technology teacher, she had not taught math "in many years". However, her school administrator had scheduled her to teach math during the upcoming school year. She wrote, "I really needed this institute to refresh many math concepts that needed to be sharpened." The other four atypical teachers ranged in teaching experience from 5 to 15 years.

Prior knowledge. Some teachers were well prepared from the outset of the institute. Others prepared themselves prior to each class, but others did not. Unprepared teachers felt that it was hard to follow instructions. We found that this situation happened for the atypical teachers. See the evidence below:

> T8 in week 1: "I wish I had more experience on the technology before this class. I don't use what I have learned enough daily, so I get lost easily during directions."
>
> T8's reflection indicated that she had weak background knowledge on technology and did not frequently practice using it - making her lag behind the others.

Learner's readiness was also reflected on the preparation for subsequent learning stages during the institute. The evidence below provided by T4 indicated that she did not review what had been taught earlier - which would have impacted her ability to learn the new material.

> T4 in week 1: "I need to focus on maintaining knowledge."
>
> T4 in week 2: "I wish I could remember all of the information to use Excel or have written directions."

T4's first week's reflection implied that she would make some changes for learning, but the second week's reflection revealed that she did not. Teachers like T4 need to be pushed for daily learning preparation in order to improve their learning effectiveness.

Desire to learn. Teachers' learning desires may be related to their background, teaching grade level, or special experiences. To catch learners' attention, it is crucial to heighten their desire to learn. However, it is a challenge for the trainer to make each topic satisfy all teachers. The evidence provided below illustrated that T6, T8, and T10 were eager to get more training about implementing the Common Core State Standard (CCSS). T6 kept this strong desire through several weeks. In addition, T8 was more interested in math, not technology. If the trainer could give these teachers more support on understanding CCSS based on their learning desires, it would have reduced their worries and concerns.

T6 in week 1: "I expected to get more information on practical applications relevant to my classroom (Common Core, lesson plans, etc.)."

T6 in week 1: "I wish I would get creative ideas on how to implement Common Core Standards in unique lessons."

T6 in week 3: "I wish we learned more teaching strategies on teaching the standards to students."

T6 in week 4: "I wish I would have gotten more Common Core training."

T6 in week 4: "I expected more information on Common Core and on a 5th grade level."

T8 in week 1: "I expected not all this!! More mathematics, less technology."

T8 in week 3: "I wish for more Common Core information. I am nervous about the upcoming school year. Even though I know this is math and technology."

T10 in week 1: "I expected more on Common Core."

Speed of learning. Learners' natural or habitual patterns of acquiring and processing information are different in learning situations. In other words, different persons prefer different learning styles and techniques. Faster learners may use multiple ways to grasp the knowledge and skills, but struggling learners may use only one or two ways and cannot maximize learning effectiveness in some situations. The evidence below implied that T4, T5, and T10 struggled when learning new information. They needed straightforward and detailed instructions in learning activities. These situations were not found in those teachers who demonstrated in the typical results.

T4 in week 2: "I wish we had more hand-written directions for Excel programs; I need to (have) written steps on how to use the geometry software and calculator."

T4 in week 3: "I wish the geometry software had written steps on how to perform different tasks."

T4 in week 4: "I wish we had written step-by-step instructions on every activity we created because I am worried I will not be able to use some things bc (because) I can't remember now."

T5 in week1: "I expected more hand-written instructions."

T5 in week 2: "I expected to have more hand-written information and I did LOL (Laugh Out Loud)."

T10 in week 2: "I wish we would have step-by-step directions so we could have them as a reference when we get back to our school."

T10 in week 4: "I expected a few more step-by-step instructions."

The above evidence also illustrated that differentiated instruction is needed to deal with various learners. For the struggling learners, extra help or scaffolding should be provided during or after the lesson.

CONCLUSION AND DISCUSSION

This study achieved the goal of answering the research questions. First, the paired-t tests of the MT test and the four surveys demonstrated that a four-week intensive

professional development program did help in-service teachers improve their understanding of mathematics concepts and their technology knowledge and skills. The program did decrease their concerns of integrating math and technology in their class, and increase their proficiency, confidence, and intended frequency of use of using technology in math teaching. Overall, these teachers not only gained more knowledge and skills of mathematics concepts throughout this program, but also would be more likely to integrate their technology knowledge into their teaching. This result verified the conclusion provided by the study of Hartsell et al. (2009). Second, the comparison between individual's pre- and post- tests scores revealed that not all participants followed the typical pattern even though the overall results showed the significant effectiveness of this program. This means we could find progressive spaces to help all teachers achieve learning effectiveness. Third, the further analysis of background information and reflections for those teachers who had more than one unexpected scores demonstrated that teachers' teaching grade level, years of teaching math, learning readiness, learning desire, and learning speed should be considered as important elements in the training plans, processes, and content to improve teachers' TPACK. Hence, it is necessary to take account the differences among teacher learners in training activities. Even though our conclusion is based on a small sample size, we believe that differentiated instruction should be a normal component for teachers' professional development in order to maximize effectiveness.

This research study had limitations. First, we used the data of 2013 Summer Math Institute as a case study for this research rather than data accumulated over multiple years. Each Summer Math Institute can only accommodate 22 teachers. These findings may not be a representative case for each year of this program. Second, the analysis of teachers' background information and reflections were only used for those who had more than one unexpected score. This might restrict the classification of results. However, as a case study, it did demonstrate that differentiated instruction is necessary for achieving the high training goal of maximizing effective learning for each participant.

We now concentrate on how the four-week intensive professional development program could incorporate differentiated instruction. Considering the diverse range of the grade levels (from 5 to 10), the participants could be divided into three groups: 5th and 6th grade group; 7th and 8th grade group; 9th and 10th grade group. Group sessions could be held periodically by a group leader and trainer to meet the specific grade level needs in mathematics standards, content, and technology integration. This would require the trainer to provide the time and space for doing so. Another strategy that the trainer could employ would be providing the time and space for participants to learn from one another as they work through new problems and activities. Gearhart and Saxe (2014) recommend time for whole-class discussions and partner work during a class. Their research using a matched-classroom design demonstrated substantially greater learning gains for students when these strategies were employed than for students in comparison classrooms. In addition, participants could divided into small groups of two or three according to their learning readiness for specific concepts or activities. This would require trainers to read the reflections at the end of each day and adjust the training strategies to respond the reflections. For some struggling teachers like T5, extra help and scaffolding needed to be provided throughout.

In closing, the idea behind differentiated instruction is to adjust instruction for each learner' skill, ability, and experience. Strategies include providing the time and space for peer tutoring and small group activities. These strategies may be difficult for traditionally educated mathematicians to implement, as they may fear a loss of control. However, the rewards of making a class dynamic and responsive to learners' needs are great.

Future studies will assess the effectiveness of differentiated instruction in the training program and explore how differentiated instruction could maximize each participant's

learning effectiveness. More qualitative data sources such as interviews and videotaping will be included in the research to perform the analysis. Conducting interviews would be a way to reach teachers' perspectives and thoughts on their learning experiences. Video recording would be a way of verifying data for interactions between the trainer and teacher learners and among teacher trainers.

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APPENDIX A

The Mathematical Content and Technology Assessment Test

Questions #1 - #6 are based on your knowledge of Microsoft Excel:

_____1. The cell labeled **F5** refers to:

a. Function key F5
b. Row F Column 5
c.Column F Row 5
d. Not sure

_____2. You need to use the "Insert Function" dialog box. How do you get it?

a. Right-click a cell and then click Insert
b. Click the Insert menu, and then click Function.
c. Type = in a cell.
d. Not sure.

_____3. In an Excell worksheet, you need to move the content of a cell into another cell. Which pair of quick keys are needed?

a. CTRL+Y, CTRL+V
b. CTRL+C, CTRL+V
c. CTRL+X, CTRL+V
d. CTRL+Z, CTRL+Y

_____4. To merge two or more selected cells into a single cell, you must first highlight the cells to be merged. The next step is to choose **Cell** from the **Format** menu. What is the 3rd step?

a. Choose the **Protection** tab from the
b. Choose the **Alignment** tab from the
c. Choose the **Protection** tab from the dialog box and deselect **Locked** dialog box and deselect **Merge Cells**
d. Not sure dialog box and select **Merge Cells**

_____5. You're creating a budget spreadsheet. You want to divide the expense (in cell B2) by the total expenditures (in cell B9). To make sure B9 in always referenced for the "fill down" function, the best formula would be:

a. =B2/B9
b. =B2/B9
c. =B2/(LOCK(B9))
d. Not sure

_____6. In the formula =sum(A1:B5), how many cells are there?

a. Two
b. Five
c. Ten
d. Not sure

Questions #7 and #8 are based on your knowledge of PowerPoint:

_____7. You're giving your presentation, and you need to click to a slide that's a few slides back. How do you get there?

a. From the Insert menu, choose the
b. Press TAB until you hit the slide you're looking for.
c. Right-click, point to 'Go' on the shortcut, menu, "Go Back" option. point to 'By Title', and click the slide you want to go to.
d. Not sure

_____8. How do you insert an equation or expression into your slides?

a. Insert/ Microsoft Equation 3.0/ Object
b. Insert/Object/Microsoft Equation 3.0
c. Insert/Microsoft Equation 3.0
d. Insert/Object
e. Not sure

Questions #9 - #11 are based on your knowledge of the TI-83 or TI-84 graphing calculator:

_____9. What is the sequence for accessing lists on a TI-83 or TI-84?

a. Stat, Edit
b. Y=, Stat, Edit
c. Stat, List, Edit
d. Not sure

_____10. On your TI 84 - Plus Silver, you accidentally hit the **CLEAR** button. How do you retrieve what you had entered?

a. [2nd], [CLEAR]
b. [2nd], [APPS]
c. [2nd], [ENTER]
d. Not sure

_____11. On your TI graphing calculator, which of the following is the correct sequence to turn off all of the plots?

a. [Y=], [4], [ENTER]
b. [2nd], [Y=], [4], [ENTER]
c. [Y=], [2nd], [4], [ENTER]
d. Not sure

Questions #12 - #15 are based on your knowledge of Geometer's Sketchpad:

_____12. You want to use Sketchpad to investigate the relationship between diameter and circumference of a circle. Now you will make a table for the diameter and circumference measurements. Which tools would you use?

a. Tabulate|New Function
b. New Function|Tabulate
c. Number|Tabulate
d. Tabulate|Number

_____13. You would like to rotate a triangle about a selected point by 180°. Which tools would you use?

a. Rotate|Transform

b. Rotate|Construct

c. Construct|Rotate

d. Transform|Rotate

_____14. When you construct shapes with Sketchpad, you will often need to construct objects that you don't want to see in your finished product. How can you make the extra objects "go away"?

a. Display|Hide

b. Display|Delete

c. Edit|Hide

d. Edit|Delete

_____15. To select Objects using Sketchpad, which tool would you use?

a. Point

b. Text

c. Arrow

d. Marker

e. Compass

Questions #16 - #26 are based on mathematical content:

Please do not use the calculator for questions 16-23.

_____16. If x = -2, y = 3, and a= -4, then $x - y(-a^2 + x)$ =

a. -44
b. 52
c. 16
d. 44
e. -56
f. Answer is not here

_____ 17. If $a \otimes b = \dfrac{a+b}{a-b}$, then $6 \otimes (5 \otimes 3) =$

a. 14
b. 90
c. 5
d. 7/4
e. Answer not here
f. Not sure

_____ 18. Simplify: $\frac{2}{3}x - 4y - \frac{1}{8}x + \frac{3}{5}y$

a. $\frac{19}{24}x + \frac{23}{5}y$

b. $\frac{3}{11}x - y$

c. $-\frac{1}{5}x + y$

d. $\frac{13}{24}x - \frac{17}{5}y$

e. Answer not here

f. Not sure

_____19.There is a list of seven numbers. The average of the first four numbers is 5, and the average of the last four numbers is 8. If the average of all seven numbers is $6\frac{4}{7}$, then the number common to both sets of four numbers is

a. $5\frac{3}{7}$

b. 6

c. $6\frac{4}{7}$

d. 7

e. $7\frac{3}{7}$

f. Not sure

_____20. Mary drove at 50 miles per hour on the highway 49 for a half of distance from Hattiesburg to Golf Port and 70 miles per hour for the other half. What was her average speed?

a. 120 miles per hour

b. 60 miles per hour

c. 58.3 miles per hour

d. 117 miles per hour

e. Answer not here

f. Not sure

_____21. Jack invested $500 into a savings account. The bank pays 12% tax-deferred interest annually compounded quarterly. About how much will Jack's account be worth after 3 years? Choose a correct formula for solving this problem.

a. $A = P \cdot (1 + r)^{mt}$ b. $A = P \cdot \left(1 + \frac{r}{m}\right)^{t}$

c. $A = P \cdot \left(1 + \frac{r}{m}\right)^{mt}$

d $A = P \cdot (1 + mr)^{mt}$

e. Answer not here
f. Not sure

_____ 22. Solve the system of equations: $\begin{cases} x + y = 2 \\ x + z = 10 \\ y + z = 3 \end{cases}$

The answer: _____.

_____23. Draw a picture to reflect the relationship among the following number sets: natural number set (N), integer number set (Z), whole number set (W), real number set (R), rational number set (Q), imaginary number set (I), and complex number set (C).

_____24. You take home $1650 per month and have a monthly car payment of $355. Your car payment is about ___ of your take home pay.

a. 21.5%
b. 4.6%
c. 78.5%
d. 460%
e. Answer is not here
f. Not sure

_____25. Mama Mia's best-selling pizza, the "Italian Feast", is 26 inches in diameter, holds 12 toppings and is currently priced at $19.95. The price per square inch for the pizza is about:

a. $0.0376 per square inch
b. $0.05 per square inch
c. $0.107 per square inch
d. $0.244 per square inch
e. Answer is not here
f. Not sure

_____26. Janice was shopping for classroom supplies at Ludson's Salvage Center at Clovertwig Mall. TI-83 Plus calculators, regularly priced $119, were 85% off. Overhead projectors, regularly priced $250, were 75% off. HP laptops, regularly priced $1200, were 60% off. Janice bought thirty calculators, one projector and one laptop. At the register, she got a teacher discount of 30%. If Mississippi tax is 7%, what was the total cost of all the merchandise?

a. $419.70
b. $2952.68
c. $807.42
d. $1153.46
e. Answer not here
f. Not sure

APPENDIX B

Survey of Concerns and Proficiency

The purpose of this questionnaire is to determine your current concerns regarding the integration of mathematics and technology into your classes. The items were developed from typical responses of teachers who ranged from no knowledge at all about the ideas to many years of experience in using them. ***Therefore, a good portion of the items on this questionnaire may appear to have little relevance to you at this time.*** For completely irrelevant items, please circle ***"NA"*** on the scale. Other items will represent those concerns that you ***do*** have, in varying degrees of intensity, and should be marked higher on the scale. Please respond to the items in terms of your present concerns about your involvement, or how do you feel about your involvement with **integrating mathematics and technology into your classes.** We do not hold to any one definition of this innovation, so please think of it in terms of your own perceptions of what it involves in your teaching situation.

1 = completely disagree **2 = somewhat disagree** **3 = somewhat agree**
4 = completely agree **NA = irrelevant**

1 2 3 4 NA 1. I am concerned about my ability to integrate mathematics with technology.
1 2 3 4 NA 2. I am concerned about not having enough time to organize each day when it comes to combining math and technology.
1 2 3 4 NA 3. I am concerned about availability of technology materials at my school.
1 2 3 4 NA 4. I would like to help other faculty in their attempts to blend technology into their subject areas.
1 2 3 4 NA 5. I have a very limited knowledge about integrating mathematics and technology.
1 2 3 4 NA 6. I am concerned about the students' abilities in technologies exceeding my own.
1 2 3 4 NA 7. I would like to how what resources are available if we decide to integrate mathematics and technology.
1 2 3 4 NA 8. I am concerned about my inability to manage all that integrating math with technology requires.
1 2 3 4 NA 9. I would like to know how my teaching or administration is supposed to change when integrating these subjects.
1 2 3 4 NA 10. I would like to revise the instructional approach for integrating technology into the mathematics classroom.
1 2 3 4 NA 11. I would like to have more information on time and energy commitments required for integrating these subjects.
1 2 3 4 NA 12. I would like to know what other faculty are doing in this area.
1 2 3 4 NA 13. I would like to determine how to supplement, enhance, or replace the mathematics teaching that I use to integrate technology.
1 2 3 4 NA 14. I would like to use feedback from students to change my integration of the two subjects.
1 2 3 4 NA 15. I would like to know how my role in the classroom will change when I am using this approach.

1 2 3 4 NA 16. Coordination of tasks, grading, and equipment is taking too much of my time with regards to integrating math and technology.
1 2 3 4 NA 17. I would like to know how using this approach is better than what I have been doing in my classroom.
1 2 3 4 NA 18. I am proficient in the use of PowerPoint in my classroom.
1 2 3 4 NA 19. I am proficient in the use of Microsoft Excel in my classroom
1 2 3 4 NA 20. I am proficient in the use of integrating Microsoft Excel into Word documents.
1 2 3 4 NA 21. I am proficient in the use of graphing calculators (ex: TI-83) in my classroom
1 2 3 4 NA 22. I am proficient in using MathType Equation Editor to create documents.
1 2 3 4 NA 23. I am proficient in using the graphing calculator to perform spreadsheet applications.
1 2 3 4 NA 24. I consider my knowledge of the Internet to be very proficient.

APPENDIX C

Survey of Use and Confidence

The following survey will determine your **use of technology** in teaching the following math concepts and your **confidence level** in teaching these math concepts. Please answer these as honestly as you can by circling the most accurate rating.

Concept	**How *frequently* do you use technology to help teach these concepts?** **1 = Very rarely** **4 = Frequently** **N/A =Not applicable**					**How *confident* are you in teaching these concepts?** **1 = Not at all confident** **4 = Completely confident** **N/A = Not applicable**				
1. Number Patterns	1	2	3	4	N/A	1	2	3	4	N/A
2. Operations with Decimals	1	2	3	4	N/A	1	2	3	4	N/A
3. Percent	1	2	3	4	N/A	1	2	3	4	N/A
4. Interest, Discount and Tax	1	2	3	4	N/A	1	2	3	4	N/A
5. Mean, Median and Mode	1	2	3	4	N/A	1	2	3	4	N/A
6. Operations with Integers	1	2	3	4	N/A	1	2	3	4	N/A
7. Area, Perimeter and Circumference	1	2	3	4	N/A	1	2	3	4	N/A
8. Ratios, Rates and Proportions	1	2	3	4	N/A	1	2	3	4	N/A

9. Model Data Using Charts and Graphs	1	2	3	4	N/A	1	2	3	4	N/A
10. Solve One- and Two-Step Equations	1	2	3	4	N/A	1	2	3	4	N/A
11. Functions	1	2	3	4	N/A	1	2	3	4	N/A
12. Tessellations	1	2	3	4	N/A	1	2	3	4	N/A
13. Probability	1	2	3	4	N/A	1	2	3	4	N/A
14. Linear Relationships	1	2	3	4	N/A	1	2	3	4	N/A

APPENDIX D

Weekly Reflections