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# Technology Professional Development and Mathematics Achievement: The Change over the Years

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# Technology Professional Development and Mathematics Achievement: The Change over the Years

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## Abstract

Teacher professional development is considered as one of the key factors for improving the quality of teaching and learning. This study aimed to investigate teachers' participation in technology professional development across the states between 2005 and 2015. The present study explored the differences in students' mathematics achievement scores based on those students' teachers' participation in technology professional development. Findings indicated that teachers in Alabama, Florida, Indiana, and Minnesota showed higher participation in technology professional development than the national average. When eighth-grade mathematics teachers substantially learned about instructional use of technology in professional development programs over the years, the average mathematics achievement scores in 2015 were significantly higher than the scores in 2005. Also, the students of those teachers who reported high participation in technology professional development in the years 2009 and 2015 had significantly higher students' mathematics achievement scores compared to those teachers who reported not participating at all.

**Keywords:** Mathematics achievement, NAEP, Teacher change, Technology professional development.

## Introduction

Technology is an essential part of mathematics classrooms (NCTM, 2014). The importance of technology implementation in teaching and learning mathematics is reflected in the standards from many organizations such as the International Society for Technology in Education (ISTE, 2014), the National Council of Teachers of Mathematics (NCTM, 2000, 2014), and the Common Core State Standards 2010. As the Principles to Actions of NCTM (2014) states, "technology in mathematics classrooms influences not only how teachers teach but also what they are able to teach" (p.84). The Standards for Mathematical Practice (SMP 5 and 6) in the Common Core State Standards recommend that students should use technology appropriately and communicate precisely to extend and deepen their understanding in mathematics (CCSSI, 2010). Moreover, the ISTE Standards share a common goal with the CCSSI about technology integration into classrooms. They both value technology as a tool for shifting the instructional approaches from lower-order thinking procedures, such as repetition and memorization, to the practices that support creativity, collaboration, problem-solving, and analytical thinking (ISTE, 2016).

Since the educational technology integration into teaching and learning increased, the investment in teacher professional development (PD) has grown substantially. In particular, funding remains key to develop a high-quality technology PD programs (Alqurashi, Gokbel, & Carbonara, 2016). The increasing investment in professional development encourages policy makers to look for evidence of its effects on teachers' knowledge, instructional practices, and student learning outcomes (Ingvarson, Meiers, & Beavis, 2005). When governments and decision makers prioritize education funding to technology integration, better technology knowledge and technology training can be delivered to teachers, and as a result, better learning outcomes can be achieved.

A well-designed professional development would help increase teacher use of technologies and so learning outcomes (Watson, 2006). A considerable amount of empirical research looked into the association between PD and teachers' or students' outcomes (Sanders & Rivers, 1996; Garet et al., 2001; Ingvarson et al., 2005; Hochberg & Desimone, 2010; Gokbel, Akcay, & Ayieko, 2016). In particular, some of those previous studies focused on evaluating the effectiveness of specific features of PD (e.g. content focus, active learning, length) on teacher and student learning (Garet et al., 2001; Ingvarson et al., 2005). As Hochberg and Desimone (2010) addressed, improved student achievement largely depends on the quality of teaching and teachers. It is evident that the impact of a high-quality teacher plays a superior role on student achievement than any other school-based factors (Sanders & Rivers, 1996).

Although there is a wide range of practices focusing on the integration of technology into classrooms, there is a need for further exploration of the impact of those practices on teacher behaviors and student achievement (Lawless & Pellegrino, 2007). Thus, the overall goal of the current study is to investigate trends and to consider implications of and for past and future education technology policy. This study differs from the existing literature in several ways. First, using NAEP state-level and national datasets from 2005 through 2015, the study aims to provide a descriptive analysis of state-level data on teacher technology PD participation across multiple time periods. Second, it examines how teachers' technology learning would impact the change in students' mathematics achievement scores over the years.

The analysis in this study builds on a previous research that investigated how fourth-grade mathematics teachers' technology professional development participation changed from 2005 to 2015 across the United States (Gokbel et al., 2016). The descriptive research highlighted a notable increase in teachers' attempts to learn how to use technology in their math instructions (Gokbel et al., 2016). Based on the previous findings, this study examines how the change differs over time for eighth-grade mathematics teachers and whether the extent teachers participate in technology professional development influence eighth-grade students' mathematics achievement scores. This study also explores any differences exist in students' math achievement by teachers' participation in technology professional development. Given the limited research on the change over time and across the States investigation of teachers' participation in learning to use technology in classroom instruction and how it affects students' math achievement, such a study becomes important.

Based on the purpose of the research, the following research questions are examined in the present study:

1. To what extent does mathematics teachers' participation in technology professional development change from 2005 to 2015 in the national average and across the nine states?
2. To what extent do mathematics achievement scores change from 2005 to 2015 of students whose teachers had a large extent participation in technology professional development?
3. Are there any significant differences in students' average mathematics achievement scores from 2005 to 2015 by teachers' participation in technology professional development?

## Theoretical Framework

This study is theoretically based on Guskey's (1986) model of professional development. In his studies, Guskey (1986, 2002) highly emphasized the importance of professional development and its potential impact on students learning. Guskey's model proposes three major outcomes of professional development; change in the learning outcomes of students after change in the classroom practices of teachers, which as a result leads to change in teachers' beliefs and attitudes. According to Guskey (2002), "significant change in teachers' attitude and beliefs occurs primarily after they gain evidence of improvements in student learning" (p. 139). Figure 1 indicates the teacher change process that teachers go through when they are involved in professional development programs.

The strength of this model is to emphasize not only teacher outcome but also its impact on student learning. Guskey (2002) suggests that the model can be utilized to investigate the influence of PD on student learning outcomes directly. Based on Guskey's model (1986), this study aims to investigate the differences in students' mathematics achievement scores when teachers participated in technology professional development over the years of 2005 and 2015.

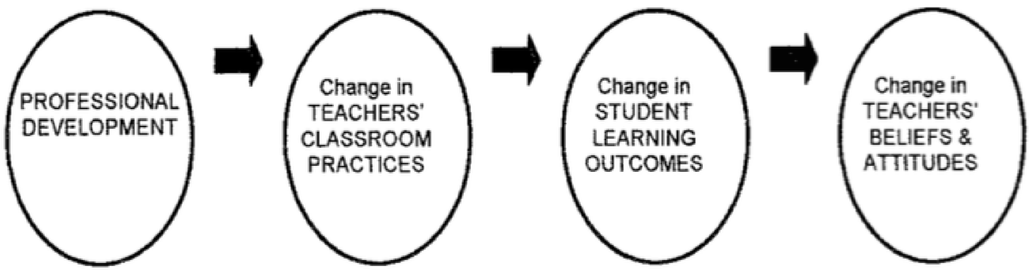


Figure 1. A Model of the Process of Teacher Change (Guskey, 1986). Used with permission.

## Literature Review

### Technology Integration in US Schooling

In the US schooling history, there have been many initiatives and attempts in reforming Pre K-12 education to meet the challenges and goals of the 21st century. In a recent report, Jones, Fox, and Levin (2011) highlighted four necessary key strategies to prepare students to acquire 21$^{st}$ century skills: (i) Building a 21st century technology infrastructure; (ii) Supporting teacher effectiveness through high-quality technology professional development; (iii) Developing and scaling technology-rich environments; and (iv) Preparing all students for college and 21st century careers (p. 3). As highlighted, technology has increasingly been integrated into classrooms and professional development programs to promote students current and future learning.

One of the important initiatives that support students and teacher development with technology integration is the Enhancing Education Through Technology (EETT) program in the US. Under Title II as amended by the No Child Left Behind Act (NCLB) of 2001, EETT program allows the Department of Education (US DoE) to provide states with education technology grants (Jones et al., 2011). The primary goal of the EETT program is to improve student achievement through the use of technology in elementary and secondary schools. Additionally, it aims to assist every student become technologically literate by the end of the eighth grade and supports the effective integration of technology with both teacher training and curriculum development (The National Coalition for Technology in Education & Training-NCTET, 2011). When considering requirement for the states to allocate at least 25 percent of EETT funds for professional development in the integration of technology into instruction (Bakia, Mitchell, & Yang, 2007), such initiatives emphasize with a great deal on in-service teacher development.

### Technology Professional Development

Teacher professional development has been considered as one of the key factors for improving the quality of US schools (Desimone, 2011). If teacher professional development is effectively implemented, it can influence teachers' learning, classroom practices of teaching, and student learning (Guskey, 2002). Desimone (2009) introduced a framework for evaluating the effects of PD on teachers and student outcomes. According to the framework that Desimone (2009) developed, an effective PD should have five core features to improve teacher knowledge and skills, improving their classroom practices, and student achievement: (i) content focus, (ii) active learning, (iii) coherence, (iv) duration, and (v) collective participation. These features are critical to being considered when designing technology professional developments as well.

Previous literature indicates that technology professional development for teachers has mostly centered on technology literacy. The primary focus of most of the studies was usually on skills development in the use of various computer applications, such as word processing, spreadsheets, commutation and media platforms, the Internet, etc. (e.g. Harris, Mishra, & Koehler, 2009; Ndongfack, 2015). Although these basic skills establish the foundation of technology knowledge, teachers need training more on how to integrate technology into classroom instruction, which is defined as technological pedagogical knowledge (Koehler & Mishra, 2009). As Koehler and Mishra (2009) states, "Technology pedagogy knowledge (TPK) requires a forward-looking, creative, and open-minded seeking of technology use, not for its own sake but for the sake of advancing student learning and understanding" (p. 66). This knowledge construction would then lead to a solid gain in teachers' technological pedagogical content knowledge that goes beyond all three principal components (content, pedagogy, and technology). In-service professional development to advance teachers' competence for efficient use of technology takes a variety of forms, including workshops, face-to-face and online courses, conferences, and training sessions. As cited in Bakia et al. (2007), teachers less frequently participate in study groups, peer observation, and coaching, which are more likely to have teachers integrate lessons learned from PD into teaching.

### Teacher Professional Development and Students' Mathematics Achievement

Wallace (2009) investigated the effects of teacher professional development on K–12 student mathematics and reading achievement when mediated teacher practices. Using NAEP 1996-2000 studies, Wallace (2009) found that professional development significantly affected teacher classroom practices and had a small but significant effect on students' mathematics achievement when mediated by teacher practice. In another study of student math achievement test scores revealed a link between higher scores and teachers who had professional development in technology (Norman, 2000; Wenglisky, 1998).

Martin's et al. (2010) investigation of instructional technology PD and teacher and student outcomes suggested that a high-quality technology professional development would lead to positive teacher and student outcomes. In their analyses, student scores in communication arts and mathematics separately for grades 3–5 were used as the focus of the study. Their findings revealed that high PD fidelity was associated with more time spent on lesson planning, reflective practice, and problem-solving for teachers whereas it was associated with higher achievement scores in math and communications for each grade level from 3 through 5 (Martin et al., 2010).

Also, Ingvarson et al. (2005) examined the effects of structural and process features of professional development programs on teachers' knowledge, practice, and efficacy, and finally student learning outcomes. In this study, the contextual factors included school support, structural features of programs included length, and process features of PD included emphasis on content, active learning, examination of student work, and feedback. Being content-focused for a PD had a positive influence on teacher knowledge, practices, and so student learning outcomes.

## Methods

### The NAEP Main Assessment

The National Assessment of Educational Progress (NAEP) provides the largest nationally representative database that includes information about what students learn and know across the United States and over the years. Since 1990, the state-level assessments of NAEP have been administered across the US in various grade levels (grades 4, 8, and 12) in mathematics. Particularly, this data provides representative samples of students' mathematics achievement in grade eight from each state every two years. As the sample of this study is the eighth-grade students, Table 1 indicates each year's sample size for eighth graders.

Table 1. Student Sample Sizes in NAEP Mathematics at Grade 8 across the Years

| Grade 8 | Year | Student Sample Size |
|---|---|---|
| (National Public) | 2005 | 162,000 |
| | 2007 | 153,000 |
| | 2009 | 161,700 |
| | 2011 | 169,500 |
| | 2013 | 164,551 |
| | 2015 | 135,100 |

The NAEP assessment items are given in a variety of formats, such as multiple-choice and open-ended questions requiring short and extended answers. The test items are classified by mathematical complexity: low complexity, moderate complexity, and high complexity. Each assessment question is designed to measure a mathematics strand: number properties and operations, measurement, geometry, data analysis/statistics, and algebra. Our study focuses on mathematics composite scale scores rather than focusing purely on one mathematics strand. Also, this study uses the available NAEP data for state assessments conducted in the last decade to provide a recent and comprehensive analysis. In state assessments, a sample of schools and students is selected to represent each participating state. In a state, 2,500 students in about 100 public schools on average are assessed for eighth-grade mathematics assessment.

NAEP data are most commonly used to investigate student achievement trends across the nation. However, during each assessment of NAEP, not only students were surveyed, but also teachers and school principals in the sampled schools complete background questionnaires. Teacher survey involves questions about their teaching experience, instructional practices, classroom organization, and professional training. The teacher questionnaires may differ slightly from year to year depending on grade level. Also, the number of technology-related professional development questions in each assessment year varies from year to year. In the teacher questionnaire, there is a technology PD-related item that has not been changed over the years for eighth-grade teachers in the NAEP state-level study to generate useful data on across the states and the years. For the purpose of this study, questions regarding the eighth-grade teachers' participation in technology professional development activities were the main focus.

The study focused on the benchmarking states in TIMSS 2011 including Alabama, California, Colorado, Connecticut, Florida, Indiana, Massachusetts, Minnesota, and N. Carolina (See Figure 2). The latest available international TIMSS assessment was released in 2015. However, contrast to TIMSS 2011, only one state, Florida, from the US participated in TIMSS 2015. The aforementioned states were selected because NCES requested them to participate in TIMSS 2011 (except Florida) to validate a Linking Study between the national assessment (NAEP) and TIMSS. The Linking Study aimed to develop TIMSS estimates for all 50 states and the District of Columbia and used those nine states to validate the estimates.

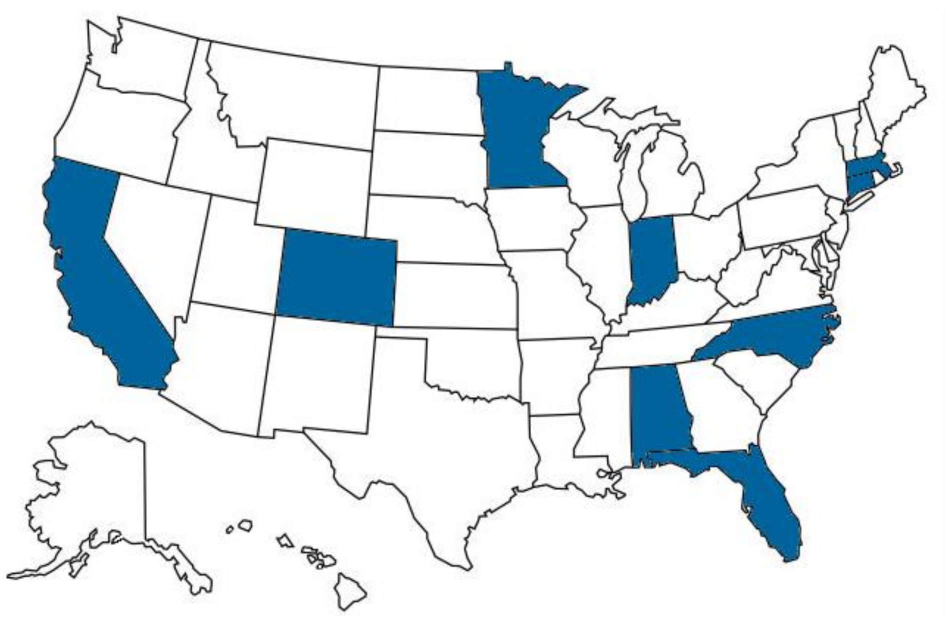

Figure 2. The Benchmark States in TIMSS 2011

## Study Variables

There were two main variables used in this study. Eighth grade students' mathematics achievement scores were the dependent variable while their teachers' participation in technology professional development activities was the independent variable. Average mathematics achievement scores of the National Public in the assessment years between 2005-2015 were particularly used as a dependent variable to address the second research question.

*Dependent Variable*

Composite mathematics achievement scores were generated from five different mathematics strands: Number properties and operations, measurement, geometry, data analysis/statistics, and algebra.

*Independent Variable*

Teachers were asked to select the extent they learned about using technology in mathematics instruction in any professional development activities during the last two years. The term of technology in this question refers to computers and other information technologies. The responses were on an ordinal scale: Not at all, small extent, moderate extent, large extent.

## The NAEP Data Explorer and Analyses

The NAEP Data Explorer (NDE) is an online data analysis system that provides detailed result tables from NAEP's national and state assessments. Every achievement item and background question in NAEP surveys are included in the NDE tool. The NDE can be used to run descriptive and inferential statistics on NAEP data, including regression, significance tests, and gap analysis on any item from the student, teacher, and administrator questionnaires. Those analyses can be performed across years, between subgroups of an item, and with any number of participating states.

When answering the first research question, to provide a clear image of the differences that exist in teachers TPD participation across the years and between the states, only the results for the highest (large extent) and lowest (not at all) options of the ordered response categories are presented in the line graphs. Each state's line graph (see figure 3) also displayed the comparison across the years. For the following research questions, the analyses were conducted on the sample drawn from national public schools without specifying the analysis for each selected state. The second research question required performing a gap analysis to examine how the differences in mathematics achievement scores of the students whose teachers learned how to use technology in classroom occurred over the years. Similarly, a gap analysis to answer the third research question was conducted across the years to see the changes in the achievement scores of students whose teachers did not take any professional development about effective classroom uses of technology. The final research question was addressed by examining mean differences of students' mathematics achievement scores by teacher technology related professional development.

## Results and Discussion

### Findings for Research Question 1

The change between 2005 and 2015 for the eighth-grade math teachers' participation in technology professional development across the states was displayed on Figure 3. In the national sample, 12% of teachers reported large extent participation in technology professional development in 2005. This percentage of large extent participation in 2005 increased to 14% in 2007, 15% in 2009, and 16%, the highest rate of all years, in 2011. Only 11% of teachers reported high participating in technology professional development in 2013, indicating the lowest percentage. Two years later, in 2015, teachers reported a slightly higher (13%) participation rate than 2013. On the other hand, 18% of teachers reported no participation in technology professional development. This percentage decreased to 17% and stayed consistent in 2007, 2009, and 2011. However, teachers' non-participation rate increased to 20% in 2013 which is the highest of all years. The year of 2015 was the lowest percentage (15%) of teachers who reported no participation in technology professional development.

In 2005, 12% of teachers in Alabama reported no participation in technology professional development. This percentage increased to 22% by 2009, but then dropped down to 15% in 2013. However, 20% of teachers reported no participation in technology professional development in 2015 in Alabama. On the other hand, in 2005, 16% of teachers reported large extent participation in technology professional development. This rate remained same during 2009, but it dropped down to 9% in 2013. In the year of 2015, only 6% of teachers reported large extent participation in technology professional development, which was the lowest of all years.
In California, the percentage of teachers who reported large extent participation increased slightly from 11% to 15% between 2005 and 2011 while 23% to 22% of teachers reported no participation at all in 2005 and 2011 respectively. However, the percentage of large extent participation decreased to 8% in 2013 and the percentage of no participation increased to 30%, which was the highest of all years in California. However, this percentage improved by 2015 as teachers who reported large extent participation increased slightly to reach 12%, and teachers who reported no participation decreased slightly to reach 13%.

For both the state Connecticut and North Carolina, the change over years was slightly steady with no dramatic increase or decrease. In Connecticut, between 2005 and 2015, teachers who reported large extent participation ranged from the highest 14% (in 2011) and the lowest 8% (in 2013). Teachers who reported no participation ranged from the highest 24% (in 2013) and the lowest 19% (in 2007). In the state of North Carolina, teachers who reported large extent participation ranged from the highest 18% (in 2011) and the lowest 12% (in 2013). Teachers who reported no participation ranged from the highest 17% (in 2015) and the lowest 11% (in 2005). Similarly, in the state of Florida, teachers who reported large extent participation ranged from the highest 21% (in 2011 and 2009) and the lowest 14% (in 2013 and 2005). Teachers who reported no participation ranged from the highest 17% (in 2013) and the lowest 10% (in 2015).

In the state of Colorado in 2005, 21% of teachers reported no participation in technology professional development. This percentage decreased to 13% by 2009, but then increased to 24% in 2015. On the other hand, in 2005, 12% of teachers reported large extent participation in technology professional development. This percentage increased slightly to 14% by 2007, but it dropped down to 13% in 2009 and to 12% in 2001 and it stayed the same during 20013 and 2015. In Indiana, there was a dramatic change in teachers' participation over the years. Teachers reported 11% large extent participation and 20% no participation in 2005. The gap was large in 2007 where 5% reported large extent participation and 30% no participation. Similarly, in 2009, teachers reported 8% large extent participation and 28% no participation. This gap started to slightly close in 2001 where

14% reported large extent participation and 17% no participation. The large extent participation increased to 15% in 2013 and to 18% in 2015, where no-participation increased slightly to 19% 2013 but then decreased to 15% in 2015.

In the state of Massachusetts, 9% of teachers reported large extent participation in technology professional development in 2005, where 22% reported no participation. The percentage of teachers who reported large extent participation was 14% then 16%, and no participation was 16% then 13% in 2007 and 2009. The gab increased in 2011, where 8% only reported large extent participation and 29% reported no participation. Then, teachers reported 10% large extent participation in 2013 and 12% in 2015; however, teachers reported 23% no participation in 2013 and 19% in 2015. In Minnesota, 8% of teachers reported large extent participation in technology professional development in 2005, where 19% reported no participation in the same year. In 2007, 11% of teachers reported large extent increase in technology professional development, where 20% reported no participation. There was an increase in large extend participation (12%) and decrease in no participation (16%) in 2009. Similarly, 14% reported large extend participation and 10% reported no participation in 2011. No-participation rate increased to reach 18% and the large extent participation decreased slightly to reach 13% by 2013. 15% percent of teachers reported large extent participation and same percentage reported no participation in 2015.

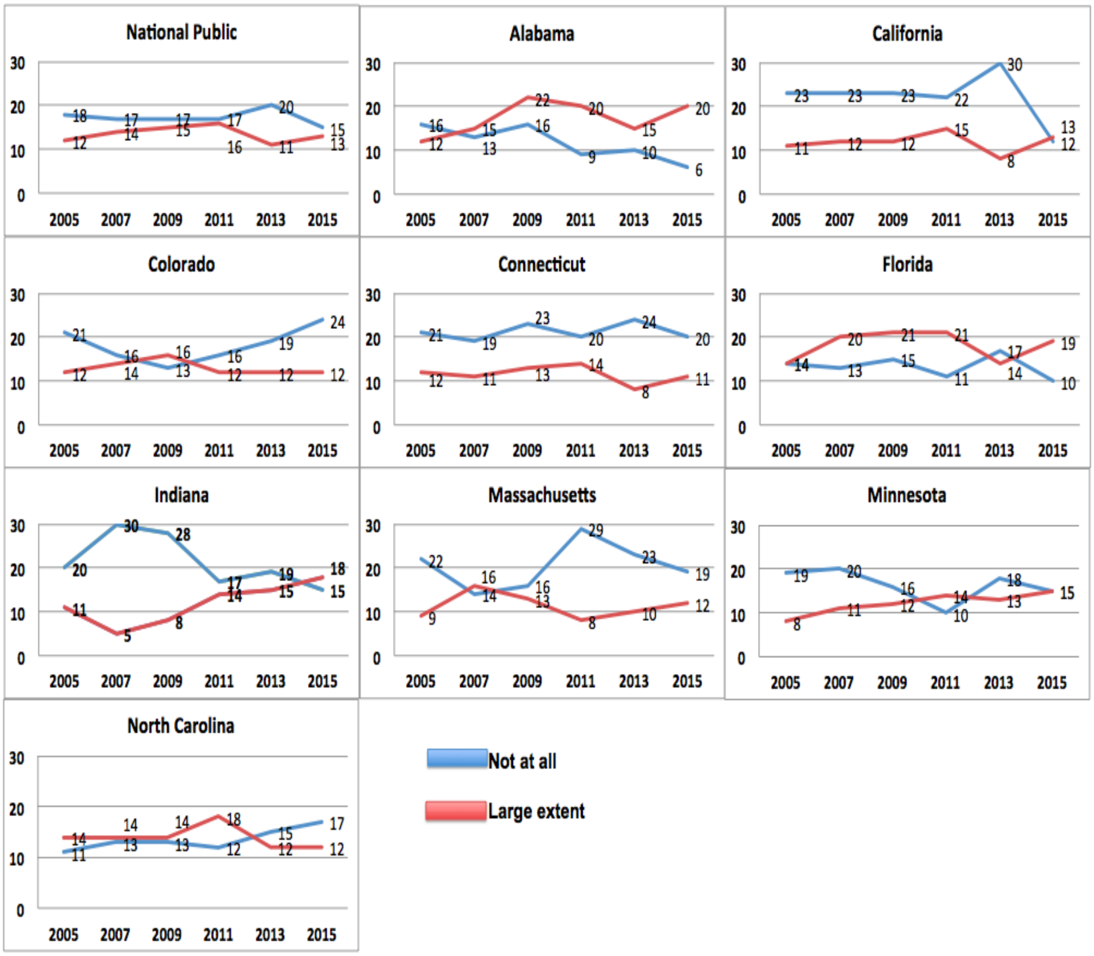


Figure 3. Eighth Grade Math Teachers' Participation Percentage Change in Technology Professional Development from 2005 to 2015 across Nine States and the National Public

**Findings for Research Question 2**

The results of the gap analysis for eighth grade students' mathematics achievement scores across the years were presented in Table 2 and 3. Table 2 demonstrates how differences in average mathematics achievement scores varied across the years for the national public. As seen in Table 2, when eighth-grade mathematics teachers substantially learned about instructional use of technology in professional development programs, mean differences in the scores ranged from -2.3 to 5.8 across the years. The average mathematics achievement scores in 2015 were significantly higher than the scores in 2005 (MD=3.5, SE=0.14, $p<0.0001$) while it was significantly lower than the average score in 2013 (MD=-2.3, SE=0.14, p=0.004). There was no statistically significant difference between 2015 and the other years, 2007, 2009, and 2011. Interestingly, average math achievement score of students whose teachers largely learned about technology use in 2013 were significantly higher than any previous year ($MD_{13-05}$=5.8, SE=0.13, $p<0.0001$; $MD_{13-07}$=2.4, SE=0.13, p=0.001; $MD_{13-09}$=1.9, SE=0.13, p=0.01; $MD_{13-11}$=1.5, SE=0.13, p=0.02). The scores in 2011 had no significant mean difference than the scores in 2007 and 2009. However, it was higher than the average mathematics achievement score in 2005 (MD=4.3, SE=0.13, $p<0.0001$). Finally, both 2009 and 2007 had statistically significant different scores than 2005 ($MD_{09-05}$=3.9, SE=0.13, $p<0.0001$; $MD_{07-05}$=3.4, SE=0.13, $p<0.0001$).

Table 2. Differences in Mathematics Achievement Scores of Students whose Teachers Learned about Technology Use by Large Extent (National Public)

| (I) Year | (J) Year | Mean Difference (I-J) | Standard Error | Sig. (p) |
|---|---|---|---|---|
| 2015 | 2013 | -2.3 | 0.14 | 0.004 |
| | 2011 | -0.7 | 0.13 | 0.35 |
| | 2009 | -0.4 | 0.13 | 0.67 |
| | 2007 | 0.1 | 0.14 | 0.85 |
| | 2005 | 3.5 | 0.14 | <0.0001 |
| 2013 | 2011 | 1.5 | 0.13 | 0.02 |
| | 2009 | 1.9 | 0.13 | 0.01 |
| | 2007 | 2.4 | 0.13 | 0.001 |
| | 2005 | 5.8 | 0.13 | <0.0001 |
| 2011 | 2009 | 0.4 | 0.13 | 0.62 |
| | 2007 | 0.9 | 0.13 | 0.21 |
| | 2005 | 4.3 | 0.13 | <0.0001 |
| 2009 | 2007 | 0.5 | 0.13 | 0.52 |
| | 2005 | 3.9 | 0.13 | <0.0001 |
| 2007 | 2005 | 3.4 | 0.13 | <0.0001 |

**Findings for Research Question 3**

Table 3 indicated significant differences in average mathematics achievement scores of students by teachers' technology professional development participation. Mean differences in the scores of students whose teachers had large extent participation in TPD and the other group of students whose teachers did not take any TPD ranged from 0.4 to 2.7. The mean differences in mathematics achievement scores in 2015 (MD=2.7, SE=0.14, $p<0.05$) and in 2009 (MD=2.6, SE=0.13, $p<0.05$) were both statistically significant. However, there were no statistically significant differences between the achievement scores of students whose teachers took TPD to a large extent and those students whose teachers recently had no TPD in the other assessment years.

Table 3. Differences in Mathematics Achievement Scores of Students whose Teachers Learned Technology Use by Large Extent and Students whose Teachers did not Learn Technology Use in Math classrooms (National Public)

| Year | Mean Difference (Large extent-not at all) | Standard Error | Sig. (p) |
|---|---|---|---|
| 2015 | 2.7 | 0.14 | 0.040 |
| 2013 | 1.1 | 0.13 | 0.343 |
| 2011 | 0.4 | 0.12 | 0.734 |
| 2009 | 2.6 | 0.13 | 0.026 |
| 2007 | 1 | 0.13 | 0.283 |

## Conclusion

This study aimed to provide a general picture of the changes in the influence of technology professional development on students' mathematics achievement across the years and the states. Findings reveal that students' mathematics achievement scores can be slightly related to whether teachers have participated in technology professional development or not. Results also show that only teachers who reported high participation in technology professional development in the years 2009 and 2015 had significantly higher students' mathematics achievement scores compared to those who reported not participating at all. Furthermore, students had the highest mathematics achievement scores in the year of 2013 followed by the year of 2011 regardless of teachers' participation in technology professional development. Students' mathematics achievement scores increased significantly from 2005 to 2015 for teachers who reported high participation in technology professional development. This significant positive effect of TPD on mathematics achievement might be a result of technology initiatives and programs launched since 2005. EETT program is one of them and it allows the Department of Education (US DoE) to provide states with education technology grants (Jones et al., 2011). When considering requirement for the states to allocate at least 25 percent of EETT funds for professional development in the integration of technology into instruction (Bakia, Mitchell, & Yang, 2007), such initiatives might boost teacher technology knowledge and the increase in teacher quality might result in better student outcomes.

Findings of this study are consisted with the relevant literature. For instance, Wallace's (2009) study found that professional development had a small but significant effect on students' mathematics achievement. Also, Norman (2000) and Wenglisky (1998) found a link between higher math achievement test scores of students and teachers' participation in technology professional development. This study contributes to previous research by looking at the change over the years in the mathematics achievement scores to identify any significant differences and if teachers' participation in technology professional development has any effect on student achievement. Although classroom technology and educational software continues to develop over the years, teachers' participation in technology professional development hasn't changed much in the national public average between 2005 and 2015. However, some states showed an increase in participation; specifically, teachers in Alabama, Florida, Indiana, and Minnesota showed higher participation in technology professional development than the national public average.

There are some limitations of this study. This study looked at the changes in the students Mathematics learning outcomes as well as teacher participation in professional development; however, it didn't offer information regarding the change in teachers' classroom practices after participation in technology professional development. Also, professional development programs can differ from state to state and from school to school, therefore, measuring the quality of professional development programs can also be an important factor that affects both classroom practices and students' learning outcomes.

Results of this study suggest that teachers who participated in technology professional development may focus on technology knowledge and technology pedagogy knowledge rather than technology content knowledge. A study by Alqurashi et al. (2016) found that teachers reported having the lowest knowledge in technology and technological pedagogical knowledge. Understanding the nature of the technology training provided to teachers is necessary for a deeper insight of the relationship between professional development and learning outcomes. With that being said, future research should investigate the effects of professional development through teacher practices to student achievement as well as quality and nature of professional development programs delivered. Future research should determine how mediating variables such as teachers' classroom practices work between professional development and student achievement and teacher knowledge and beliefs. Also, future studies should consider identifying what makes technology professional development programs of high quality and how each they can be related to student achievement to provide deeper insights into the effectiveness of technology professional development.

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