



ISSN: 2148-9955

International Journal of Research in Education and Science (IJRES)

www.ijres.net

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To cite this article:

Hill, K.K., Bicer, A., & Capraro, R.M. (2017). Effect of teachers' professional development from MathForward™ on students' math achievement. *International Journal of Research in Education and Science (IJRES)*, 3(1), 67-74.

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Effect of Teachers' Professional Development from MathForward™ on Students' Math Achievement

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Article Info

Article History

Received:
09 April 2016

Accepted:
14 November 2016

Keywords

Professional
development
MathForward™
Mathematics education

Abstract

MathForward™, developed in 2004-2005 in cooperation with the Richardson (TX) Independent School District, was implemented nationwide in 2007. The program integrates TI technology and professional development while focusing on student achievement and teacher efficacy. This study investigated the effect of the MathForward™ program on student achievement scores of Algebra I students from a southeast Texas high school. The specific purpose of this study was to understand whether there was an effect on students' STARR mathematics scores, accounting for teacher professional development and years of experience. To do this, structural equation modeling (SEM) in M-plus was employed. The result of the present study showed that our model fits well to the data and the explained variance of students' mathematics achievement ($R^2 = .14$).

Introduction

The MathForward™ Program and TI Navigator System are products of Texas Instruments (TI). According to TI's website, MathForward™ was developed in 2004-2005 in cooperation with the Richardson (TX) Independent School District and was implemented nationwide in 2007. The program integrates TI technology and professional development while focusing on student achievement and teacher efficacy. MathForward™ was developed to meet the needs of all students—struggling, proficient, English Language Learners, and special needs. The TI Navigator System is included with the technology of the MathForward™ program. With the TI Navigator System, teachers can assess students' knowledge of the concepts being taught, send and collect files, capture all students' calculator screens, and allow a student to be a presenter by projecting that student's calculator screen. The MathForward™ website explains that as part of the MathForward™ program, teachers are provided with professional development that concentrates on best practices and the integration of TI technology, including the Navigator system, into classroom lessons. In addition, teachers are provided with online resources and activities. National mathematical standards have been revised since the implementation of MathForward™. Common Core State Standards (CCSS) were adopted by 43 states causing the states to revise the standards for the states' mathematics curriculum (Common Core State Standards Initiatives, n.d.). For example, the State of Tennessee revised the mathematics standards for Algebra I in 2013 (Tennessee Department of Education, 2013) and the State of Texas, while not adopting the CCSS, revised the mathematics standards for the middle school in 2012 (Texas Education Agency, 2012). Is the ten-year-old MathForward™ program, in conjunction with the new standards, influencing student achievement scores?

Literature Review

The use of technology in the classroom is required through state and national standards. Sixth grade mathematics students are required to use technology as one of the tools necessary to solve problems (Texas Education Agency, 2012), and Algebra I students are required to use technology to graph functions (Tennessee Department of Education, 2013). The use of technology is included with the Common Core State Standards as part of Mathematical Practice Number 5: Use appropriate tools strategically (Common Core State Standards Initiative, n.d.). Technology is, therefore, a necessity in the mathematics classroom.

Several problems have existed with teachers using technology. These problems include learning to use the technology, implementing the technology, and integrating the technology into the curriculum (Lee, Feldman, & Beatty, 2012; Smerdon et al., 2000; Wood, Mueller, Willoughby, Specht, & Deyoung, 2005). Teachers who felt

more prepared to use technology were more likely to use technology (Smerdon et al., 2000). Veteran teachers (teachers teaching more than 3 years) felt less prepared to use technology than newer teachers (Smerdon et al., 2000). However, with technology constantly changing, teachers felt a need to continually keep up with the revisions but were finding it difficult to find the time to learn and then integrate the new technology (Wood et al., 2005). Technology benefits mathematics learning. In fact, a large effect for mathematics achievement was indicated when students experienced auxiliary computer assisted instruction (CAI) (Cheung & Slavin, 2013). Calculator use during instruction and testing led to developing the operational skills, computational skills, problem-solving skills, and those skills necessary to understand mathematical concepts (Ellington, 2003). Network-supported, function-based algebra (NFBA) had a proactive effect in improving student mathematics assessment outcomes (Stroup, Carmona, & Davis, 2005). Therefore, teachers should incorporate technology into the mathematics curriculum to improve student achievement. Teachers can acquire the knowledge to integrate technology into the classroom through professional development.

Student achievement increased commensurately with the hours teachers participated in professional development (Yoon et al., 2007). When professional development focused on student learning and developed the teacher's pedagogical skills of a specific content, there was a positive effect on teaching practices (Darling-Hammond & Richardson, 2009). One type of professional development utilized by many school districts is coaching. Coaching allows continuous training of the teacher and can be geared toward a specific instruction practice. When teachers are trained with a specific practice in mind, the teaching improved (Desimone, Porter, Garet, Yoon, & Birman, 2002). Professional development provided the means for teachers to continually improve pedagogy, content, and student learning. Ongoing and meaningful professional development was a part of the TI MathForward™ program. Professional coaches were provided through the program (TI MathForward™, n.d.). The coaches' sole responsibility was assisting the teachers to integrate the technology and pedagogical content into their lessons (Penuel, Singleton, & Roschelle, 2011). As a result of the professional development and coaching incorporated into the program, three school districts have indicated gains in mathematics achievement (Penuel, Singleton, & Roschell, 2011; Penuel, 2008a; Penuel, 2008b). Therefore, professional development was strongly related to teachers' successful implementation of the program.

Research Questions

1. How do students' mathematics scores change based on their teachers' coaching and professional development hours received and their fidelity classification?
2. Does MathForward™ have an effect on students' STARR mathematics scores, accounting for teacher professional development and years of experience?

Method

The MathForward™ program was funded by a grant from the Department of Education. The program was comprised of several facets that included technology, curricula, professional development, and coaching. It was technology-rich, using the TI-Nspire™ and the TI-Navigator™. Teachers were provided 48 hours of professional development each year to support the curriculum implementation and technology use. In addition, teachers received coaching from TI MathForward™ specialists through modeling instruction, co-teaching activities, demonstrating best practices, and focusing on TI technology integration in pre-algebra and algebra curricula. The school day was also modified so that teachers had common planning time so they could meet a minimum of three hours each week to share strategies, support each other, and ensure program fidelity. To ensure a seamless integration, the MathForward™ curriculum was integrated into the district's own pre-algebra and algebra courses. The MathForward™ curriculum was designed to use the TI-Nspire™ calculators to make difficult-to-learn mathematics concepts more accessible at each grade level. The program also was aligned with College and Career Readiness Standards (Texas Higher Education Coordinating Board [THECB] & Texas Education Agency [TEA], 2009).

Participants

Participants for this study consisted of nine high school teachers in southeast Texas. The teachers had between 1 and 22 years of teaching experience with all being highly qualified. Of the nine teachers, five had 1 to 5 years of teaching, two had 6 to 10 years of teaching, and two had over 10 years of teaching. One teacher had taught for 2 years prior to teaching with the district. The remaining teachers have only taught with the district. Based on classroom observations, professional development hours, and coach rankings teachers were given a ranking

of novice, intermediate, or expert with regard to their level and fidelity of implementation. A novice implementer was a teacher who used some MathForward™ lessons and who used the TI Navigator System for quick polls to assess student correctness but not to guide instruction. Teachers who used the TI Navigator System for quick polls and screen captures and used MathForward™ lessons with minimal guidance were classified as intermediate implementers. Expert implementers integrated the TI Navigator System for quick polls and used the assessment to clarify any misconceptions, consistently used MathForward™ lessons with no guidance, and learned to adapt lessons to their students. One teacher in the study was classified as novice, five teachers were classified as intermediate, and three teachers were classified as expert implementers.

Measures and Analysis

In the present study, the years of teaching experience and the years of receiving professional development were predictor variables with students' mathematics achievement as the outcome variable. To test the hypotheses that the years of teaching experience indirectly influenced students' mathematics achievement through the number of professional development hours teachers received, structural equation modeling (SEM) in M-plus was employed. Structural equation modeling provides an estimate of the suitability that the hypothesized structure fits the data through fit indices with well-accepted cutoffs.

Results

To determine if the hours of professional development teachers received improved student achievement, confidence intervals were created and reviewed. (See Figure 1.) The greatest number was compared to the fewest number of professional development hours teachers received. The greatest number of professional development hours was 32, and the mean score of the students whose teachers received 32 hours of professional development was 38.59 ($SD = 9.641$). There were some teachers who did not receive any professional development hours, and their students' mean score was 29.33 ($SD = 7.779$). The mean difference effect size for these two groups (teachers who received 32 hours of professional development and teachers who did not receive any professional development) was Cohen's $d = 1.057$. This Cohen's d indicates that the results are practically important.

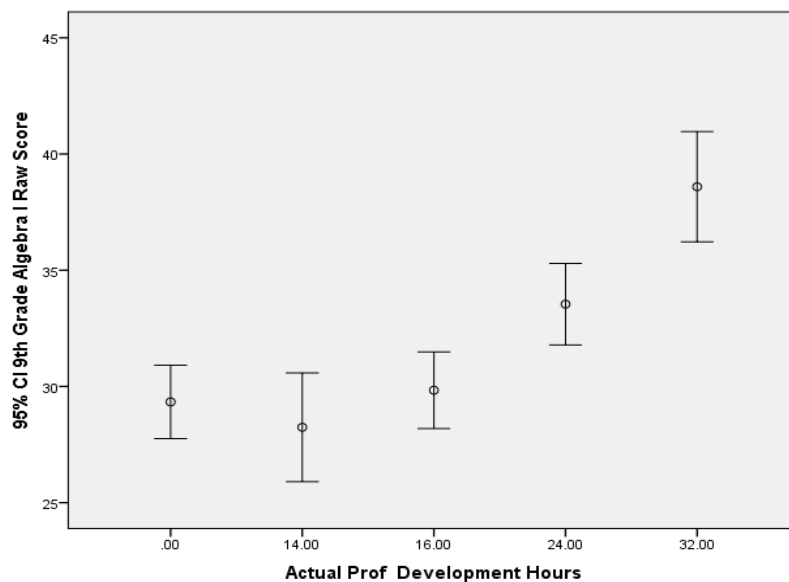


Figure 1. Confidence intervals for actual professional development hours

In order to understand whether student achievement improved based on coaching hours, the means of the students' raw scores were compared to the coaching hours teachers received. (See Figure 2.) The students of the teachers with the least number of coaching hours (6.00 hours) had a mean score of 38.59 ($SD = 9.641$). The students of the teachers with the most number of coaching hours (16.25 hours) had a mean score of 30.12 ($SD = 7.437$). The effect size for these variables was Cohen's $d = 0.984$, which indicates these differences are practically important. Comparing mean scores with the two lowest numbers of coaching hours, the mean of the

students' raw scores for the students with teachers having the least number of coaching hours (6.00) was 38.59 ($SD = 9.641$) and the mean of the students' raw scores for the students with teachers having the second lowest number of coaching hours (9.25) was 44.69 ($SD = 5.359$). (Refer to Table 1.) The effect size for these variables was Cohen's $d = 0.782$, indicating practical importance for these differences.

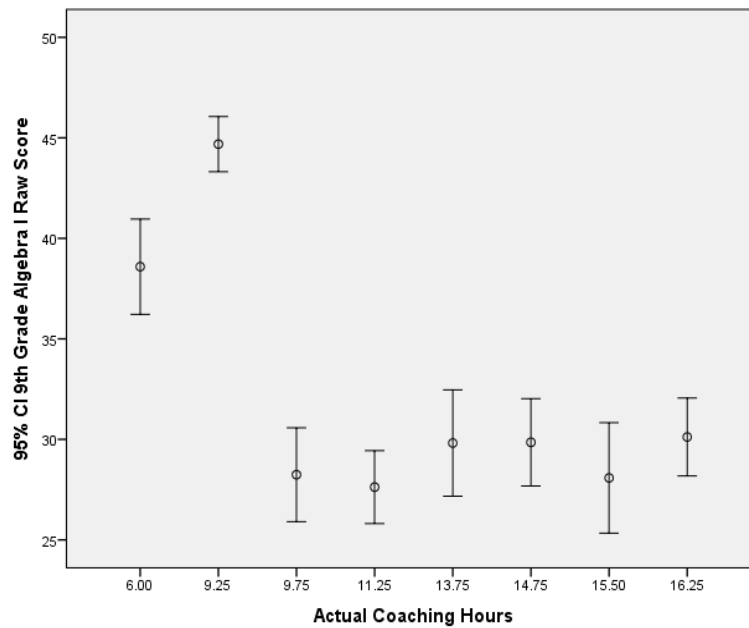


Figure 2. Confidence intervals for actual coaching hours

Table 1. Raw score means for actual coaching hours

Actual Coaching Hours	Mean	N	SD
6	38.59	66	.641
9.25	44.69	61	.359
9.75	28.24	37	.010
11.25	27.63	115	.823
13.75	29.82	38	.057
14.75	29.85	54	.947
15.50	28.08	37	.244
16.25	30.12	59	.437

The teachers' fidelity classifications were also analyzed with the students' raw scores. (See Figure 3.) The means of the students' raw scores were 29.82 ($SD = 8.057$) for the teachers classified as novice implementers, 34.03 ($SD = 11.187$) for the teachers classified as intermediate implementers, and 29.52 ($SD = 7.817$) for the teachers classified as expert implementers. The effect size for the teachers classified as novice and intermediate implementers was Cohen's $d = 0.432$. The effect size favored the intermediate implementers. The effect size for the teachers classified as intermediate and expert was Cohen's $d = 0.467$. For the sake of interpretation, the Cohen's d was computed subtracting the smaller number (expert implementers) from the larger number (intermediate implementers). Once again, the effect size favored the intermediate implementers.

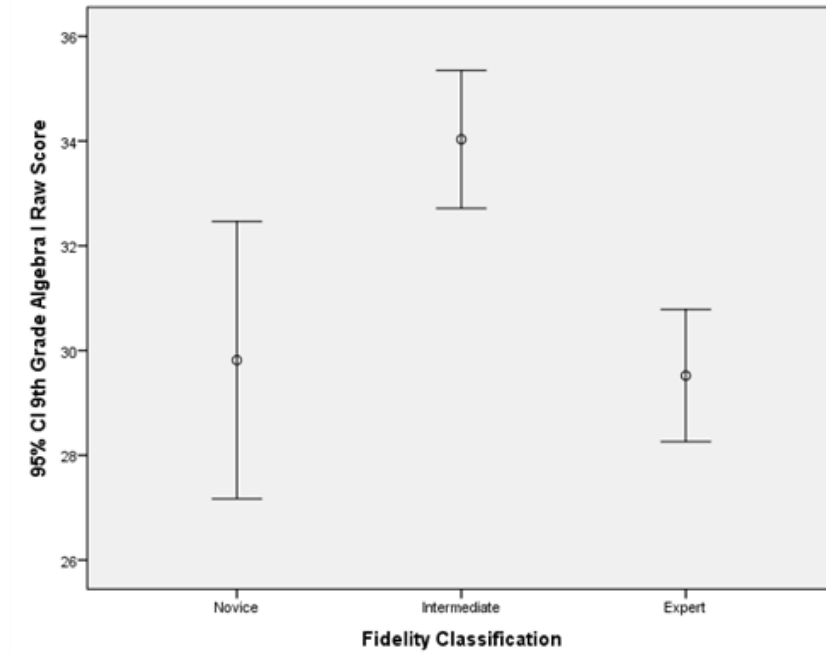


Figure 3. Confidence intervals for fidelity classifications

In order to understand whether the professional development hours teachers received were a mediator for the relationship of years of teaching experience and students’ mathematics achievement, two models were drawn. The first model (see Figure 4) showed that the years of teaching experience were related to students’ mathematics achievement through the number of professional development hours teachers received. The goodness-of-fit indices for this model were: Chi-square = 212.971, $p < 0.05$ ($df = 3$), CFI = 0.99, and SMR = 0.01 indicating an adequate model fit to the data and the explained variance of students’ mathematics achievement ($R^2 = .13$).



Figure 4. Direct effects of teacher professional development with indirect effect of teachers’ years on students’ mathematics achievement

The second model (see Figure 5) was drawn with the number of hours of professional development received as a partial mediator to the relationship between the years of teaching experience and students’ mathematics achievement. This information was gathered by drawing a direct path from years of experience to mathematics achievement. This direct path was statistically significant ($\beta = 0.063$, $p < 0.05$) indicating there were other predictors which were not taken into consideration in the present study that may have differential effects on the relationship between the years of teaching experience and students mathematics achievement. The second model also showed an adequate model fit with 14% of explained variance of students’ mathematics achievement ($R^2 = .14$). All three paths in the second model were positive and statistically significant ($p < .05$) indicating these three paths in this context were appropriate (see Table 2).

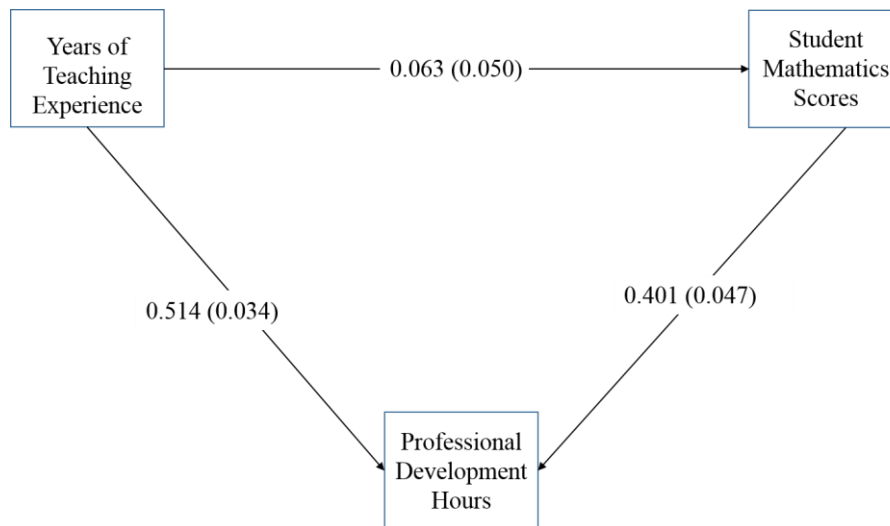


Figure 5. Direct effects of teacher professional development with direct and indirect effects of teachers' years of experience on students' mathematics achievement

Table 2. Standardized parameter estimates, p values, and relationship of variables for the second model

Variables (Mathematics Achievement on)	Estimates (β)	p	Relationship
Years of Teaching Experience	.063	<.05	Positive
Professional Development Hours	.401	<.05	Positive
Professional Development on Years of Teaching Experience	.514	<.05	Positive

Results and Discussion

Teachers received professional development and coaching as part of the MathForward™ program that showed an increased amount of integrating the technology into their lessons. Coaching is a professional development model that can be used to deepen understanding, to perfect skills, and to provide “just in time” information or feedback. However, coaching was used to diagnose and remediate implementation deficiencies. Therefore, aggregating coaching and other professional development confounds the developmental aspects of learning to implement the program. Because the teachers who received more coaching were also having more difficulties implementing the program, counting those hours as general professional development was likely inappropriate because the teachers' students were not benefitting from strong implementations. Therefore, coaching hours and the relationship between professional development and students' mathematics scores was statistically significant ($p < 0.05$). The trend in the confidence intervals indicates that the more professional development the greater the student outcome measure on average, which follows reports from other researchers (cf. Amenta-Shin, 2000; Saxe, Gearhart, & Nasir, 2001; Yoon et al., 2007; Johnson, Kahle, & Fargo, 2007). In other words, as the number of professional development hours their teachers receive increased, the students' mathematics scores tended to be higher.

Another variable of interest in this study was the number of coaching hours teachers received. The teachers who had more coaching hours (hours greater than 9.25) did not have students with higher means. The students with

the higher raw scores were students with teachers who received the least amount of coaching (hours less than 9.75). Again, this fits with the previous analysis and interpretation that coaching was used to support weak implementations and students received a weak implementation at best or a contradictory one at worst (Capraro et al., in press). One obvious assumption is that teachers with the lower coaching hours knew how to incorporate the technology into the lessons and deliver the curriculum because of some combination of knowledge, level of experience, and professional development. The greater the level of fidelity the less the teacher had a need for coaching. This result is tightly intertwined with teachers' fidelity classification.

Fidelity classifications in this study were based on classroom observations, professional development hours, and coach rankings. These classifications were a determinant as to how much technology was integrated into a lesson. Teachers classified as intermediate implementers had the greatest mean students' mathematics score. This mean was statistically significantly different ($p < 0.05$) from that of students whose teachers were classified as both novice and expert implementers. However, these ratings fail to take into account that the second highest group the coaches spent time with was the expert implementer. Perhaps interpersonal relationships were at play and coaches ranked some teachers higher than they should have been due to the coaches working more closely with them (Moers, 2005; Prendergast & Topel, 1993; Scriven, 1975). It is not clear from the data how this result is reconciled with the previous two classifications, but this provides an interesting avenue for exploration.

The hours of professional development teachers received and the years of their experience were combined in one model to reveal the effects of teacher professional development on students' mathematics achievement when controlling for the teachers' years of experience. This model was also considered as a mediated model that shows the years of teaching had a mediator effect between professional development teachers received and students' mathematics achievement. The two models together suggest that the benefits of professional development depend on the level of attention the teacher gives to the professional development. If less experienced teachers are given more professional development, the achievement gap between the less experienced teacher and the more experienced teacher might be decreased or vice-versa. This is only the second study that demonstrates that professional development may be mediated by years of experience to influence mathematics performance. The implication of this finding, while not causal, could influence theory moving forward. More research can be conducted to ascertain if there is a relationship between the number of years of experience a teacher may have, the number of professional development hours a teacher may receive, and the students' raw scores. Another avenue for research could be the effect of the amount of technology integrated into a mathematics lesson on students' mathematics scores. An additional research topic could be to determine student achievement in the students' mathematics classes after they participated in the MathForward™ program.

Acknowledgements

This report is based upon work supported by the U.S. Department of Education under Grant No. P334A110173. All analyses contained in this report about the implementation, MathForward™, or TI-Navigator™ were based on data provided by the partners to the external evaluator. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the U.S. Department of Education or the GearUp program.

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