INFLUENCE OF THE MANDATED TEXAS PUBLIC SCHOOLS' GRAPHING CALCULATOR IMPLEMENTATION IN EIGHTH-GRADE MATH ON TEACHING PRACTICES AS PERCEIVED BY EIGHTH- AND NINTH-GRADE MATH TEACHERS

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Abstract

The purpose of this study was to explore the influence that the Texas public schools mandated graphing calculator implementation in eighth-grade math had on teaching practices as perceived by eighth-grade and ninth grade math teachers. We wanted to know how this state mandate influenced the teaching practices of eighth-grade math teachers in Texas and what challenges if any, the teachers experienced during the implementation process. The study included math teachers from a school district in North Texas. Findings indicated that teachers need continuous support and ongoing professional development with the use of a graphing calculator for instruction to ensure successful integration of the calculator into the mathematics classroom.

Keywords: graphing calculator, eighth grade mathematics, academic achievement

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Whether students should be allowed to use a calculator in the mathematics classroom has been discussed for over four decades (Watters, 2015). In 2014, the discussion became a reality for 8th-grade math students and teachers in Texas, as the Texas Education Agency (TEA) (2014) mandated that all districts would integrate the use of a graphing calculator into their 8th-grade mathematics curriculum. The policy required all students to use graphing calculators on the eighth-grade Mathematics State of Texas Assessment of Academic Readiness (STAAR) assessment at the start of the 2014-2015 school year (Texas Education Agency, 2016).

Research has shown that integrating calculators into the mathematics classroom could have a positive impact on student achievement and motivation (Bottge, Grant, Stephens, & Rueda, 2010). When students are allowed to use calculators in the mathematics classroom their perceptions of mathematics could improve (Close, Oldham, Shiel, Dooley, & O'Leary, 2012). Lee and McDougall (2010) suggested that using calculators in the mathematics classroom could provide students with an opportunity to experience more success in mathematics and develop a deeper understanding of mathematics concepts. In

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fact, calculator use in the mathematics classroom can increase students' confidence, motivation, and anticipation to learn mathematics concepts (Tan, Harji, & Lau, 2011).

However, implementing calculators into mathematics classrooms could cause stagnation in the students' development of mathematical concepts (Hunsaker, 1997). Using calculators could have the same negative implications as computation errors when used incorrectly in the teaching of mathematics (Lee & McDougall, 2010). Moreover, early use of the calculator can cause students to know a procedure for getting an answer but lack or miss the mathematical concepts learning objective and increase the levels of frustration and confusion amongst the students (Fital-Akelbek & Akelbek, 2013).

This study was designed to explore the influence that the state mandated calculator implementation in eighth-grade mathematics had on teaching practices as perceived by math teachers in one Texas school district. The research questions guiding this study were:

1. What influence did implementing calculators in eighth-grade mathematics have on teaching practices?
2. What challenges did teachers encounter when implementing calculators in eighth-grade mathematics?

Literature Review

Calculator Discussions in the 1970s

Researchers began debating the topic of implementing calculators into the mathematics classroom in the 1970s (Watters, 2015). Bell (1975) found that calculators could help teachers determine conceptual gaps that may exist even when paper and pencil calculations seem to show mastery. However, without proper guidance, overuse of a calculator could lead students to view the calculator as a requirement and not as a tool. Therefore, teachers must be deliberate when implementing calculators into the curriculum because proper implementation could positively impact the curriculum and allow time for students to expand on the problem-solving component of mathematics (Gawronski & Coblentz, 1976).

Calculator Discussions in the 1980s

Wilf (1982) noted that in the 1980's the calculator conversation shifted to the collegiate level. The author suggested that the implementation of technology at the collegiate level in courses such as calculus could lead to a stronger focus on the mathematical concepts and less focus on the mechanics of the content. However, Miel (1980) suggested that improper implementation of the calculator could lead to more stress for the student and cause more harm than good in the classroom. Without proper guidance, students could use improper strategies or misinterpret the results from the calculator.

Calculator Discussions in the 1990s

By the 1990's, it was time for teachers to accept the fact that calculators would be a staple in the mathematics classroom (Henriksen, 1995). Borba (1995) purported that the implementation of technology in the mathematics classroom could create pedagogical challenges for math teachers. For successful implementation, the teacher must use more open-ended activities during instruction. Further, these activities could lead the students to generate questions that teachers are unable to answer. Borba suggested that while these questions may be uncomfortable for the teachers, this level of complexity in student learning is essential for sustained academic growth in mathematics.

Calculator Discussions in the 21st Century

Doerr and Zangor (2000) noted the importance of the teacher's role in ensuring that the calculator is implemented and used as a resource in the mathematics classroom. However, teachers' comfort and confidence level with the calculator has a significant impact on the seamless integration of the device into the classroom. Doerr and Zangor suggested that when teachers understand the limitations of the calculator and are flexible with its use in the classroom they can ensure that it does not become the authority source in the classroom.

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Lee and McDougall (2010) found that calculators can have the same negative impact as computation errors when teachers inappropriately use them during instruction. Consequently, it closes the door for advancing students' conceptual understanding of mathematical concepts and increases the level of frustration and confusion amongst the students, due to the lack of an in-depth understanding of the content (Fital-Akelbek & Akelbek, 2013).

Methodology

Research Design

The research design of this study was a bounded phenomenological case study. A case study allowed the researchers to use a variety of data sources to explore the phenomenon within its context (Baxter & Jack, 2008). The shared phenomenon of this case study was the influences that the state-mandated calculator implementation in eighth-grade mathematics had on teaching practices. The study is classified as a bounded case study because the researchers worked within boundaries set by time and place (Creswell, 2013).

Creswell (2013) argued that social constructivists personally gather information to understand the perspective of the participants and their environment. The researchers obtain the views of the participants by utilizing open-ended questions to develop an awareness of the study. In this study, the researchers maintained an active collaboration with the participants while they were able to share their perspective of the mandated calculator implementation into eighth-grade mathematics. The researchers used open-ended questions called a guided protocol to gain a real understanding from the participants' perspectives.

Participant Selection

Participants in this study taught eighth or ninth grade mathematics for at least three consecutive years. They were identified by their peers as model teachers by receiving Teacher of the Month or Teacher of the Year nominations. The study included 12 eighth and ninth grade teachers from one North Texas school district. Purposeful sampling ensured well-versed responses for this bounded phenomenological case study (Creswell, 2013). The researchers met with the participants twice. To generate dialog and creativity, the researchers initially met with the participants in a small focus group setting with two to four teachers in each group. There were four small focus group interviews. After each focus group meeting, the researchers then conducted one-on-one phone interviews with each participant to explore the research questions further.

Data Collection

Creswell (2013) recommended using focus groups when the researcher is interviewing three or more participants. The researchers placed the twelve participants into four separate focus groups based on their proximity to the primary research campus. The researchers scheduled the discussion groups at a convenient time for the members and allotted enough time for each group to complete the interview process. The group setting provided an opportunity for the participants to engage in a meaningful group discussion about the use of graphing calculators in the eighth-grade mathematics curriculum. Also, participants discussed questions from the guided protocol and their experiences with the state calculator mandate. After each group interview, the researcher contacted each participant by phone to explore their answers to the research questions further.

Treatment of Data

Creating categories is a useful strategy for organizing data (Creswell, 2013). To properly organized and analyze the data the researchers transcribed field notes to a Microsoft Word document providing an exact typed replication of the interviews. After carefully reading the transcripts the participants' responses were arranged into categories by common themes identified by the researchers using the data analysis spiral by Creswell (2013). The coding process helped the researchers to generate a way to include multiple perspectives from the participants. The researchers stored the data on a password-protected computer.

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Provisions of Trustworthiness

To ensure the trustworthiness of the study, the researchers piloted the guided protocol, used triangulation of interviews, and conducted member checking (Creswell, 2013). To triangulate the data, the researchers justified the themes by analyzing the facts found from the data. School artifacts, websites, and field notes contributed to the triangulation of the data. The researchers utilized member checking by allowing participants to review their transcripts for accuracy. Additionally, the researchers included all information in the findings, even when it was contradictory to the themes. The researchers also clarified personal bias in an epoche to maintain trustworthiness of the study.

The epoche detailed the researchers' biases. The researchers acknowledged that as mathematics teachers, their personal feelings, interests, and opinions influenced the choice to study this topic. Additionally, as math teachers, the researchers have personal experiences with student struggles and successes with calculator implementation. However, the researchers noted that they must not allow their prejudices to influence the study. The researchers also maintained that they had, to the best of their ability, set their biases aside to gain proper perspectives from the participants of the study.

Findings and Analysis of Data

The purpose of this study was to explore the influence that the state mandated calculator implementation in eighth-grade mathematics had on teaching practices as perceived by math teachers in one Texas school district. The participants in this study were six eighth-grade math teachers and six ninth-grade math teachers. These teachers were from one school district in North Texas. The teachers selected met the participant criteria detailed in the methodology section. What follows are the findings of the two research questions presented in this paper.

Research Question One

Research question one explored the influence that implementing calculators in eighth-grade mathematics had on teaching practices. Teachers discussed any change they made to their delivery of the concepts because of the mandate for students to utilize the calculator. Additionally, the teachers discussed the influence that the calculator implementation had on the written mathematics curriculum. Findings for this research question included the following:

- teachers were able to move at a faster pace;
- teachers increased the number of higher order thinking questions; and
- eighth-grade curriculum changes were guided more by the TEKS than calculators.

Teachers were able to move at a faster pace. According to the teachers, the calculator mandate allowed them to move at a faster pace with their students. The eighth-grade teachers noted more change in their delivery of the concepts than the ninth-grade teachers. Several of the eighth-grade teachers mentioned that they saw a change in their delivery of their grade level content. They discussed how they were no longer focusing on the computation, or the skill practice, before practicing the eighth-grade concepts. One eighth grade teacher stated that "It expedites some of our lessons, in terms of the computation; they're not getting tripped up on basic computation."

One teacher stated that she no longer uses the paper and pencil method to teach certain eighth-grade concepts because the students use the calculator. The teachers said they also noticed that they were no longer avoiding certain number sets because there were fewer concerns with issues that may arise due to computation errors. One teacher mentioned "I feel like we get further, again because of time…we have more time to spend on those higher-level concepts compared to what we did before." Another chimed in:

> We can get a little further into it, deeper in to it, because we're not taking out, even if it's 10 minutes, to teach them how to plug something in the calculator. We don't have to take that 10 minutes anymore.

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Teachers increased the number of higher order thinking questions. Both the eighth and ninth grade teachers emphasized they were able to increase the number of higher order thinking questions that are used on a test and in the classroom since the implementation of the calculator in eighth-grade mathematics. One teacher said, "I have always left the Pre-AP extension questions, as bonus, on my on-level test, but I noticed that more students are attempting the bonus questions now that they get to use one." The teachers attributed the students' attempt at these higher-order thinking questions to their ability to use the calculator on the assessment.

All of the teachers talked about how they were able to have more conceptual conversations about their mathematics content now that the students were no longer concerned with computation errors. The participants also noticed an ability to have more in-class discussions about the "why" behind the mathematics than before the implementation of the calculator. One teacher stated that he no longer has to focus on the arithmetic with some concepts. He said, "We actually have time to discuss the "why.'' In addition, the teachers talked about their ability to use more relevant real-world questions and activities now that they were not as concerned with students getting lost in the computation. One teachers elaborated:

> Some things I feel like we never went real deep into them because we couldn't get past the computation part of it. And now that we can, I feel like we can apply to more real-life situations, with more real-life numbers, they don't have to work out nicely every time. Which is what you would see if you were doing math outside of the classroom, anyway. So, I think in that sense, it helped me be more real world oriented.

Eighth grade curriculum changes led more by TEKS than calculator. The ninth-grade teachers did not notice a change in their curriculum because of the eighth-grade implementation of the calculator. There was a discussion regarding an increase in the rigor seen in the ninth-grade content earlier in the year, but there was no consensus on whether this increase in rigor was due to the eighth-grade implementation of the calculator or if it was teacher initiated.

However, in eighth grade, the teachers noticed a significant change in their curriculum at the time of the mandated calculator implementation. The teachers also noted that the mandated calculator implementation was done simultaneously with the implementation of the new eighth-grade math Texas Essentials of Knowledge and Skills, or TEKS. One of the eighth-grade teachers stated, "The calculator makes the problems more doable, but the TEKS forced the changed in curriculum more than the calculator."

Research Question Two

Research question two investigated the challenges that implementing calculators in eighth-grade mathematics had on students. The teachers discussed the challenges they faced when applying the calculator into the mathematics classroom. There was also discussion regarding the grade level content that suffered the most from the calculator implementation. This research question also explored the negative influence that implementing the calculator in eighth-grade mathematics had on students across their core curriculum. Findings for this research question included the following:

- teachers felt ill-prepared for the implementation;
- decreased understanding of mathematic concepts and;
- negative influence on science.

Teachers felt ill-prepared for the implementation. The teachers agreed that they did not receive any training on how to properly implement the calculator into the mathematics classroom. They utilized online resources to train themselves on some of the functions of the device. One teacher exclaimed "Thank God for Google! Without it, there were many times that would not have been able to help my students. Google taught me a lot! I had to use it to for a lot of the functions on the calculator." Another teacher expressed concern regarding who would manage the distribution and upkeep of the calculators. She worried about storing them, tracking them, handling damaged equipment, and what the students would use at home if they did not have access to the calculator. The teachers agreed that proper training on how to properly implement the calculator into the mathematics classroom could have reduced some of the struggles they experienced with the implementation.

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Decreased understanding of mathematic concepts. The teachers discussed several math topics that they felt the use of a calculator would have an adverse impact. More precisely the content they discussed included scientific notation, graphing, and fractions. Several of the teachers noted the negative influence of the use of a calculator with scientific notation. Particularly, one teacher said:

> The kids don't even try to move the decimal; they go straight to the calculator. Then they get confused when the "E" pops in there. When they ask me, I show them how to move the decimal and they always say, "Oh, that was easy!

There was also discussion regarding the diminishing understanding of the power of ten as it relates to scientific notation. Teachers have seen a misconception reinforced by calculator when graphing. If the student does not follow the proper steps when using the calculator to represent discrete the data, there is the potential of displaying the discrete data as continuous data. The teachers noted that students already struggle with distinguishing between continuous and discrete data. There was also discussion regarding a potentially adverse influence when working with fractions. One teacher said, "Since the kids have the calculators they convert all the fractions to decimals. They don't even try to work with fractions." The others agreed and expressed concern because when fractions have algebraic expressions as numerators, this will not be an efficient strategy.

Negative influence on science. The reduction in computation practice in the mathematics classroom has negatively affected the students in their eighth-grade science classes. One of the teachers noted that her science colleagues expressed frustration with the mandated calculator implementation. She said the science teachers were concerned because all eighth-grade math students received a calculator but only students with the calculator accommodation could use the device in their science class. One of the participants said:

> I feel bad for the science teachers. They have to convert fractions to decimals in science but we don't teach that anymore, directly anyway. So, the kids who don't get a calculator could potentially fail their Science STAAR test for not understanding a math skill.

Conclusions, Implications, and Recommendations

Conclusions and Implications

Research question one examined the influence that calculators had on teaching practices. The findings suggested that implementing the calculator had a positive impact on teaching practices by allowing teachers more time to focus on helping students develop a conceptual understanding of the mathematic concepts. The reduction in computation time allowed the teachers to move at a faster pace and adequately address more of the state driven curriculum. The teachers were also able to focus on helping students develop conceptual understanding of the mathematic concepts since they were no longer focusing on the skill practice of the concept. Students were engaging more frequently in classroom conversations that were started from higher order thinking questions. The increase in the use of higher order thinking questions helped the students develop their conceptual understanding of the mathematic concepts. The teachers in this study said they were able to explore more conceptual development opportunities due to the reduction of students in need of skill practice. The findings are consistent with Bouck (2009), who suggested that the reduction in student computation time allowed could present more learning opportunities for students.

Research question two examined the challenges that came about when implementing calculators in eighth-grade mathematics. The findings suggested several challenges with implementing the calculator. These included a lack of training for teachers, the student over-reliance on the device, and the potential of reinforcing student misconceptions when using the calculator. The teachers found themselves using the Internet to find answers to questions they had regarding the functionality of the calculators. Not knowing how to carry out a particular function on the calculator made the teachers uncomfortable when trying to help the students with the parts of the calculator that they were unsure of or did not understand. Not all mathematic problems can be solved by using a calculator; some students were baffled and confused when this would occur. Improper use of a calculator could lead to the development and reinforcement of misconceptions of math concept students are learning. The findings indicated that teachers must receive training on how to integrate calculators into the mathematics

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curriculum to prevent the challenges cited. Kersaint et al. (2013) found that it would not be academically beneficial for students if teachers lack the proper training on how to integrate technology into the classroom.

The study suggests that in order to implement successful use of calculators in the math classroom, administrators must provide teachers continuous content specific training on how to integrate the calculator, the appropriateness of its use, and the adverse influences on students learning. Building on the strengths and understanding the weaknesses or challenges of calculators within the classroom is important for the quality use of this technology in the classroom.

Recommendations for Future Research

This study focused only on mathematics teachers. Suggestions for future research should include how science teachers perceive the implementation of calculators into eighth-grade mathematics; the impact the use of calculators has on student learning, achievement and the Mathematics State of Texas Assessment of Academic Readiness (STAAR) eighth-grade test results; and a comparative analysis of student responses by type of STAAR test questions before and after the mandate to determine if they are the same or different. Future studies might determine if the use of the calculator implementation resulted in more rigorous conceptual approaches to questions on the STAAR test.

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