Technology v. Tradition in Algebra Education

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Abstract

The topic of this capstone is the effect that calculator usage has on the learner proficiency of 15 9th grade algebra students Throughout this research, pre- and post-assessments were used to gather data which was then analyzed using quantitative research methods such as descriptive statistics. The problem that this research sought to address was that some algebra students were struggling to complete the basic arithmetic portion of the algebra content. The research question was, “How will incorporating calculator use into an algebra curriculum affect learner proficiency in algebra?” This research was an action research which resulted in an instructional intervention being developed based on the conclusion from the research that implementing calculator use into the algebra classroom positively affected learner proficiency.

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Chapter 1: Topic and Problem

Research Type

This research is an action research with an instructional intervention.

Research Topic

The topic for my proposed research is the effect that calculator use has in algebra education as compared to traditional methods of teaching algebra without calculators. This topic aligns with, and is important to, the field of curriculum and instruction because student learning and proficiency is directly tied to the instructional practices used in the implementation of curriculum and learning objectives. “We have to rethink what it means to teach [students] how to do basic math in the calculator age” (Baum & Jefferson, 2020, para. 1). In many traditional math classes, teachers would not allow the use of calculators. In my own high school education, I was not allowed to use a calculator until I had passed both algebra and geometry. My teacher’s reason for this method was that it would craft his students into stronger mathematicians. I have continued this practice into my own teaching arsenal. However, calculator usage is a subject of debate for many math teachers, “One side argues for the use of efficient and available technology in the classroom, while the other argues for numeracy and fluency to the highest order” (Vilson, 2013, para. 1).

Problem Statement

Students in my basic algebra class struggle to complete arithmetic portions of the algebra content; this impacts their ability to succeed in the actual algebra course content, and will cause them to either fail their course or struggle in future courses.

Problem Impact and Root Cause(s)

The impact of the identified problem could have lasting effects on students' success in later math classes. For instance, a strong understanding of basic arithmetic concepts in algebra is absolutely necessary for understanding more complicated courses such as trigonometry and calculus. The covid-19 pandemic only added to this problem, "Math teachers say they have tried to streamline their curriculum to only teach the most relevant content this year, given that instructional time is at a premium" (Will, 2020, para. 4). I believe one of the root causes of this issue was a prolonged period of disconnect from in-person mathematics instruction during the Covid-19 pandemic. For nearly two years, students had to learn math online and over video calls, "It can be more challenging for teachers to engage in effective math instructional practices via remote platforms" (Schwartz, 2020, para. 3). The remote-learning aspect from the pandemic has caused many students to stop thinking about math, and arithmetic in particular, as a physical practice. Algebra requires a strong understanding of, and skill in arithmetic.

Research Question(s)

The research question that aligns with the previous problem statement is, "How will incorporating calculator use into an algebra curriculum affect learner proficiency in algebra?"

Justification

For many years now, education has constantly had to evolve and adapt to changing times and changing technology. Calculators have been around for a long time and are an invaluable tool for many mathematicians. However, there is still some debate about the place of calculators in the classroom. Some educators believe in a more traditional route of not allowing students to use calculators while other educators actively incorporate technology such as calculators into their curriculum. This research is an opportunity to gain valuable insight into this debate and

provide perspective on whether or not calculators in a high school algebra class are beneficial to students' learning, proficiency, and comprehension.

Chapter 2: Review of the Literature

Introduction to the Literature Review

For the last century, technology has constantly been evolving to meet a variety of humanity's needs. In the realm of mathematics, calculators were invented to make computations easier, faster, and more convenient. The question remains then, are calculators beneficial for students to use when learning mathematics? This literature review will focus on calculator use in algebra curriculum and instruction and the surrounding learning needs of algebra students in a modern algebra class. Throughout this literature review, two common themes will be seen, student-centered practices and methods for increasing student learning. First, student-centered practices are at the forefront of this research. Afterall, shouldn't every educator be concerned with centering the curriculum and instructional practices around the students? Teaching responsible use of technology such as calculators is a student-centered practice because it enhances student learning and engagement while expanding the overall study of algebra to new and exciting heights. Second, methods for increasing student learning are vital to creating an ever-improving learning environment. Educators, in general, are highly skilled individuals in their field; however, educators must always be assessing and improving their curriculum and instruction. For this reason, methods for increasing student learning have an important place in education, and are directly tied to incorporating calculators into algebra education.

Student-Centered Practices

At the heart of education should always be student-centered practices. Implementing technology such as calculators is an innovative way to ensure that students are well-equipped to take on challenging math concepts; however, this student-centered practice is a topic for some debate. Many traditional math teachers favor keeping calculators out of the classroom while many modern math teachers believe calculators have a place in the classroom (Vilson, 2013). Some proponents for integrating calculators into math education argue that "when you unlock the power of calculators, you give students access to mathematics in whole new ways" (Baum, 2020, para. 16). One argument against the integration of calculators is that many students already struggle with their ability to solve complex problems (Fry, 2023). Effectively using student-centered practices goes beyond calculators; students must not simply be given the tools to succeed but also the knowledge of how to use those tools responsibly. An increasingly common trend in educational institutions is to restrict the use of cell phones during school hours. These sorts of restrictions stem from students' lack of knowledge in responsible use of technology in school (Whitby, 2015). In order to strengthen students' responsible use of all technology in schools, calculators may be a good place to begin. Building on this theme of responsible technology use in school means asking tough questions about the advantages and disadvantages of calculators in the classroom "many families have questions about when or if kids should use a calculator" (Hodnett, n.d., para. 1). Families are not wrong to have questions about calculators in the classroom; however, there is already some helpful information from the National Center for Education Statistics (NCES) about this topic, "The understanding and competent use of technological tools are indispensable to U.S. students, all of whom will have a role in the nation's progress in the 21st century" (*Calculators and Computers*, n.d., para. 7). This

argument by the NCES is strengthened by a study published in 2006 which showed that integrating calculators into math education has shown in some cases favorable learning outcomes for areas such as functions & graphs (Ellington, 2006, p16-26). This is a topic of some debate; however, integrating calculators into the classroom is an innovative student-centered practice that has potential to both strengthen students' math skills and increase students' responsible use of technology in school and life.

Methods for Increasing Student Learning

Methods for Increasing Student Learning are at the forefront of effective education. Educators must always be assessing and evaluating their practices to ensure all the learning needs are being met. One leading reason for integrating calculators into the classroom is to ensure all students have access to the tools they need to succeed "All students can build mastery in mathematics when the conditions are right" (Marlow & Novak, 2022, para. 1). Ensuring that all students have the tools they need to succeed means looking out especially for English Language Learners, "students who speak English as a second language need special support to make sense of the complex instructions and linguistically challenging word problems that make up much of math instruction" (Noonoo, 2023, para. 1). Calculators could prove to be a valuable tool for increasing student learning, but many schools struggle with the responsible integration of technology in school. Technology, and calculators specifically, have the potential to be powerful tools for increasing student learning, but this sort of integration requires careful consideration and planning in order to have a positive effect on a school's learning culture (Marcinek, 2014). Another benefit of integrating calculators into the classroom is the increased student understanding of useful educational technology.Many educators and students struggled to adapt to the rapid switch to digital education tools when the Covid-19 pandemic began (Berwick,

2020). Students may be more resilient to a possible rapid switch to digital learning in the future if they already have adequate knowledge of important educational technology tools such as calculators. Resilient learners are comfortable facing challenges and have a growth mindset for learning and developing their knowledge and skills (Davidson, 2022). In order to effectively integrate calculators and increase student learning, educators must look beyond simply giving students a calculator and telling them to use it. Effective integration of calculators will encourage students to become more resilient and responsible learners; therefore increasing student learning. An important note about integrating calculators into the classroom is that the United States is not the only country where this idea is considered. An article published by University College London states, “using the devices [calculators] in maths lessons can help to boost pupils' calculation skills” (*Calculators Can Help Boost Children's Maths Skills, Research Suggests*, 2018, para. 2). This further highlights the breadth of this topic in education around the world; educators from other countries have also considered this method for increasing student learning. However, any integration would likely fall short of its goal if effective feedback is not provided to students, “Teachers can give feedback that produces learning growth” (Adams, 2023, para. 1). Increasing student learning goes beyond simply increasing student learning in mathematics. Educators are most effective when they are teaching the content and teaching lessons that will help students both in class and outside of class. Integrating calculators into the classroom requires resilience, responsibility, and feedback in order to increase student learning. The decision to integrate calculators into the classroom can be difficult for some teachers (Mason, 2010).

Conclusion

Calculators have been around for a long time now, and the question of their place in math education is still debated. There are logical arguments for and against the integration of technology in the classroom. However, in this age of constantly new and changing technology, it could prove valuable to teach students from a young age the responsible and effective use of technology; beginning with calculators. The integration of calculators into the classroom, when done effectively, could be a highly effective student-centered practice that increases student learning.

Chapter 3: Research Methodology

Research Question(s)

The research question that aligns with the previous problem statement is, “How will incorporating calculator se into an algebra curriculum affect learner proficiency in algebra?”

Participants or Stakeholders

The participants in this capstone research project are the 9th grade students in my basic algebra class. The students themselves would be directly benefiting from the interventions being developed from this research. By continuously performing research, and designing interventions based on that research, the world of education becomes better and brighter. For this particular research, there will be 15 students involved. The students who participate in this research come from varying ethnicities and backgrounds. One specific characteristic of the participants is their socio-economic background. These students come from a diverse socio-economic background ranging from lower-class, middle-class, and even some upper-class of the socio-economic spectrum. Another specific characteristic of the participants is their background in mathematics education. Most of the students participating in this research have struggled along their journey to learning mathematics. The plethora of diversity in knowledge and skills of mathematics among the student stakeholders creates an excellent environment for researching the aforementioned issue in mathematics education.

Data Collection Instrument(s) and Alignment to Research Question(s)

The instruments I will be using will address the research question directly by giving me valuable insights about the effect of teaching algebra with integrated use of calculators on students’ skills in concepts such as area and perimeter. The pre-assessment will yield important data about the students’ knowledge and comprehension before the research has been conducted,

and the post-assessment will yield important data about the students' knowledge and comprehension after the research has been conducted; therefore, providing a clear display of data to answer the research question.

Method

This research will make use of quantitative research methods because it will require the use of numerical data based on pre- and post-assessments. Mathematics is all about numbers and data. The analysis of the numerical data aligns with the research question by providing a clear picture of the knowledge and comprehension before the instructional intervention with the pre-assessment, and after the instructional intervention with the post-assessment. A comparison of the pre-assessment data with the post-assessment data will provide valuable insights as to the effectiveness of teaching algebra with integrated use of calculators on students' performance; therefore, aligning with the research question.

Data Analysis Technique(s)

The primary form of data analysis I will use to analyze the data is descriptive statistics. I will use the data collected from the research to calculate the mean, median, mode, and standard deviation of the numerical scores from each learner. This data will then be used to help in answering the research question. Using the data collected and the analysis of that data, a clear determination can be made about the effect that using calculators in algebra has had on students' algebra proficiency. "How will incorporating calculator use into an algebra curriculum affect learner proficiency in algebra?" The answer to the research question may be determined based on the data collected from the research project. Either the use of calculators in algebra learning has had a positive impact on learner performance, or it has not. The data collected during the research project would help in answering that question.

Timeline of Data Collection Activities

The timeline of the data collection activities is simple. On day one of the research, the pre-assessment will be given in order to gather important data regarding the knowledge and comprehension of students' algebra skills before the instructional intervention. Following a ten day instructional unit of algebra in which calculators are used by students, the post-assessment will be administered to gather important data regarding the knowledge and comprehension of students' algebra skills after the instructional intervention.

Resources

As both a teacher and a researcher, I have a wide-range of resources that I would require for this research. First, as a teacher I will need all the appropriate resources to create the assessments/data collection instruments which includes a printer, paper, and a computer. The data collection instruments include a pre-assessment and a post-assessment which would be created using a word processor and therefore require the use of a computer to create. Additionally, a decent calculator would be useful for efficiently calculating the statistical mean, median, mode, and standard deviation of the data collected.

Data Security and Confidentiality

I will ensure privacy and confidentiality of human subjects involved in the project and all data gathered will involve coding all participants' identities in the data collection to ensure privacy. A numbering system will be used to label each data and provide confidentiality of the data results. Furthermore, data will be kept in a safe and secure location accessible only by myself. The procedure to be used to remove all personal identifiers from the data collected involves coding all participants' identities in the data collection to ensure privacy. The data and study documentation will be securely stored in a lockbox kept in my personal desk. This location

is accessible only by me and will provide a safe and secure location for storing important data and documentation relating to the research. After the appropriate amount of time, the data will be completely destroyed by means of a paper shredder to ensure total destruction of confidential material and data.

Conclusion

Calculators in mathematics education is a topic of some debate. Some educators do not believe students should learn to use or rely on calculators, and other educators believe that students should be taught the effective and responsible use of calculators early on in their academic careers. To complete this research, a pre- and post-assessment will be used to gather necessary data. Furthermore, quantitative research methods will be used to make statistical inferences about the gathered data in order to support research conclusions with sound logic and data. This research seeks to find a logical answer to that debate that is based on data and analysis of that data. Furthermore, this research is important to the field of curriculum & instruction and especially important to the field of mathematics education because it could yield valuable insights into a long debated topic; technology vs tradition in algebra education.

Chapter 4: Results

Summary of Research

This research was conducted to gain an insight into the effectiveness of calculator use in a 9th grade Basic Algebra classroom. The research was conducted over the span of 10 instructional days and included 15 participants. Participants completed a pre-assessment without a calculator and then completed a post-assessment after the 10 day instructional unit which included the use of basic four function calculators. The research question is, “How will incorporating calculator use into an algebra curriculum affect learner proficiency in algebra?” This research directly connects to the research question by providing important data and insights that are necessary for finding an answer to the research question. Data collected through data collection instruments such as pre- and post-assessments provided necessary information to reach a conclusion about this research and an answer to the research question. For instance, The mean score of participants on the pre-assessment was 67.80% while the mean score of the participants on the post-assessment was 84.67%. This is an improvement of 16.87% which is a notable improvement in learner proficiency.

Summary of Results or Findings

PARTICIPANT	PRE-ASSESSMENT %	POST-ASSESSMENT %
1	64	87
2	61	92
3	72	79
4	75	87
5	87	98
6	63	92
7	85	89
8	63	76
9	57	78
10	74	86
11	66	88
12	54	69
13	81	94
14	56	82
15	59	73

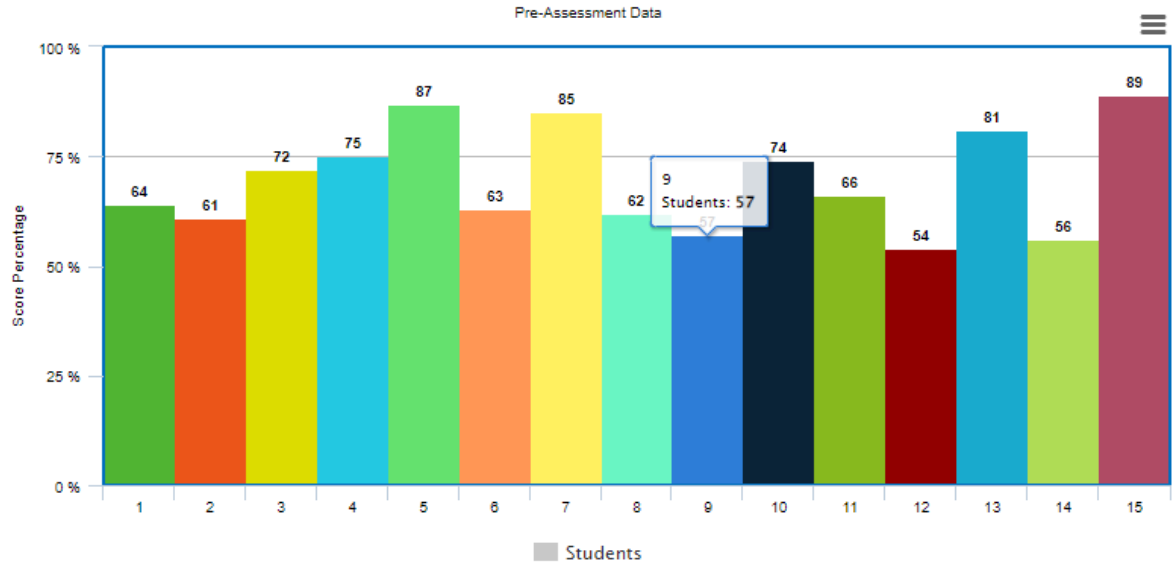
DESCRIPTIVE STATISTICS OF PRE-ASSESSMENT DATA:

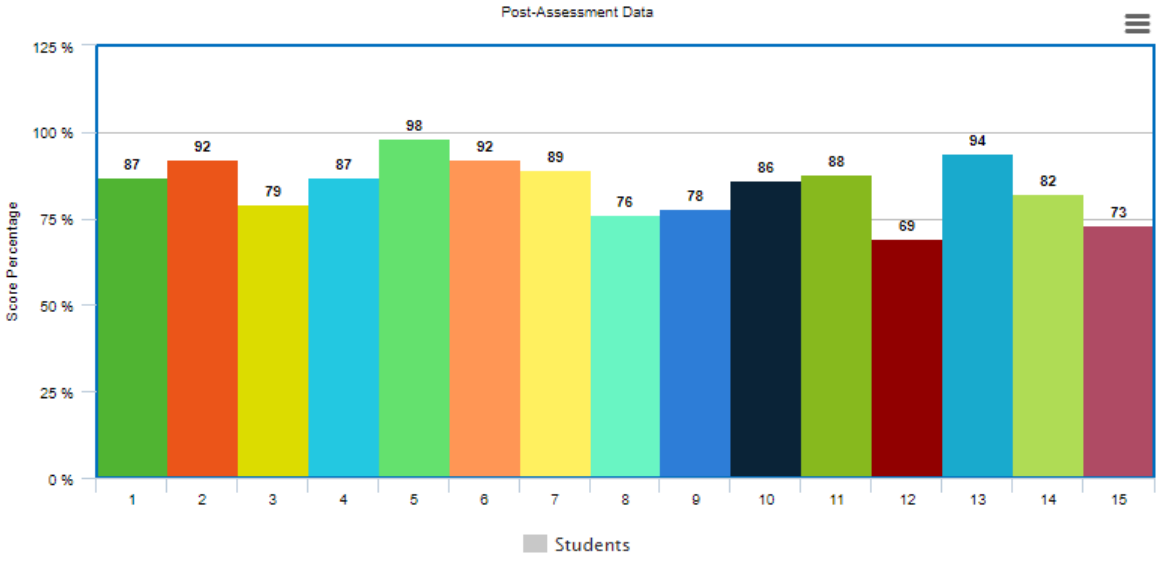
$mean = 67.80\%$
$median = 64.00\%$
$mode = 63.00\%$
$standard\ deviation = 10.26\%$

DESCRIPTIVE STATISTICS OF POST-ASSESSMENT DATA:

$mean = 84.67\%$
$median = 87.00\%$
$mode = 87.00\%\ \&\ 92.00\%$
$standard\ deviation = 7.98\%$

Analysis of the data from the pre- and post-assessments show a 16.87% increase in the mean score for participants. This increase in mean score indicates a notable improvement in learner proficiency following the instructional unit which incorporated calculators into the algebra curriculum. Additionally, the median and mode scores increase significantly between the pre- and post-assessments; also indicating improvement in learner proficiency. Finally, the standard deviation decreases by 2.28% between the pre- and post-assessment which indicates a more accurate data set surrounding the mean score. Lower standard deviation scores correlate to a more clustered data set which is indicative of the overall accuracy and reliability of the data set.





Implementation

This research was implemented over the span of two weeks of instructional time. On day one, the pre-assessment was administered in order to gather important data regarding the knowledge and comprehension of students' algebra skills before the instructional intervention. Following a ten day instructional unit of algebra in which calculators are used by students, the post-assessment was administered to gather important data regarding the knowledge and comprehension of students' algebra skills after the instructional intervention. Data analysis was the final component in order to provide a clear statistical determination about the data collected and research results. For data analysis, descriptive statistics was used on the data collected from the research to calculate the mean, median, mode, and standard deviation of the numerical scores from the pre- and post-assessments. This data was then used to help in answering the research question.

Answer(s) to the Research Question(s)

The research question is "How will incorporating calculator use into an algebra curriculum affect learner proficiency in algebra?" Based on the analysis of the data collected from this study, the answer to the research question is clear; incorporating calculator use into an algebra curriculum & instruction positively affects learner proficiency in algebra. The data paints a clear picture of participant scores that all increase on the individual level which translates to a notable increase in mean, median, & mode scores between the pre- and post-assessments following the implementation of calculators into the algebra curriculum. Furthermore, the lower standard deviation of the

post-assessment as compared to the standard deviation of the pre-assessment is a promising sign that the data is both accurate and clustered around the mean which indicates a positive trend in learner proficiency.

Product

The product is an instructional intervention. The intervention would involve including calculators into the algebra curriculum and instruction. Specifically, basic four function calculators could be used to strengthen students skills and proficiency in algebra. This instructional intervention will enhance learner proficiency in algebra education by directly altering the algebra curriculum and instruction to be more focused on fostering proficiency in algebra despite any weaknesses in arithmetic. Algebra is not always the easiest concept for students to grasp, and not allowing the use of common mathematical tools such as calculators could further the divide between failure and success in algebra class.

Chapter 5: Conclusions

Overview of Conclusion(s)

The research problem is that some students in my basic algebra class struggle to complete arithmetic portions of the algebra content; this impacts their ability to succeed in the actual algebra course content, and will cause them to either fail their course or struggle in future courses. The leading conclusion of this research is that implementing calculators into algebra curriculum and instruction has a positive, beneficial effect on learner proficiency. This conclusion is supported by the collected data which shows a notable increase in mean scores of students before and after the research was conducted. This research had a relatively low impact on the educational environment. By implementing calculators into the algebra curriculum and instruction, the educational environment was minimally impacted. For example, the content being taught was not altered, nor was the teaching of the content altered. Furthermore, the participants underwent the learning of the new material and technology in the same physical environment as they always do which aided learners by keeping them in a familiar and safe educational environment

Strengths and Weaknesses of Methodology

This research made use of quantitative research methods such as descriptive statistics. The strength of this methodology is the fact that the descriptive statistics, such as the mean, median, and mode, can be accurately calculated using the collected data. Therefore, there can be little doubt as to the accuracy of the quantitative data. However, a weakness of this methodology is the lack of non-numerical indicators it provides. Qualitative research methods would have provided additional data that could have aided the results and conclusions of this research. Nevertheless

the quantitative methods used for this research have provided the necessary quantitative data to aid in reaching logical and data-driven conclusions.

Influential Factors

Influential factors which may have affected the results include the diversity of the participants and the age of the participants. The wide-ranging diversity of the participants meant that there were students from many different socio-economic backgrounds. It was something that I needed to be conscious of as I planned this research as I knew that some participants would have had access to technology such as calculators before while other participants may not have had that same access. This factor could have affected the results by skewing the scores towards the participants who were already somewhat familiar with the calculator usage. Additionally, the age of the participants may have also affected the results. The participants ranged in age from 13-14 years old. Anyone who has taught teenagers before would agree that tenagers can at times be resistant to change and learning. Some participants were less excited to learn the new technology which may have affected the collected data because those participants either did not adequately learn to use the calculators or simply did not care enough to try.

Recommendations for Further Investigation

One area that I recommend for further investigation would be the effect that calculator use in elementary & junior high math education would have on learners' arithmetic proficiency upon beginning high school. The participants in this research did not have any official education regarding the use of calculators before this research was conducted. It would be interesting to investigate if teaching students to use calculators at a younger age would positively or negatively affect their proficiency in important areas such as arithmetic.

Barriers or Limitations to Drawing Conclusions

One limitation that affected the ability to draw conclusions based on the data was the lack of qualitative data. This study made use of quantitative research methods; however, having additional qualitative data could have provided an even clearer picture of the results from this research.

Implications of Research on Educational Practice

This research provides multiple implications for future educational practice. The first implication is that calculators can be an effective tool for boosting learner proficiency in algebra class. The findings indicate that implementing calculators into the algebra curriculum and instruction had a positive effect on learner proficiency. The second implication is that researching new methods and practices is a useful educational practice in order to determine what is effective and what is not. Educators should never feel limited by the methods and practices that they are comfortable with. Researching new methods and practices can lead educators to discover new and exciting practices, or it can lead them to rule something out and consider other ideas.

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Appendix A

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Task 4

Instructional Intervention

The purpose of this instructional intervention is to provide clear steps and procedures for implementing calculators into the algebra curriculum.

1) Gather resources. Basic four function calculators can be acquired in most consumer retailers or through various educational supply retailers.

2) Introduce students to calculators by beginning with a brief tutorial of the effective use of calculators in algebra.

3) Thoroughly outline responsible use of educational technology such as calculators in the educational setting.

4) Incorporate the use of calculators into the regular algebra curriculum by teaching students to use the calculators during the regularly planned practice and assessments.

5) Provide consistent assessments to measure and monitor learner proficiency in algebra concepts throughout the implementation and use of calculators in algebra education.

Appendix B

Basic Algebra Involving Arithmetic Pre-Assessment

NAME_____ DATE_____

Solve each algebra problem without using a calculator. Please show all work.

1) Solve the equation for x:

$27x = 81$

2) Solve the equation for x:

$x - 12 = 24 + 2x$

3) Solve the equation for x:

$16x - 48 = 19x + 4$

4) Solve the equation for x:

$2x + 7x = 39 - 4x$

5) Solve the equation for x:

$11x = 77 + x - x$

6) Solve the equation for x:

$x - 11x = -100$

7) Solve the equation for x:

$28x = 112$

8) Solve the equation for x:

$14x - 6x = 496 - 376$

Basic Algebra Involving Arithmetic Post-Assessment

NAME_____ DATE_____

Solve each algebra problem using a calculator. Please show all work.

1) Solve the equation for x:

$16x = 64$

2) Solve the equation for x:

$x - 9 = 21 + 3x$

3) Solve the equation for x:

$14x - 28 = 17x + 3$

4) Solve the equation for x:

$2x + 4x = 36 - x$

5) Solve the equation for x:

$10x + x = 99$

6) Solve the equation for x:

$x - 14x = -130$

7) Solve the equation for x:

$37x = 222$

8) Solve the equation for x:

$11x - 6x = 629 - 534$