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Enhancing STEM Education for East Tennessee in a Post-COVID World

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Enhancing STEM Education for East Tennessee in a Post-COVID World

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ABSTRACT

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I have identified a need for an analysis of the middle and high school STEM education curricula in the East Tennessee Region which does not effectively integrate technology into their current instruction, which results in low student engagement, motivation, and achievement in the instruction and learning of algebra and geometry. I propose a program to identify specific applications and methods to be integrated into these programs which will improve the abilities of teachers to positively impact their students' understanding and mastery of algebra and geometry.

Using emerging and novel STEM subject instruction, teaching, and engagement methods, and focusing on the analysis of the current uses of technology, identifying specific applications and computing systems, and providing necessary resources and support to teachers, the program I am proposing aims to cast a wide net for effective programs and adapt to new and innovative methods.

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I would like to thank Doctor Anant Godbole for the opportunity as a graduate assistant and to work with the Niswonger Foundation in the STEM Learning Design (LD) Program which ignited the fire and passion in me to pursue my journey in bringing about a change in the East Tennessee educational system for math and science classes, teachers, and students by inspiring the desire to pursue careers in the STEM field.

And I would like to thank my husband and family for their patience, encouragement, and support during these past few years, and most of all, I would like to thank my Lord and Saviour, Jesus Christ, without whom none of this would have been possible.

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BIOGRAPHY

Jennifer Lauer, nee Scott, graduated high school in East Tennessee and attended East Tennessee State University for part of her college courses when circumstances moved her to Maryland where she attended and graduated from the University of Maryland, College Park with a Bachelor of Science degree.

Jennifer worked briefly for the United States Dept. of Agriculture (USDA) in Beltsville, Maryland and later for the National Aeronautics and Space Administration (NASA) at the Goddard Space Flight Center in Greenbelt, Maryland.

Not long after, she decided to build a career of homeschooling her children, which allowed her to apply her knowledge and aptitude in STEM subjects, particularly math, to the math and science department of the Cedar Brook Homeschool Academy in Clarksburg, Maryland. She built an in-person and online tutoring business[1] for high school and college level students for nearly two decades before her husband retired and the family moved to East Tennessee, where she has assisted a local homeschooling group, New Vision[2], and consults with Alchemy Global STEM Institute (AGSI)[3] a STEM and robotics education program.

Her most notable work has been as a graduate assistant with the Niswonger Foundation in their STEM Learning Design (LD) Program under Dr. Anant Godbole which has helped define her future in teaching. As part of her path to her master's degree she assisted Dr. Ariel Citron-Arias in teaching OpenAI's AI-4-All[4] program to graduate and local Niswonger teachers.

1 BACKGROUND

This study aims to investigate the current use of technology in middle and high school STEM programs in the East Tennessee Region and determine the need for specific applications, computing systems, and methods that can be embedded into existing engaged teaching programs to improve the abilities of teachers and positively impact students' understanding and mastery of algebra and geometry mathematics.

The research will focus on identifying the specific technology resources and support that teachers require to effectively integrate technology into their instruction, and how technology can be used to enhance student engagement, motivation, and achievement in the learning of algebra and geometry.

The study will also examine the effectiveness of different technology integration strategies and explore how technology can be used to support the needs of diverse student populations. The research will provide valuable information for educators, administrators, and policy makers on the current use of technology in middle and high school STEM programs, and the potential of technology to support the teaching and learning of not only algebra and geometry mathematics, but other STEM subjects as well.

This study will focus on the following steps:

1. Research: Investigate the need for applications and specific computing systems to be embedded into the engaged teaching of middle and high school algebra and geometry mathematics.
2. Review: A review of existing research on the use of technology in mathematics education would be conducted to identify current trends and best practices. This would include studies on the use of applications and specific computing systems in the teaching

of algebra and geometry, as well as research on the impact of technology on student engagement, achievements in mathematics, and the instructors' overall satisfaction with the amended process and its outcomes.

3. Methodology: The study would be conducted using a mixed-methods approach, including both a survey and follow-up interviews. The survey would be distributed to a sample of middle and high school teachers who teach algebra and geometry, and it would gather data on the current use of technology in their classrooms, as well as their perceptions of the need for specific applications and computing systems to be embedded into the teaching of these subjects. Follow-up interviews would be conducted with a smaller subset of teachers to gather more in-depth information on their current use of technology and their perceptions of the need for additional technology in their classrooms.

4. Data Analysis: The survey data would be analyzed using descriptive statistics to identify patterns and relationships in the data. Any interview data gathered would be used to identify common themes and patterns in the teachers' responses.

5. Results: The results of the study would provide insight into the current use of technology in the teaching of middle and high school algebra and geometry, as well as the teachers' perceptions of the need for additional technology in their classrooms. It would also provide recommendations for the use of technology in the teaching of these and other STEM subjects, including innovative and newly emerging teaching and learning methods that would be beneficial to both teachers and students.

6. Conclusion: It is my belief that, at the very least, this study can provide our teachers with many untapped resources that are being developed every day and used to drastically improve student learning, comprehension, and retention of nearly all subjects, not just

STEM-related fields. Not only would this study provide valuable information for educators, administrators, and policy makers on the current use of technology in the teaching of middle and high school algebra and geometry, it would help to understand and define the direction of how future generations of both teachers and students can quickly learn and apply critically needed expertise in STEM fields. It would also provide recommendations for the use of technology in the teaching of these subjects and help to inform the development of professional development and technology integration initiatives.

2.1 Research

In the past two decades, there has been a trend in the use of technology in STEM education programs partially based on the growing body of research conducted by Ardito, Serpe, and Nirode, specifically in the areas of algebra and geometry in middle and high school programs in the US, specifically in the East Tennessee Region (ETR).

The Tennessee STEM Innovation Network (TSIN) and Battelle Education, which is associated with East Tennessee State University (ETSU) is a key proponent of improving STEM educational programs in, as the name implies, Tennessee. TSIN, through several grants, has begun to establish STEM "Hubs" in the East Tennessee Region to assist in the implementation of STEM programs.

In Middle Tennessee, TSIN partnered with the University of Memphis' Center for Research in Educational Policy to evaluate the efforts of the Tennessee Rural STEM Collaborative (TRSC) in a study during the 2015-2016 school year, whose purpose was to determine the STEM needs in rural Tennessee[5]. It was found that approximately 90 percent of students were familiar, or knew of, local STEM employment opportunities and felt it could benefit them in the future. In the same study concerning teachers, nearly all felt confident that all who were involved would benefit from a program that would broadly implement STEM education in the region.

While demonstrating the value of promoting the availability of STEM subjects to demographic areas that are under-resourced continues to be a major undertaking, TSIN also provides the much-needed accessibility by students to the advanced concepts in STEM subjects.

However, my experience in teaching, specifically in the STEM fields of Algebra and Geometry to middle and high school students, has led me to believe that there is a connection between teachers and the application of innovative technology and instructional methods that is not being emphasized enough by the education system.

2.2 Key Trends and Best Practices

Some of the key trends and best practices that have been identified include:

Specific teaching methodologies: Inquiry-based and problem-based learning are effective teaching methodologies for incorporating technology into the teaching of algebra and geometry. These methodologies encourage students to actively engage with the material, work collaboratively, and develop critical thinking and problem-solving skills.

Specific applications such as online applications, interactive simulations, virtual environments, and virtual and augmented reality can enhance students' understanding of mathematical concepts and improve their problem-solving skills.

Specialized technologies such as artificial intelligence, robotics, and coding platforms have been used in the teaching of algebra and geometry and have been shown to promote student engagement and motivation, as well as improve students' understanding of mathematical concepts and problem-solving skills.

The impact of technology on teacher-student engagement can enhance teacher-student engagement by providing opportunities for interactive and collaborative learning, as well as increasing student motivation and interest in the subject matter. Additionally, technology can be used to personalize instruction and support the needs of diverse student populations.

Program outcomes: Studies have shown that technology integration in STEM education programs can lead to improved student achievement and understanding of mathematical concepts, as well as improved problem-solving skills. Additionally, technology integration has been shown to promote student engagement and motivation in the learning of algebra and geometry.

Overall, recent research has shown that technology can be an effective tool in the teaching of algebra and geometry in middle and high school STEM programs, when used in conjunction with effective teaching methodologies and appropriate resources and support.

2.3 Current Research and Studies

While the following studies are current, they are from educational systems nationwide, however, most indicate that specialized technologies, including artificial intelligence, robotics, and a broad field of coding platforms used in the teaching of algebra and geometry have promoted student engagement and motivation as well as enhancing middle school and high school students' understanding of math concepts while also improving their problem-solving skills.

A study by Ardito et al. (2014) found that the use of robots in the teaching of algebra led to increased student engagement and motivation in the learning of math concepts and found that the use of robots improved students' engagement, teamwork, and problem-solving skills[6]. Ardito conducted robot-based challenges among several New York schools using LEGO Robotics assemblies. Researchers found that, in cumulative state-mandated testing, those students who participated in the challenges scored higher in algebraic concepts than those that did not participate (Ardito, 2014).

Incorporating algebra and coding, a study by Serpe (2017) found that the use of a coding in the gamification of an Algebra I unit for teaching purposes led to increased student engagement and motivation in the learning of algebraic concepts and problem-solving skills[7].

In the study, Serpe identified the success of motivating students through the aspect of developing video games by learning the basic steps of complex problem analysis and simple algebraic computing to design basic video games.

In a study that investigated the teaching of geometry through a coding platform by Nirode (2011), found that students were able to discover conjectures or verify theorems and provided students with accurate and dynamic visual aids that injected a technological change from the pace of the typical classroom routine[8].

These studies and research demonstrate that the use of innovative and unique learning methods and platforms in the teaching of algebra and geometry can have a positive impact on student engagement and motivation as well as improving students' understanding of mathematical concepts and problem-solving skills. Additionally, their use can also lead to greater success in these subjects and in STEM related courses and future careers.

2.4 Findings and Gaps

In the study by Ardito, while the use of robotics exploration "toys" motivated students to learn algebraic math concepts while exercising their creativity and bringing their imagination to life, the study was implemented at the college level to interest younger middle and high school students in STEM subjects. Further reading of Ardito indicates that robotics assignments and the associated coding were not part of a consistent curriculum from which basic skills are built upon throughout the school year. Alternately, the robotics program was used in a “non-linear fashion” to generate group discussion, collaboration, and improved communication among students.

The study conducted by Serpe in which the application BootStrap was used to gamify algebra I lessons, covered only 10 instructional segments, and was delivered to only 15 students in 1 of 7 algebra classes held during the year. With better-than-expected results where most of the participating students scored higher after using the program, it was also noted that teachers viewed the role of the BootStrap program to be not only helpful in teaching a subject they were minimally familiar with, but also giving them the experience and confidence to consider further exploration of using such programs.

In the study by Nirode and Foley, an already built dynamic geometry software (DGS) was used which visually represented calculations entered by students to visualize the translation of formula variables to actual geometric shapes. Although a limited number of DGS programs were available at the time of Nirode’s study (2012), similar applications are widely available, even on your phone (3D Calculator).

We can see from this short selection of studies that a variety of methods were used to generate interest and motivation in STEM subjects at early levels, and although we must credit these studies as successes in their own right, the one facet that each study has missed is this: What solicitation has been conducted of current teachers to determine their perceptions of technology integration into their classrooms?

Before any innovative teaching technology can be successfully incorporated into the classrooms of TODAY, it needs to be vetted by the professionals who are teaching now. Today’s educators know the capabilities and limitations of their students and the institutions they work for certainly know the populations that are serviced by their institution. I propose that bringing the combined successes of Ardito, Serpe, and Nirode into a program that solicits today's teachers' perceptions of their students, and their technological needs will result in a highly successful and geographically customized STEM curriculum that will serve the specific needs of the individual industries and job markets wherever it is implemented.

3 METHODOLOGY

3.1 Teacher Survey

While test results establish needed benchmarks within the education community, they only provide a snapshot of the immediate effectiveness of instructional programs. Correlations can be made connecting any student's test scores to later evaluative data, such as on-the-job performance reviews and performance or outcome data. Other factors that severely impact education outcome data sets are many and varied, including socioeconomic strata, employment and earning potential, and generational and regional biases, beliefs, and standards of living.

Overall, testing results are beneficial in determining gross directional changes for current curricula, and can be relied on, in general, as being a predictive basis for future behavior and performance in the workplace. While testing data is reliable and factual, I propose that focusing on the characteristics, capabilities, and recommendations of the current teaching cadre is the key to an improved outcome.

3.1.1 A Starting Point

The most reliable starting point is to determine what technology is currently being used in the local school systems, how teachers are currently using it, and what are teachers identifying as far as technology being used or is needed to meet the challenges that their students face.

The survey was developed to target certain data points, in general:

- The experiences of the teaching staff.
- The current use of technology in the classroom.
- The perspective of the teaching staff regarding the effectiveness of technology in the classroom.
- Identifying the effects of technology immersion for students.

- Determining the potential impacts of innovative teaching methods on student learning

The survey is comprised of five sections with a sixth section for closing remarks/comments. The five main sections are further broken down into detailed questions. (See Appendix A for the complete survey.)

The intention of the survey is to provide information on the current use of technology in the instruction of algebra and geometry and teachers' perceptions of the need for additional technology resources. It will also provide insight into the teachers' comfort level with using technology, their need for professional development and support, and their views on how technology is impacting student engagement, motivation and achievement in algebra and geometry.

The survey begins with the collection of brief demographic information in Section 1. Section 2 identifies the current frequency and integration of technologies in the classroom, as well as benefits from its use. Section 3 focuses on the teachers' perception of the impact of technologies used. Section 4 addresses resources and support structures for the use or future integration of technologies. Lastly, Section 5, which largely depends on student observation, solicits the teachers' professional opinion coupled with their experience in the field as to whether technology and innovative teaching methods would have a measurable effect on student comprehension and long-term retention.

3.2 Data Analysis

3.2.1 The Survey (Appendix A)

Using the teacher survey as referenced above, in conjunction with current trends and the research conducted in the case studies above, some expected patterns and relationships include:

1. Experience and education level: Teachers with more experience and higher levels of education in mathematics or mathematics education may be more comfortable and proficient with using technology in the classroom.
2. Frequency of technology use: Teachers who use technology more frequently in their instruction may perceive a greater need for specific methods and applications, computing systems, and technologies that could be embedded in their classrooms.
3. Integration methods: Teachers who use technology for interactive activities and online assessments already in the classroom may also perceive a greater need for unique or innovative methods to implement identified applications and technology that could improve the learning environment in their classrooms.
4. Perceptions of technology use: Teachers who perceive technology as enhancing their instruction or identify alternate/innovative technologies that may bridge gaps in algebra and geometry may have a higher technology proficiency level and be more comfortable with using technology in the classroom and implementing new teaching strategies.
5. Professional development: Teachers who have received professional development on how to use technology in the teaching of certain STEM subjects may be more comfortable and proficient with using innovative technology in the classroom.
6. Support: Teachers who feel they have enough support to integrate technology into their instruction may feel more capable and proficient in working with new or innovative technology in the classroom.
7. Student engagement and achievement: Teachers who perceive the use of technology in instruction as positively impacting their students' engagement, motivation and achievement may be more likely to adopt and use new technology more frequently in their instruction.

8. Technology proficiency: Teachers who rate their current technological proficiency as advanced may identify a greater need for innovative technologies that could be used in their classrooms.

These expected patterns and relationships can provide valuable information for educators, administrators, and policy makers on the current use of technology in the teaching of algebra and geometry, as well as the teachers' perceptions of the need for additional technology in their classrooms.

3.2.2 Survey Results (Appendix B)

As targeted in the data analysis and expected trends, our randomized, synthetic survey results (which, surprisingly, in real life are generally reflected in these contrived results) the following summary can be made:

Based on the fictitious survey data provided, it would appear that many math teachers are using technology in their classrooms to some extent, with interactive whiteboards being the most used. The majority use technology as a visual aid and for online assessments, while a smaller percentage use it for interactive activities. This suggests that there is potential for more interactive and engaging uses of technology in math classrooms.

However, despite the widespread use of technology in the example study, it can be inferred that there may be concerns among teachers regarding technical difficulties and an over-reliance on technology. Additionally, the data point to a rational assumption that some teachers may feel that they lack the necessary training and support to effectively integrate technology into their instruction.

The data also suggest that there may be a need for additional professional development opportunities related to technology use in teaching math, particularly in the areas of algebra and geometry. Providing more resources and support for technology integration could benefit instruction in these areas and potentially increase student engagement, achievement, and motivation.

It is also noteworthy that a majority of teachers in our study tend towards the belief or assumption that technology can increase student engagement and achievement in algebra and geometry, highlighting the potential benefits of technology integration in these subject areas. However, the results suggest that it appears that not all teachers feel comfortable or are able to use technology in their classrooms, indicating a need for additional training and support.

Overall, the survey data suggests that while many math teachers are currently using technology in their instruction, there is room for growth and improvement in terms of incorporating more interactive and engaging technology tools and providing necessary training and support for teachers.

4 IMPLEMENTATION

4.1 Program Goals

There is a need in the East Tennessee Region to develop and implement a program that intends to improve its educational system, not only for its students, but also improve the instructional programs for all teachers of STEM curricula in a post-COVID learning environment that will:

1. Integrate innovative and emerging technologies and improve the education model the East Tennessee Region; and,

2. Improve the methods used by teachers in the region in middle school, high school, and college education systems to implement and deliver such a model.

Overall, what is needed is an adaptation of the current education model and traditional teaching methods to the fast moving online and virtual learning environment and the assimilation of innovative teaching and learning mechanisms that is afforded by the exploding worldwide connected community.

The general goals of the proposed program are:

1. Integrating effective teaching and learning methods.
2. Improving the current methods used by teachers.
3. Improving the STEM curriculum in the State of Tennessee.
4. Improving the college education and ongoing education of teachers.
5. Develop a pilot project for testing the new methods and technologies.
6. Identifying the most effective methods and technologies.
7. Incorporating these new methods and technologies in STEM fields.
8. Preparing students for future careers in STEM fields.

9. Provide students with opportunities to explore and gain experience in these fields through internships, partnerships, and other hands-on experiences.
10. Encourage students to pursue education and careers in STEM fields through counseling and guidance.

4.2 Conducting the Program

Conducting this program and delivering such concepts at the state or county level with the desired outcome being the improvement and enhancement of students' grasp and comprehension of STEM application concepts coupled with the basics of programming, requires innovative and improved delivery methods that seek to capitalize on established and foundational methods as well as existing state educational requirements but also strive to push the boundaries of existing teaching paradigms.

Administrative and teaching personnel must continue to adapt to new methods and techniques as well as accurately identifying those that are outdated, ineffective, and have proven, anecdotally, their diminishing value as evidenced in college-level entrance exams and competency surveys from workforce organizations.

4.3 Goals and Benchmarks

4.3.1 Goals

The following goals and benchmarks have been identified as necessary to implementing change and promoting improvement in existing teaching methods, but more importantly, in the human outcome of understanding, comprehension, and application.

The long-term goal of the program is to improve students' understanding of STEM subjects in middle and high schools through the effective use of traditional and newly developed instructional methods by teachers. A secondary long-term goal of the program is to introduce new teaching methods, enhance traditional methods, and encourage teachers to seek improvements in their given institutions and fields of expertise with a generational goal of improving the scholastic proficiency of the future general population.

To determine the effectiveness of the program, the results of current instructional methods as well as the short- and long-term retention of STEM subject instruction will need to be bench marked using current data collection methods that target the appropriate student and teacher populations within the geographical area of the program research. These benchmarks will, of necessity, reflect both the strengths and weaknesses of the teaching methods currently being employed, whether successful or not.

Theoretically, the surveyed data can include results up to the time of implementation of the research program, but unfortunately will not include retention data until sufficient time has elapsed to gather such data. Because of advancements in other areas such as the improvement of programming languages, instructional innovation, and influences on the target student and teacher populations, the survey data categories should remain at high-level collection sources.

4.3.2 Benchmarks

Short-Term Benchmarks:

1. Increase the number of students scoring proficient or above on standardized STEM tests.
2. Improve teachers' knowledge of the latest educational standards and methodologies for STEM subject.
3. Increase the use of technology and hands-on learning experiences in STEM classes.

Long-Term Benchmarks

1. Improve the teacher-student connection and delivery of instructional material through teacher-driven, innovative, and emerging methods and technologies.
2. Improve overall student test scores in end-of-year/end-of-program testing and college/professional learning exams.
3. Improve basic subject matter retention rates, specifically in STEM subjects, which would be reflected in greater proficiency and competence in industries and the workforce in the East Tennessee Region.

4.4 Guidance for Teachers

This program does not seek to alter or change a teacher's approach to learning or conducting their established lessons. Instead, the intent of this program is to provide teachers with those tools and methods that they currently identify as missing or subpar in the effective delivery of the curricula they are given to teach with the overarching goal of ensuring long-term retention of the information, accuracy and proficiency in applying the subjects learned, and the ability to extrapolate data and infer solutions to problems in the post-education world.

4.4.1 Teaching Strategies

There is no single teaching strategy that is universally effective for all teachers and all students in imparting the intricacies of STEM subjects in middle and high school classrooms. However, data from the National Center for Educational Statistics[9] has shown that several teaching strategies can be effective in promoting student learning and understanding in STEM subjects, including:

1. Project-based learning: This approach engages students in real-world, hands-on projects that require them to apply their STEM knowledge and skills.

2. Inquiry-based learning: This approach allows students to ask questions, design experiments, and explore scientific and mathematical concepts in an open-ended and discovery-based manner.
3. Collaborative learning: This approach involves students working together in small groups to solve problems, discuss and critique ideas, and engage in hands-on activities.
4. Technology integration: This approach involves using digital tools and resources, such as artificial intelligence, simulations and virtual labs, to support student learning and understanding in STEM subjects.
5. Problem-based learning: This approach involves presenting students with real-world problems or challenges and having them work through the problem-solving process to develop solutions.

It's important to note that effective teaching in STEM subjects often involves combining these and other teaching strategies to create a dynamic and engaging learning environment that addresses the diverse needs and abilities of students. Teachers should also continually assess and adjust their teaching strategies based on student feedback and performance, as well as remain up to date on effective teaching practices in STEM education.

4.5 Suggestions for Improvement

The following selections and recommendations are intended as examples to address each of the identified areas of improvement or enhancement. Rather than offering these methods as individual courses merely for certification purposes or as ad hoc courses to be chosen cafeteria-style, it is recommended that teachers at all levels of experience, tenure, and position participate in the items selected by the individual institutions or educational organizations to establish instructional consistency, a rigorous learning attitude and environment, and predictably improved student retention and future proficiency.

1. Pursue professional development opportunities to stay up to date with the latest educational standards and methodologies for STEM subjects.

In the East Tennessee region, there are several organizations and institutes that offer professional development opportunities for teachers including workshops, online courses, and conferences. These include:

- University of Tennessee, Knoxville[10]
- East Tennessee State University[11]
- Tennessee Department of Education[12]
- The Tennessee Science Teachers Association[13]
- The Tennessee Educational Technology Association[14]
    - Workshops and training sessions can provide up-to-date applications and delivery methods on the effective use of technology and hands-on learning experiences in STEM classes. The University of Tennessee offers a range of workshops for teachers:
        - Hands-on STEM activities for the classroom: This workshop focuses on providing teachers with hands-on activities and experiments they can use in STEM classes to engage and inspire their students.

- Integrating technology in STEM education: These workshops explore the use of technology in STEM education, including the use of software and tools to support student learning and engagement in STEM subjects.
- Project-based learning in STEM education: This workshop focuses on the use of project-based learning in STEM education, including strategies for designing and implementing STEM projects that challenge and motivate students.
- Teaching critical thinking and problem-solving skills in STEM: This workshop explores strategies for teaching critical thinking and problem-solving skills in STEM subjects, including hands-on activities and lessons that can be used in the classroom.
- Engaging students in STEM through inquiry-based learning: This workshop focuses on the use of inquiry-based learning in STEM education, including strategies for designing and implementing inquiry-based STEM activities and lessons.

2. Online courses: UTK and other educational institutions also offer a variety of online courses for teachers, including courses on curriculum design, teaching strategies, and technology integration[15]:

    - Curriculum Design: Focuses on the development and implementation of effective curriculum in K-12 schools, includes curriculum development and alignment, lesson planning, and assessment strategies.
    - Teaching Strategies: These courses focus on effective teaching practices and strategies for classroom management, motivation, and engagement. Topics may

include differentiated instruction, formative assessment, and behavior management.

- Technology Integration: These courses focus on the use of technology in the classroom, including the integration of digital tools and resources to support student learning. Topics may include the use of digital tools for assessment, the integration of technology in STEM subjects, and online learning.

3. Conferences and Seminars:

- Provides encouragement and support to teachers to continue their professional growth and bring new ideas back to the classroom.
- Provides access to resources such as textbooks, lesson plans, and technology to support the delivery of a high-quality STEM curriculum.

4. Certification Programs:

- UTK's College of Education also offers certification programs in STEM education, technology integration, and online teaching and learning, providing in-depth training and professional development opportunities for teachers.

5 CONCLUSIONS

Assuming the successful implementation of an effective program as described above and using the survey results from teachers, some expected achievements and outcomes for students, teachers and the program's overall acceptance and growth include:

- For students:
- Improved understanding and mastery of algebra and geometry concepts.
- Improved problem-solving skills.
- Enhanced engagement and motivation in the learning of algebra and geometry.
- Greater success in STEM related courses and future careers.

A key expectation for students participating in the program is an improvement in their understanding and mastery of algebra and geometry mathematical concepts. By incorporating technology into the instruction of these subjects, students will have access to a variety of engaging and interactive resources that will enhance their learning experience. This, in turn, will lead to an improvement in problem-solving skills, which are essential for success in STEM related fields.

Additionally, using technology, students will be more engaged and motivated in the learning of algebra and geometry, which will lead to greater success in these subjects and in STEM related courses and future careers.

2. For teachers:

- Improved understanding and proficiency in the use of technology in the classroom.
- Improved teaching methodologies and strategies for incorporating technology into instruction.

- Greater job satisfaction and sense of accomplishment.
- Increased ability to personalize instruction and support the needs of diverse student populations.

Another key expected outcome is the improvement of the teaching methodologies and strategies for incorporating technology into instruction for the teachers who participate in the program. By providing professional development and support, teachers will gain a better understanding and proficiency in the use of technology in the classroom. This will enable them to effectively integrate technology into their instruction and to personalize instruction to better support the needs of diverse student populations. As a result, teachers may experience greater job satisfaction through a sense of accomplishment and well-educated students.

3. For the program:

- Greater acceptance and adoption of the program in schools and districts.
- Increased participation and engagement from students, teachers and parents.
- Increased funding and support from government and private organizations.
- Increased impact and success rate of students in STEM related fields.

Lastly, because of the potential for improved outcomes, the program is expected to gain greater acceptance and adoption by schools and districts, as well as increased participation and engagement from students, teachers, and parents. Over time, and with well-defined parameters to be examined, and specific, predictable outcomes as evidenced in test results and performance evaluations, the success of the program can be documented and used to garner increased funding and support from government and private organizations. This will allow the program to have a greater impact and success rate on the students in STEM related fields, which can be seen as an overall long-term success of the program.

Overall, an effective program that incorporates technology into the teaching of algebra and geometry in middle and high school STEM programs can lead to improved student achievement and understanding of mathematical concepts, as well as improved problem-solving skills. Additionally, technology integration can promote student engagement and motivation in the learning of algebra and geometry. Teachers will also benefit from improved understanding and proficiency in the use of technology in the classroom, improved teaching methodologies and strategies, and increased ability to personalize instruction and support the needs of diverse student populations. The program can expect greater acceptance and adoption, increased participation, and engagement and, potentially, increased funding and support.

APPENDICES

APPENDIX A (Survey)

This survey is intended for middle and high school teachers of algebra and geometry that gathers data on the current use of technology in their classrooms and their perceptions of the need for other specific applications, computing systems, and technology that could be embedded in their classrooms:

1. Demographic questions:

- What is your current teaching position? (e.g., middle school math teacher, high school geometry teacher)
- How many years of experience do you have teaching mathematics?
- What is your highest degree in mathematics or mathematics education?

2. Current technology use:

- What technology do you currently use in your mathematics classroom? (e.g., interactive whiteboard, tablets, graphing calculators)
- How frequently do you use technology in your mathematics instruction? (e.g., daily, weekly, monthly)
- How do you integrate technology into your instruction? (e.g., use it as a visual aid, use it for online assessments, use it for interactive activities)
- What are the benefits you see from using technology in your instruction?

3. Perceptions of technology use:

- How would you rate your current technology proficiency level? (e.g., beginner, intermediate, advanced)
- How do you think technology could enhance your instruction of algebra and geometry?
- What specific applications, computing systems, or technology do you think would be most beneficial to your students in the learning of algebra and geometry? (e.g., virtual reality, online graphing calculators, interactive simulations)
- How do you think technology could help to increase student engagement and motivation in the learning of algebra and geometry?
- Are there any concerns you have about using technology in the instruction of algebra and geometry?

4. Professional development and support:

- Have you received professional development on how to use technology in the teaching of mathematics?
- Are there any additional professional development opportunities you would like to receive on the use of technology in the teaching of algebra and geometry? (e.g., workshops, online training, mentoring)
- How comfortable do you feel with using technology in the classroom? (e.g., very comfortable, somewhat comfortable, not comfortable)
- Do you feel that you have enough support to integrate technology into your instruction? (e.g., technical support, IT support)

- How do you think providing more technology resources and support could benefit your instruction of algebra and geometry?

5. Student engagement and achievement

- How do you think technology use in instruction impacts student engagement in the subject of algebra and geometry?
- How do you think technology use in instruction impacts student achievement in the subject of algebra and geometry?
- How do you think technology use in instruction impacts student motivation in the subject of algebra and geometry?

6. Closing question

- Do you have any additional comments or suggestions on the use of technology in the instruction of algebra and geometry?

This survey is intended to provide information on the current use of technology in the instruction of algebra and geometry and teachers' perceptions of the need for additional technology resources. It will also provide insight into the teacher's comfort level with using technology, their need for professional development and support, and their views on how technology is impacting student engagement, motivation and achievement in algebra and geometry.

APPENDIX B (Survey Results)

*Note: This survey could not be distributed to teachers in the Niswonger Program prior to the writing of this thesis due to several complications that Dr. Godbole is able to elaborate on. However, the survey is planned for distribution before the 2023 Fall semester.

How the survey was conducted

The National Center for Educational Statistics contains large amounts of statistical data, but specific data sets for the questions in the survey were difficult to isolate and use in my research. A Google search led to a wildly varied and contradicting set of results that were not specific enough to completely satisfy the survey questions.

Since the survey was not distributed in time for the presentation of this thesis, I chose to use a variety of random number and color generators found on the internet to generate nearly all survey answers. Late in the development of my thesis, it was brought to my attention that artificial intelligence may be able to assist in finding and aggregating the results to form quasi-realistic answers for the synthetic survey. A colleague referred me to the site openai.com, also known as Chat GPT. Having little experience in the actual application of artificial intelligence, it was beneficial that, in a previous semester, I was briefly associated with Open AI through Dr. Ariel Cintron-Arias and his work on AI-4-All.

Prior to identifying OpenAI (Chat GPT)[16] as a resource, I used a random color generator to assign teacher degree levels, which I incorporated into the survey. Later, I was able to identify the distribution of college education levels earned among teachers and potential professional development opportunities for teachers using OpenAI to scour its own stored data from the NCES site. Along with this data, OpenAI also provided the location of the data on the NCES site. For the purposes of a synthetic and non-qualifying survey and considering the depth of the data on the NCES site, I chose to use the randomly generated data. OpenAI was able to assist in locating data for only two of the survey questions: Section 1, Question 3, and Section 4, Question 2:

Section 1 Demographic Questions Q3: What is your highest degree in [math] education?

While the random color generator assigned the answers as Bachelors (300), Masters (450), Doctoral (150), and Other (100), a search of the NCES data using OpenAI resulted in a somewhat similar ranking of degrees, but not the same distribution, with most graduating with a Master's degree (48%), Bachelors (47%), Doctoral (2%) and Other (3%).

Section 4 Professional Development and Support Q2: Are there any…opportunities you would like to receive…?

While the NCES site did not have specific percentages for responses to this question, OpenAI identified categories of "other opportunities" for teachers. Using these suggested opportunities, the results in the survey answers were randomly generated.

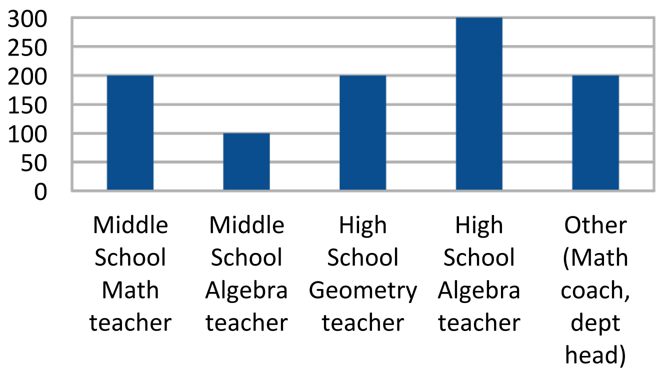
As stated previously, the remainder of the survey questions were answered by random number or random color generators found online.

The Survey Results

Described below is a fictional data set based on the survey questions, with responses randomly generated to reflect a somewhat realistic distribution:

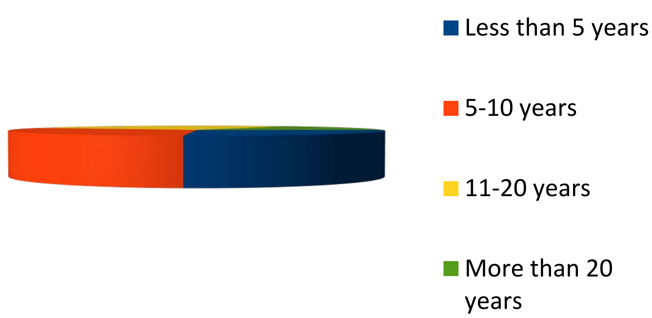
Demographic questions:

What is your current teaching position?

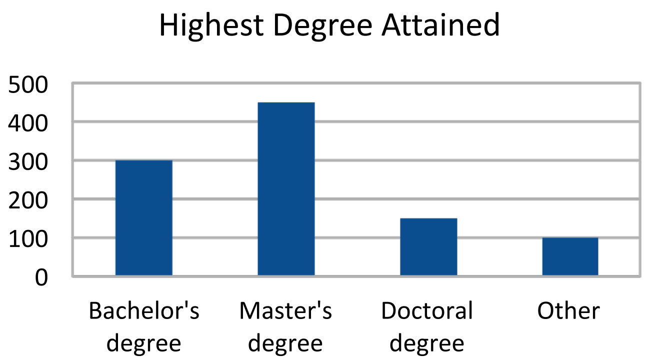


200 Middle School Math Teachers
300 High School Math Teachers
200 High School Geometry Teachers
100 Middle School Algebra Teachers
200 Other

How many years of experience do you have teaching mathematics?

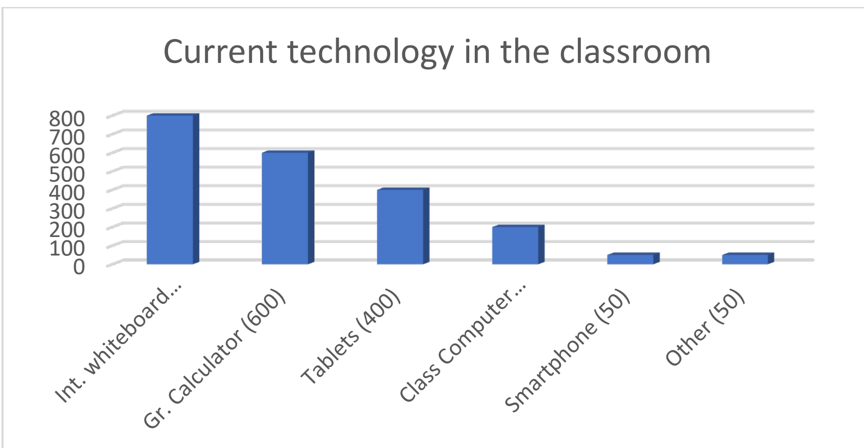


What is your highest degree in mathematics or mathematics education?



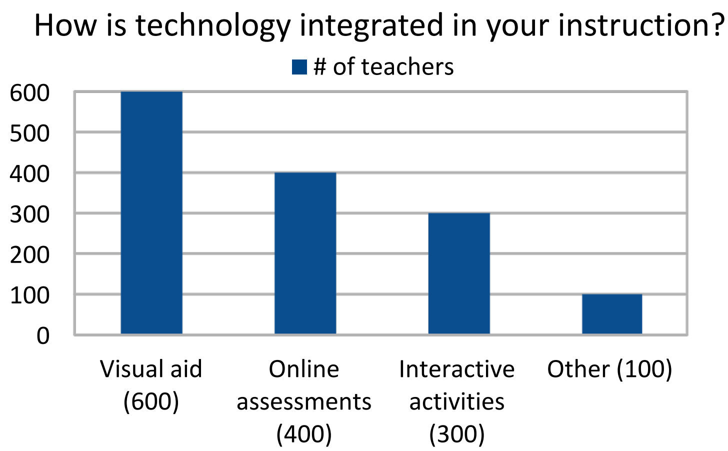
BS: 300
M: 450
PhD: 150
Other: 100

2. **Current technology use:**

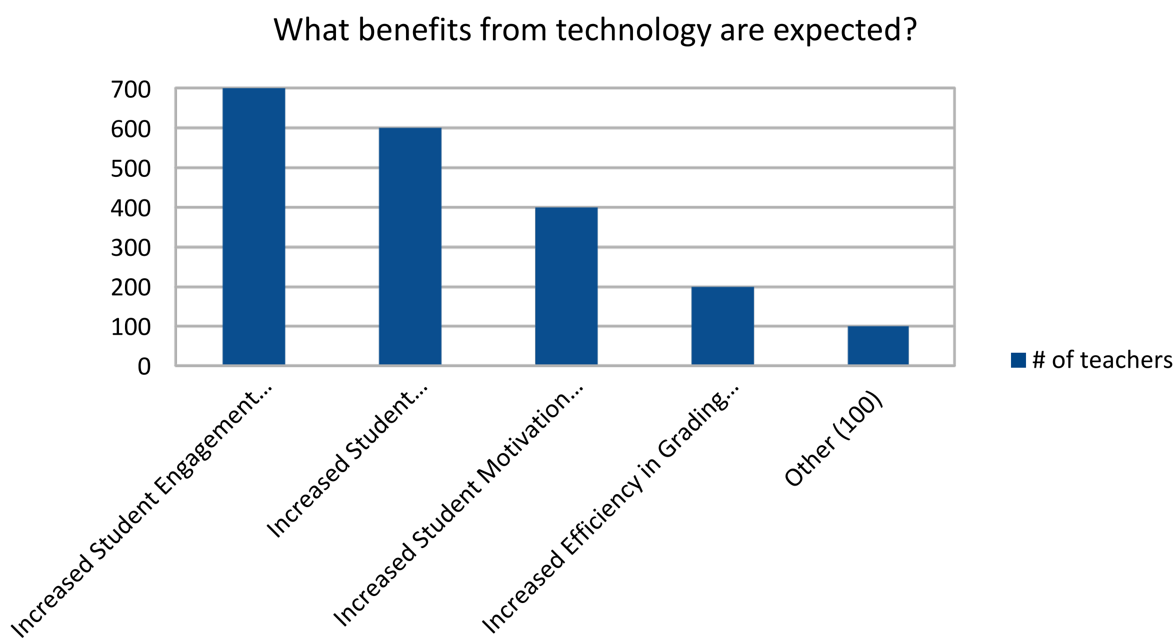


How frequently do you use technology in your mathematics instruction?

How do you integrate technology into your instruction?

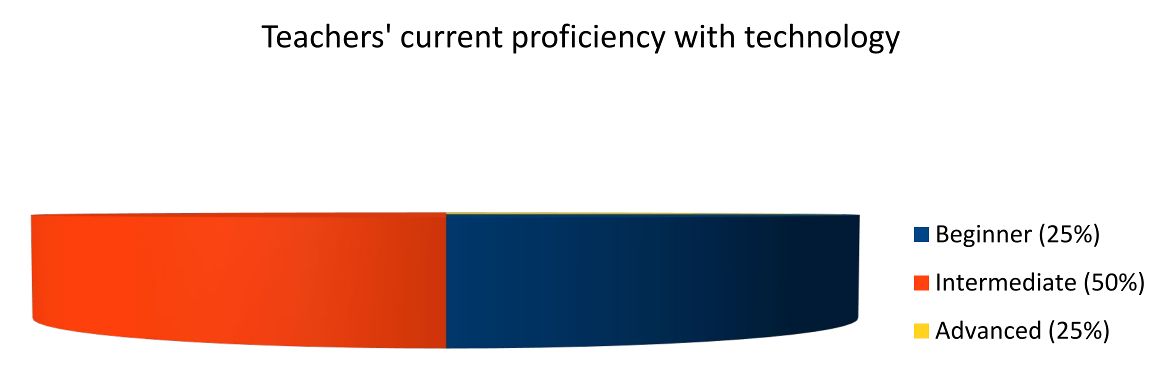


What are the benefits you see from using technology in your instruction?

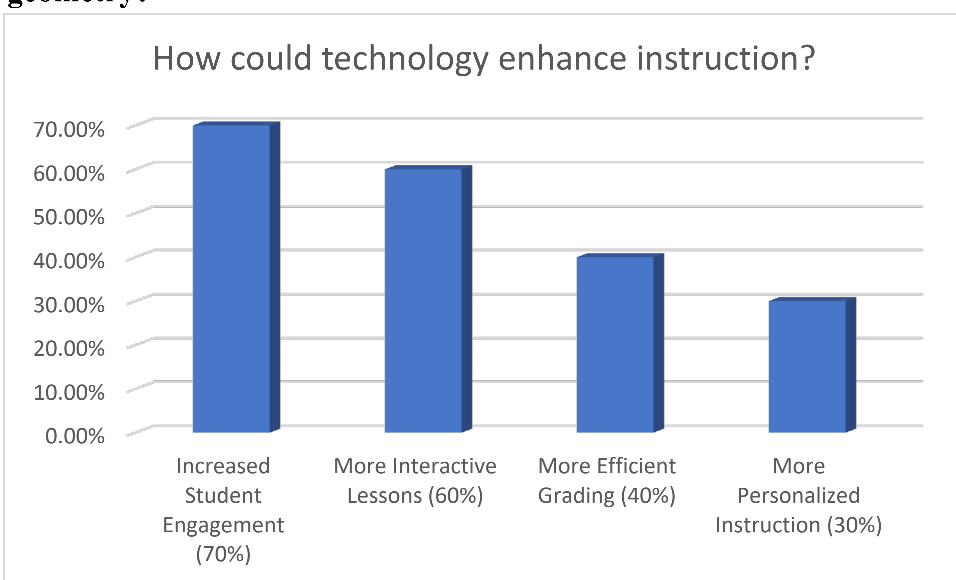


Perceptions of technology use:

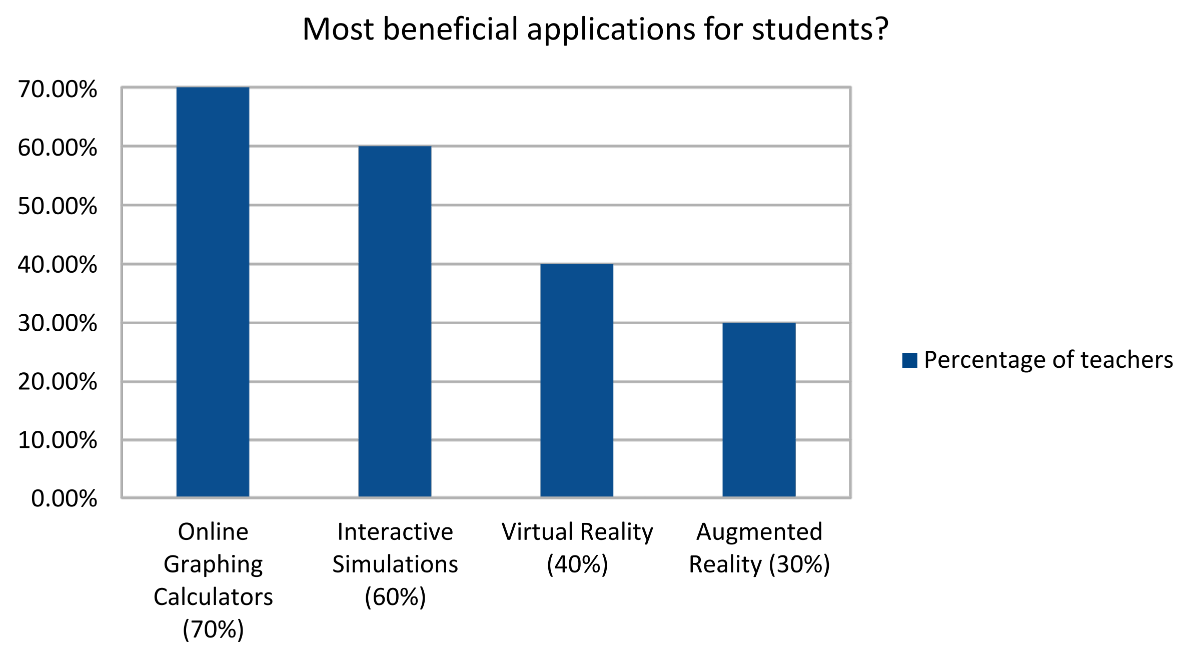
- How would you rate your current technology proficiency level? (e.g., beginner, intermediate, advanced)



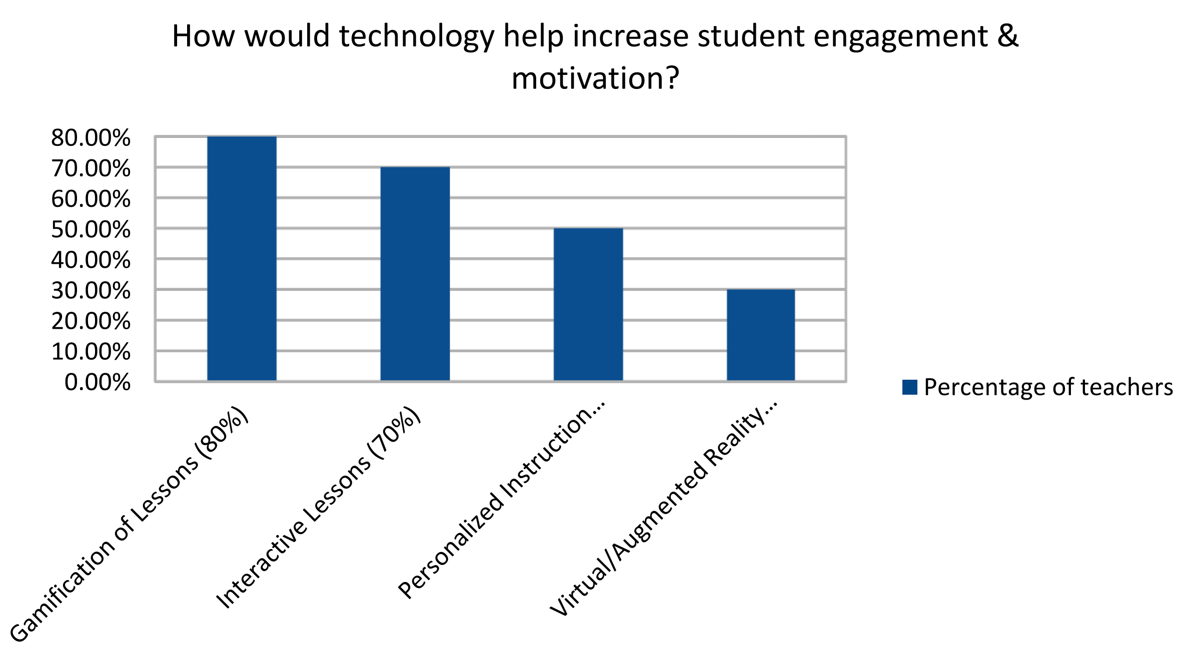
How do you think technology could enhance your instruction of algebra and geometry?



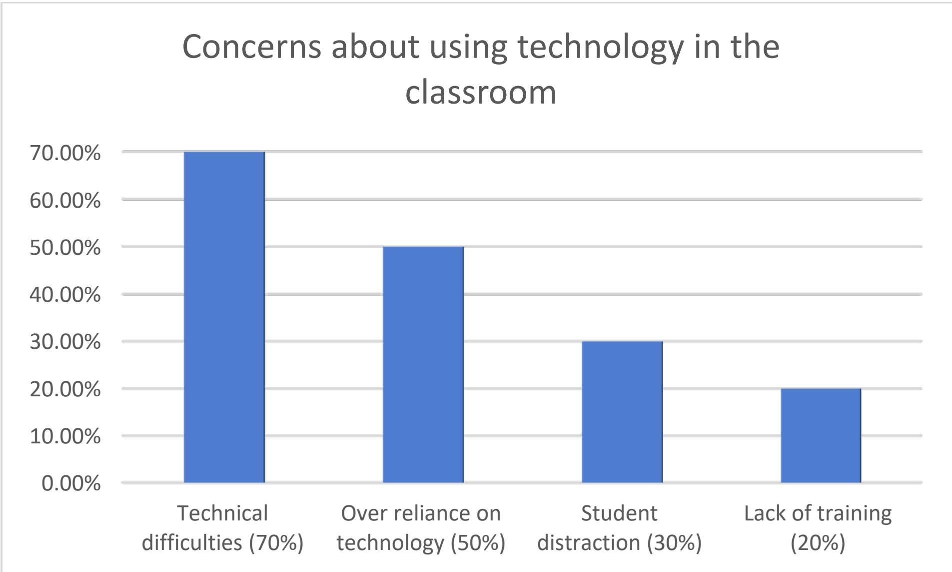
What specific applications, computing systems or technology do you think would be most beneficial to your students in the learning of algebra and geometry? (e.g., virtual reality, online graphing calculators, interactive simulations)



How do you think technology could help to increase student engagement and motivation in the learning of algebra and geometry?



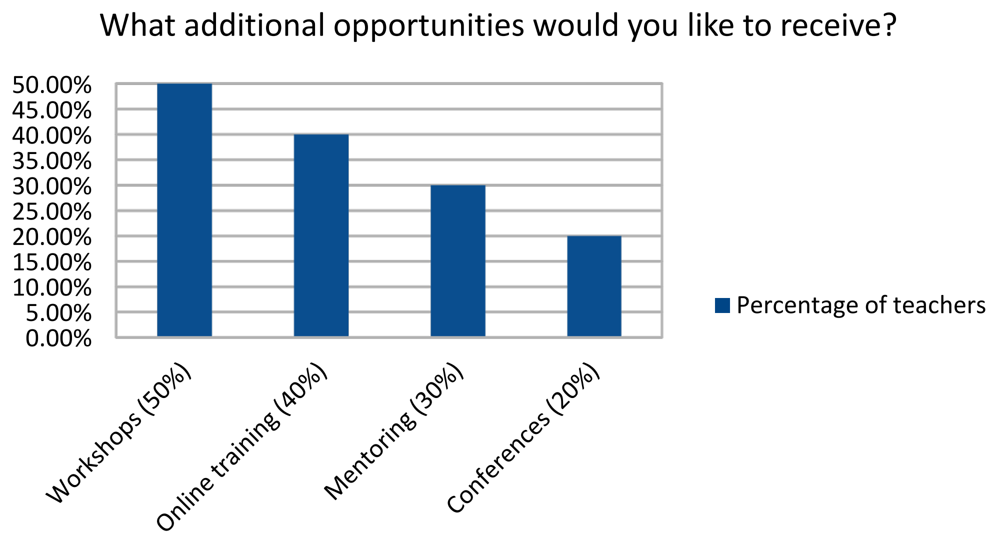
Are there any concerns you have about using technology in the instruction of algebra and geometry?



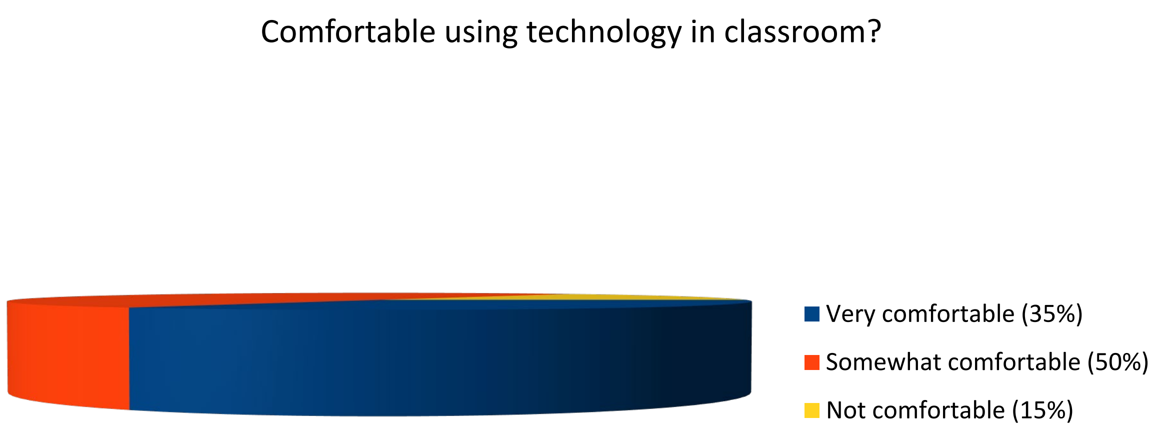
4. **Professional development and support:**

Have you received professional development on how to use technology in the teaching of mathematics?

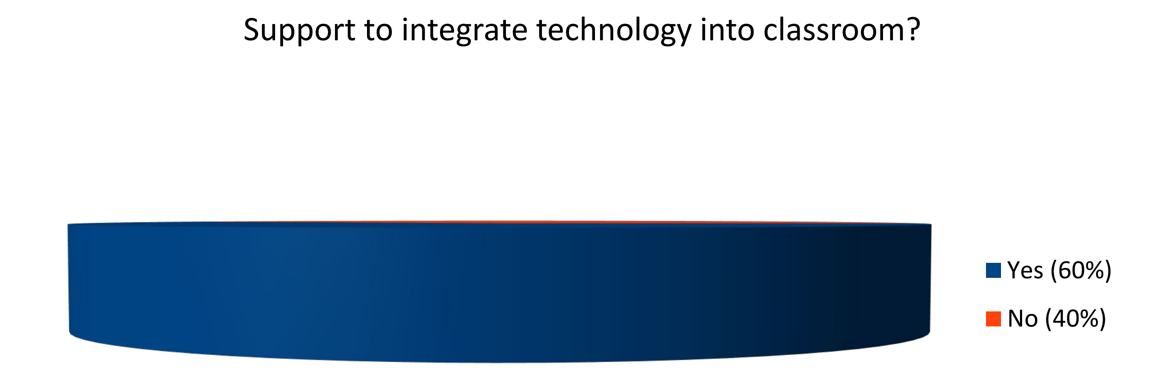
Are there any additional professional development opportunities you would like to receive on the use of technology in the teaching of algebra and geometry? (e.g., workshops, online training, mentoring)



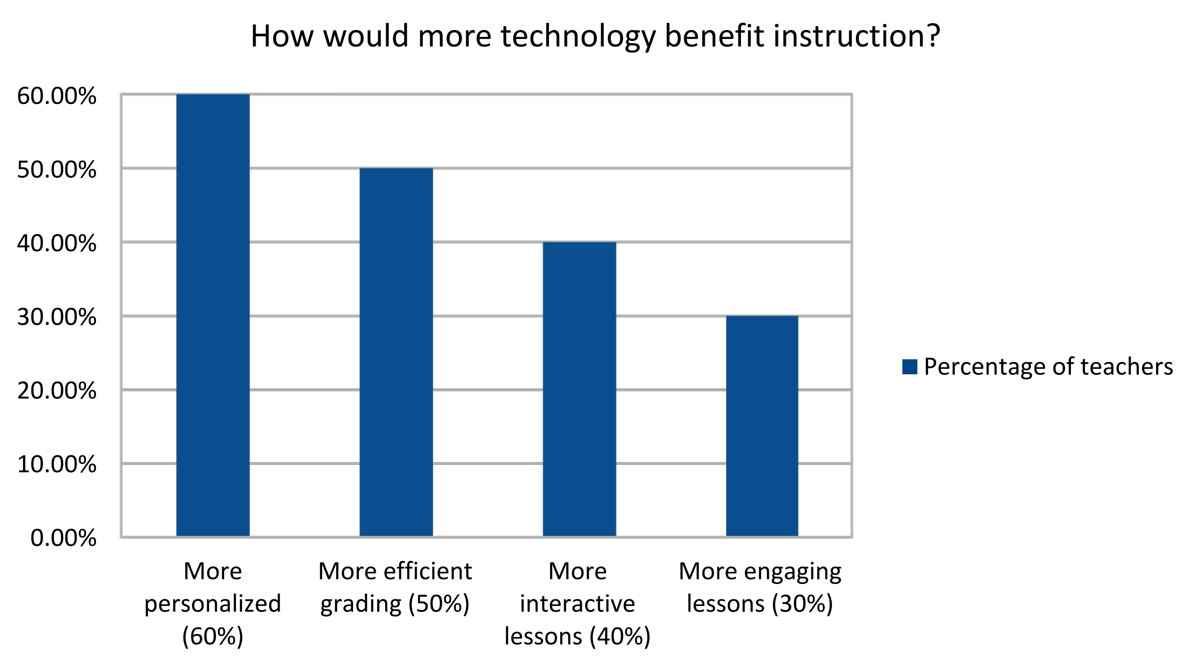
How comfortable do you feel with using technology in the classroom? (e.g., very comfortable, somewhat comfortable, not comfortable)



Do you feel that you have enough support to integrate technology into your instruction? (e.g., technical support, IT support)

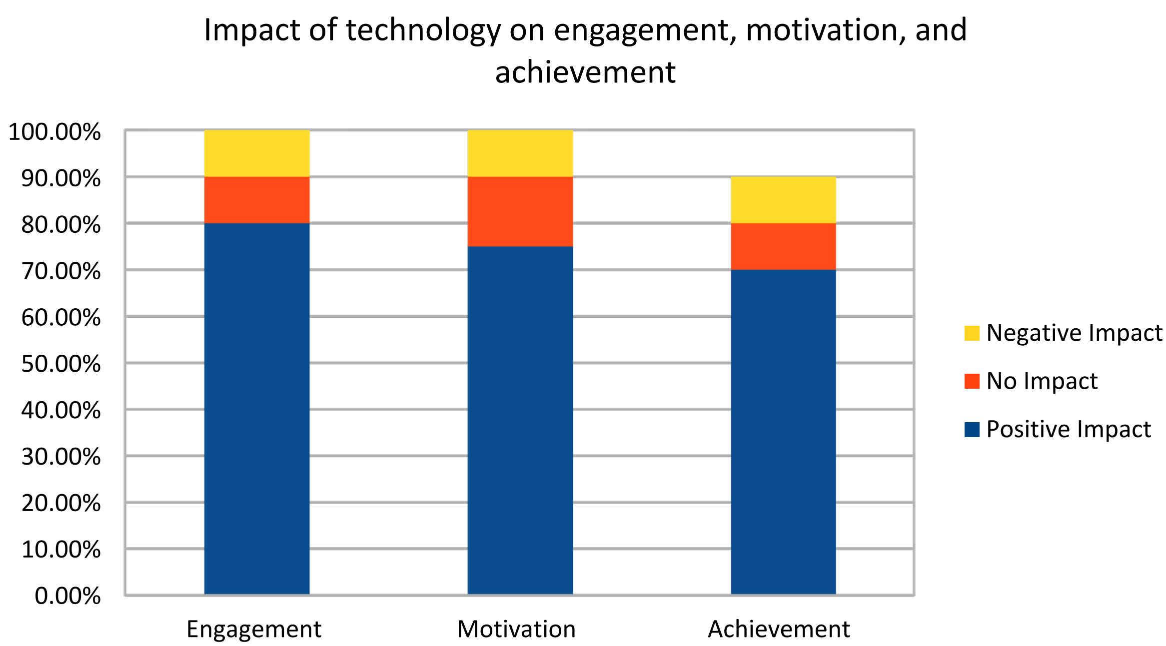


How do you think providing more technology resources and support could benefit your instruction of algebra and geometry?



5. Student engagement and achievement

How do you think technology use in instruction impacts student engagement, motivation, and achievement in the subject of algebra and geometry?



6. Closing question

Do you have any additional comments or suggestions on the use of technology in the instruction of algebra and geometry?

- Many teachers commented that they would like to see more technology resources and support made available to them, as they feel that they do not have enough currently. Several teachers also suggested that more professional development opportunities be offered to help them better integrate technology into their instruction.

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