

**Educational Technology in Math Classroom: Technology Integration Influence on Math  
Teaching and Learning**

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**Abstract**

This paper aims to answer the following question: How does technology integration in the math classroom influence teaching and learning? The methodology included an extensive analysis of quantitative and qualitative data obtained through a literature review and analyzed through a conceptual framework that combined activity theory, anchored instruction theory, and self-study framework. The study concluded that educational technology integration in math classrooms facilitates teaching and learning by increasing students' interest, engagement, and self-efficacy. Meanwhile, options such as simultaneous access to apps with the students and various feedback analysis resources contribute to successful teaching.

*Keywords:* Educational Technology, Multimedia, Gamification, Facilitate Teaching and Learning

Using technology in education has a long history. Wright (2018) mentions that although in the 1920s and 1930s, people like Pressey created machines to assist teaching and learning, integration was unsuccessful simply because of fear of technology, cost, and doubting its effectiveness. Afterward, the situation improved in the 1950s when American politicians like President Eisenhower responded to Russia's technological advancement, which he called the Sputnik crisis, by supporting technology integration into education. Later on, according to Li and Ma (2008), technology usage in educational settings became widespread as more compatible microcomputers with lower prices entered markets by the late 80s. Finally, as Ran et al. (2022) mention, the technological development milestone of 2006 that introduced mobile devices and augmented reality increased natural technology augmentation in education even further.

### **Statement of Problem**

The pandemic of 2019 that sent all students in the United States to online learning shed a stronger light on educational technology and its application in education. Many research topics focus on teaching methods that enhance teaching effectiveness and student learning. According to Li and Ma (2010), educational technology refers to the technical means, such as computers, educational software programs, interactive media, and telecommunication systems, that support teaching and learning. Although technology implementation in the educational system is emphasized at the local, state, and federal levels (Kaczorowski, 2019), we rarely find math teachers who integrate technology into their pedagogies besides technological devices such as projectors. As Wright (2018) puts it, "Advanced technology has the potential for positive change, but it is necessary to make sure that people embrace science over mysticism" (p. 5). This paper aims to answer the research question: How can educational technology integration increase student understanding of concepts in mathematics and improve student learning in math or

support teaching? The objective is to find the potential benefits of using technology in mathematics classrooms for teachers and learners and help math educators to make informed decisions regarding technology applications.

### **Justification of the Study**

Wright (2018) reports on Stanford philosophy professor Patrick Suppes' prediction of computer and software integration in education. Suppes believed that Alexandre the Great benefitted from Aristotle's tutoring tremendously. However, training Aristotle-like figures to tutor a large population is not cost-effective and even impossible. Through technology implementation and purposeful educational software, we can make the benefits of individualized tutoring and learning support available to all students (Wright, 2018). Technology is gaining a more vital role in human lives as time passes. In the 21st century, educators' access to various technological tools and applications has increased enormously (Ran et al., 2022). However, research to evaluate their impact on learning is slower than their development speed (Jackson et al., 2013). When the internet and technology are blended into students' lives with exciting multimedia technologies and applications innovations, it is necessary to focus on the efficiency of technology integration in math classrooms (Nasir et al., 2012).

### **Positionality**

I come from the Middle East, where schools typically lag behind the latest research findings and technology due to poor economy, war, and Western sanctions, to name a few. When I started working in the U.S. as a para educator, teachers' thirst for research-based practice and technology implications in education caught my attention. I realized how technology facilitates teaching, primarily through apps with monitoring options and immediate feedback, and it supports learners' higher levels of cognition in different ways. I have gradually realized that

technology implementation became a significant part of my teaching philosophy due to my life experiences and new vision. I stand with the National Council of Teachers of Mathematics (2015) and believe that the technology must be used strategically and thoughtfully in "all classrooms to support all students' learning of mathematical concepts and procedures" (para. 1).

### **Review of the Literature**

In the world of Education, technical means such as computers, educational software programs, and interactive media systems that support teaching and learning are referred to as educational technology (Li & Ma, 2008). Researchers like Nusir et al. (2012) recommend educators consider updating their knowledge and adopting technological methods and strategies to create a compatible education for today's learners. For instance, they advise teachers to increase students' interactivity by integrating the multimedia learners use outside the class in their pedagogy. But how does technology integration in the math classroom influences teaching and learning? In this section, we review some research findings on the influence of technology on teaching and learning, students' engagement, interaction, and self-efficacy.

### **Multimedia and Gamification**

In two separate experiments, researchers evaluated the effect of multimedia on math teaching and learning. First, Kaczorowski et al.'s (2019) researched the impact of multimedia on diverse learners by implementing a mobile technology-based multimedia math called an e-workbook during core math instruction. Researchers categorized 19 fourth-grade students, into three subgroups, Tier 1, Tier 2, and MLD (mathematical learning disabilities), based on a comprehensive evaluation of each student's report. Then, they observed their work habits within different comparative conditions, the traditional Paper and Pencil Worksheet, the Scaffolded Worksheet (SCW), and an e-Workbook that contained multimedia for ten calendar weeks. The

SCW had similar question reviews, color coding, and organization as the e-Workbook without multimedia. However, their teacher's interview results showed a roughly 100% increase in all the subgroup's engagement during all sessions throughout the intervention. Besides that, 72% of the students also preferred using the e-Workbook. The findings suggest that the incorporation of multimedia helped all the students, regardless of their learning ability, to expand their learning opportunities and facilitated mathematical knowledge inquiry.

Further, Nusir et al. (2012) conducted a study on four first-grade classes, randomly divided into two groups, learning two topics from the math curriculum. In the first step, group one was offered instruction and assessment in a traditional teaching way, while group 2 was offered the interactive multimedia program for instruction and assessment, and they swapped strategies in the second round. Both teams took a math exam at the end of each session. Researchers found that S.D. for the multimedia group was 2.06 and for the traditional was 1.41, and the correlation between the results from both tests of students who took both tests was +0.29. Test scores showed that the group that used computer-based interactive multimedia outperformed the traditional group, confirming the positive impact of multimedia interactive programs on primary students' math learning. As Nusir et al. (2012) mention, student motivation increased due to the graphics and animation used, particularly with the famous cartoon characters. The increased attention based on engagement could lead to increased learning and better math performance.

In another article, researchers studied the effects of gamification on math learning. In their quasi-experimental study, Jagust et al. (2018) compared 54 students' performances in three classes and in four different conditions of gamification labeled as non-gamified, competitive, adaptive, and collaborative to explore the benefit of various combinations of game elements such

as narratives, adaptive algorithms, and simple collaboration. The non-gamified students were presented with a digital lesson through the Math Widget but with no gamification feature. The other groups interacted with different combinations of competitive, adaptive, and collaborative game elements separately. The effect of gamification on performance confirmed a significant interaction [ $F(6, 54) = 2.716, p = 0.0014$ ], a significant difference between the gamified and non-gamified ( $p = 0.002$ ). However, the difference between the three different gamified experiments was nonsignificant.

In Mexico, Lopez-Morteo and López (2007) also evaluated students' motivation and behavior toward mathematics and the learning outcome after introducing recreation-oriented learning elements called Interactive Instructors of Recreational Mathematics (IIRM). The study analyzed the motivational effect in three short, motivation-oriented courses for three separate groups of high school students (A-C) interacting with a math game named Arithmetic Memory Game or ArithMem. They define the collaborative electronic learning environment as a collaborative workspace that generates knowledge through playful learning objects. Meanwhile, they surveyed 77 students at a local high school as Group D. Afterwards, they conducted a K.S. on the data, all four groups answered questions, and the result was a significance level ( $p=0.01$ ). After analyzing students' answers to pre-written questionnaires, it was concluded that students expressed excitement about using computer games and interaction tools. Furthermore, results were encouraging by 70% of students answering questionnaires positively regarding motivation power. In general, 70% of students also felt comfortable using games in learning environments. Furthermore, almost 60% believed that the system was adequately usable. Meanwhile, they appreciated that the content was offered innovatively through recreational learning objects.

On the other side of the globe, Lin and Cheng (2022) conducted a quasi-experiment by applying a technology-enhanced board game to support students in reviewing and applying prime factorization concepts after traditional instruction to elementary students in Taiwan. The same teacher taught the control and experimental groups with their 20 years of teaching for the instruction part. However, the control group students took the traditional review and knowledge application route, while the experimental group took the technology route. The board games used are card games developed using mobile and sensor technologies. The measurement tool consisted of a learning attitude questionnaire, a learning motivation questionnaire, a prior knowledge test, and a learning achievement test. Students' prior knowledge and learning attitude was tested before the teacher conducted the three teaching sessions over two weeks. Finally, both groups took a learning attitude questionnaire, a learning motivation questionnaire, and a learning achievement test. An independent t-test was used to ensure the homogeneity and equivalent prior-knowledge test and learning attitude to conduct a fair study. The result of the average learning achievement score of the experimental group was significantly higher than that of the control group,  $p = 0.044 < 0.05$ . Meanwhile, the two groups had a significant difference in the learning attitude post-questionnaire,  $p = 0.001 < 0.05$ . Regarding the learning motivation after participating in the review session, the result of the independent sample t-test showed a significant difference between the two groups ( $t(20) = 3.59$ ,  $p = 0.002 < 0.05$ ), confirming a higher motivation in the experimental group.

In the Midwest, another group of researchers ran an experiment on 55 students from two 4th-grade classes of the same math instructor in an elementary school. Jackson et al. (2013) conducted a study to examine the effect of integrating an interactive tabletop into an elementary mathematics classroom. Researchers used self-report and performance data to analyze the effects



of embedded technology on 26 students in the experimental class and 27 in the control group. Results indicated that there were no significant main effects of time or treatment conditions (Time [ $F(1, 40) = 0.34, p = 0.56, g2 = 0.01$ ] & Treatment [ $F(3, 40) = 2.58, p = 0.07, g2 = 0.16$ ]). This means the attitudes toward technology in the classroom were equivalent across time and gender groups in the pretest and posttest. The results of the students' reaction questionnaire were received from 14 students out of 26, marked as positive or negative. Although subsequent coding and interpretation were not conducted due to the small turnout, the overall reaction was positive. For the performance results, the average of the first-semester two math tests was treated as a pretest score, and the average of the two math tests in the second semester was treated as a posttest score. The MANOVA was conducted, and although it did not show a significant main effect of time  $F(1, 41) = 0.198, p = 0.658, g2 = 0.004$ , there was a significant improvement in the math test in the male experimental group ( $ps$  more than 0.09).

Regarding the benchmark scores, they used the average of the three tests as the pretest and the last benchmark score as the posttest score. The multivariate analysis showed significance within the main subject effect of time and the main subject effect of condition. The pairwise comparison revealed much higher post-treatment scores than pretest scores across groups. So, an analysis of variance ANOVA was conducted, which showed no significant difference over time  $F(3, 44) = 0.399, p = 0.75$ . So, when the grades were the criteria for math achievement, boys showed significant improvement, and when the benchmark scores were the criteria, students in the experimental group showed achievement but were not significantly different compared to the control group students. Regarding the cognitive learning of all students, when grades were chosen as the criteria, the improvement was more promising.

### **Context Matters**

To understand the influence of contextual factors on educational technology integration success, Li and Ma (2008) conducted a meta-analysis research on 81 independent effect size findings from 39 studies that included 59,147 students in K-12. The goal was to understand how the magnitude of the effects of technology fluctuates in response to various study features.

Their final model for analysis included all significant variables performed for their first and second sample populations. In the 1st population, the grade level significantly predicted the effect of the technology on math achievement, and it was more significant with the same technology used in secondary compared to elementary school. The second population result showed gender and grade level as the most reliable predictors and the enhanced effect associated with students in elementary and groups of greater than 55% females. The results confirmed students benefitted from technology and that regardless of the sample population, students' grade level contributed most to the effect of technology on mathematical achievement.

Li and Ma (2010) conducted another study examining the existing empirical evidence on the impact of computer technology (C.T.) on mathematics learning in K-12 classrooms. Their research was based on 85 independent effect sizes extracted from 46 primary studies involving 36,793 learners in k-12 classrooms since 1990. The overall effects of C.T. on students' math achievement were taken by weighted mean effect size, giving more weight to findings from larger samples. ANOVA was used for subgroup analysis to calculate the average effect of C.T. among groups. Another analysis was done, applying a simple WLS regression model to examine the relative impacts of study features. The average weighted Cohen's  $d$  was 0.28 SD, 95% confidence interval from 0.13 to 0.43. This explains that although the low Cohen  $D$  reflects a small magnitude change, the positive change is most likely due to the intervention. They state that C.T. implementation had an overall positive impact on math achievement, with the mean

ES=+0.71. They also found a small magnitude of more advantage for elementary students than for secondary students (SD 0.22). In addition, the influence of teaching methods on technology success in math achievement was notable (1.00 SD), and constructivist settings resulted in more success. Moreover, the results of 1.31 SD showed a significant effect on students with special needs compared to general education students (Li & Ma, 2010).

Comparing all the elements, they conclude in their research that learner's achievement is noteworthy when C.T. was used (a) on special needs students, (b) in elementary mathematics classrooms, and (c) where a constructivist approach to teaching was practiced. The ultimate efficacy of C.T. integration was on special education students, and the type of C.T. that showed the best result was the C.T. involving multimedia for the presentation.

### **Other Effects of Technology Implementation on Math Teaching and Learning**

Murphy (2016) is another researcher who did a literature review to investigate different educational research studies that examined technological augmentation in math classes and its impact on students' overall performance. The literature is derived from various research sources, including research on the effects of iPad in geometry class, the influence of wireless technology on the interaction between teachers and students with hearing impairment, and the impact of technology-enhanced curriculum on learning advanced algebra. The review confirmed that integrating technology into the curricula increases student interaction and engagement and enhances learning.

A study on geometry students at a high school showed that iPad increased students' engagement. An experimental group consisted of 57 students who used iPad as the technology integration tool, while the control group was 53 students taught the same content without technology integration. Data was collected through teacher observation, student self-reports, and

student surveys. Researchers reported a higher rate of student engagement in the experimental group. However, comparing the test scores revealed that the control group had slightly higher scores, negating the hypothesis. Although students using iPads reported a somewhat higher rate of self-efficiency, researchers were unsure if the report was meant to be for using technology or learning the geometric content.

Murphy (2016) reports on a study on seven hearing-impaired students and one hearing-impaired teacher in a middle school in Taiwan over one school year. The technology integrated was a teacher-used whiteboard that could transfer content to each student's tablet when used. They collected quantitative data through general observations and students' input through essays to compare students' work accuracy before and after using the internet tablet. Besides increased participation and focus, the report showed a 75% decrease in mathematical errors after technology use.

Murphy's (2016) another report is on a study conducted on 606 Algebra 2 students and teachers over two years in 7 different high schools in Massachusetts where a technology program named SimCal was implemented in all classrooms at random times and for various times instead of district instruction. The focus was to understand the potential effect of technology on the students learning algebraic concepts and whether it came with a deeper understanding than the traditional district instruction. Findings confirmed improved student engagement, teacher-student interaction, and demonstration of higher-order problem-solving techniques.

Murphy (2016) concluded that educational technology integration increases learners' engagement, enhances learning, and supports students in gaining higher-order thinking skills that can help students even beyond the classroom. He also confirms that the proficiency and attitude of the instructor behind the technology are strongly related to successful results.

### **Educational Technology Affects on Math Teaching and Learning**

A close analysis of the literature review confirms that educational technology implementation affects learners and teachers in different positive ways. For example, multimedia and gamification increase students' interest, resulting from their deeper and longer engagement (Jackson et al., 2013; Jagust et al., 2018; Kaczorowski et al., 2019; Lin & Cheng, 2022; Lopez-Morteo & López, 2007; Nusir et al., 2012). Learners' interest in multimedia or gamification features helps them stay more engaged and consequently affects their learning.

In Jagust et al.'s (2018) experiment, both adaptive and collaborative gamified conditions had embedded narrative features. Students reported high interest in the stories that motivated them to compete against the computer virus. So, when researchers used linear regression and slope comparison to show the performance trend and the number of solved problems (correct or incorrect), they found a negative trend in the non-gamified experiment showing that students' rates decreased, and they solved fewer and fewer as time passed. The negative trend compared to the other three experimental conditions could be due to students' loss of engagement. Promoting students' engagement and learning is what anchored instruction theory addresses. In their research, Kaczorowski et al. (2019) confirm that all students, specifically the MLD, reported enjoying the different channels to review their work. For example, widgets used for immediate feedback not available in the PPW and SCW conditions offered the opportunity for them to identify their procedural errors on the spot. The participants' interview results in their research showed that 67% of students reported using pop-ups, and 61% reported using review videos.

Besides, technology integration in pedagogy affects self-efficacy in learners. For example, in Murphy's (2016) report on the research with iPad in Geometry high school classes, students who accessed iPad reported a slightly higher rate of self-efficacy. Promoting a feeling of

self-efficacy in students improves their learning behavior and could affect their academic experience positively.

One question regarding technology implementation is if the duration of intervention relates to efficacy. For example, in Li and Ma's (2010) study, the SD of 0.35 showed more significant effects with a shorter intervention period. Specifically, the intervention that lasted one term had a more substantial impact than those that lasted longer (Li & Ma, 2010). Their findings align with Ran et al.'s (2022) findings that short-period intervention could have the best results on math achievement. However, Murphy's (2016) report on the study that was taken out on 606 Algebra 2 students over two years shows that the impact of the long-term integration was significant.

One essential finding from the literature review is that the existence of educational technology does not simply result in effectiveness in teaching and learning. For example, Murphy (2016) noted that although 57 students using iPad in the research showed more engagement than the 53 students in the control group, their academic outcome was not as great. He mentioned that researchers attributed this to the difference between the pedagogy and teaching methods of the instructors. Li and Ma's (2008) article also verifies that the difference in research outcome and the effectiveness of technology integration in different studies is most likely due to how it is implemented in the curricula, teaching method, and theory. Similarly, their other research showed that the effect of methods of teaching was also notable (1.00 SD) and concluded that constructivist methods were most effective. Hence educators' teaching philosophy and methods play a vital role in the context. As Li and Ma (2008) cite, C.T. application does not eliminate other contextual or pedagogical factors. Instead, it is part of good teaching.

### **Methodology**

Besides collecting quantitative literature from a pool of peer-reviewed articles, I decided to stretch my knowledge. To get a better view of the findings and evaluate the problem of practice in the present time, I also interviewed an exceptional special educator who is experienced in both general and Special Education. A sample of the questions is attached in Appendix A for reference. Meanwhile, the theoretical frameworks used for data evaluations and findings are introduced in detail in this section.

### **Theoretical Framework**

I am positioning this meta-analysis research based on the activity theory, anchored instruction, and self-study framework. Self-study allows teachers to reflect deeply and critically on their positionality and pedagogical choices to understand their teaching and students' learning. My opinion about the significance of educational technology integration in teaching pedagogy comes directly from my personal life experiences and challenges. As Kaptelinin (2014) explains, based on the activity theory, technology is a mediator to bring out the purposeful activity in the context of meaningful and purposeful activity. By augmenting the educational technology in the mathematics classroom, mediators such as computers, educational software programs, interactive media, and telecommunication systems are purposefully interwoven into the pedagogy and facilitate teaching and learning.

Meanwhile, implementing technology to support students in building new knowledge by providing meaningful, problem-solving contexts is aligned with anchored instruction. According to Kurt (2021), "Anchored instruction is often considered to be a form of situated learning, which connects prior knowledge to authentic situations," and this is what the embedded stories and games bring to students by connecting knowledge building to their real-life contextual experience. This conceptual framework provides a strong structure for building this research.

### **Interview with the Community Research Partner**

As a student and a person working in the field of Education, I see the vital role of educational technology in our math classrooms. However, although different types of technology are becoming more accessible, research on its impact on math education has a long way to go. To gain a deeper understanding of how educational technology integration affects teaching and learning mathematics and possibly get some professional advice, I decided to interview an experienced teacher. The individual I chose as a community partner is a mother and an educational specialist. She started her career as a general education teacher in an elementary school and entered secondary special Education six years ago. She is an excellent example of a growth mindset among her colleagues and has a unique passion for adapting research-based teaching strategies. Furthermore, she is currently completing her Master of Education in Educational Technology, which makes her a perfect fit for my research community partner. Due to confidentiality matters, I address this community partner as Mrs. S throughout this paper.

#### **Interest, Engagement, Personalized Learning**

My first question to Mrs. S was if she thinks educational technology implication affects students' interest and engagement in math class. She explains her experience with interactive apps such as iReady, mentioning that the embedded features play an essential role in students' interaction. For example, iReady has short animated clips and videos that engage students. There are two sections in iReady. One is the section for teacher-assigned lessons, and one is for My Path, a personalized practice section for students based on their statistical performance analysis. Besides assigning them two lessons to pass each week, she encourages them to practice the My Path section. Every Monday, students work on iReady, and she follows up with their progress.



During practice, when a student cannot get the correct answer for a concept in different questions, the app adjusts the questions. It allows a revisit to previous and new foundational concepts. So, compared to the traditional practice where learners have to wait for the teacher to check their work and review the content, they stay engaged without interruption for help. Moreover, Mrs. S sees gamified apps, such as Prodigy, targeting primary grades as more successful in keeping students interested and engaged. She recalls that many of her middle school students asked her to allow them to practice Prodigy, although it is a recommended app for elementary students. So, she hopes that more tested grade-level-related math games like this become available for secondary students too.

Regarding student learning, Mrs. S thinks that Interactive apps with immediate feedback adjust questions based on students' performance and allow reviewing previous content necessary for building new knowledge. As a result, students are individually helped based on their performance and need. In addition, access to these types of programs that offer personalized lessons allows continuity in learning and holds the student accountable for learning. Meanwhile, students' focus and accuracy improve when they have to meet the goal of teacher-assigned lessons, and they want to avoid the same mistakes. I experienced this with our SPED students, who try harder and work better to maintain their level in iReady.

Recalling teaching 8<sup>th</sup>-grade math last year, Mrs. S mentioned that programs like Apex helped students with graphing and offered various demos. Based on her experience, through technology employment and interactive visualization and simulations, her students better understood abstract mathematical concepts that were not available to them otherwise. Kaczorowski et al. (2019) refer to this as leveraging technology to teach challenging math concepts.

**Teacher's Role**

Replying to my question about the teacher's role in a technology-assisted environment, she said that the teacher's strategy plays an essential role in successful technology implementation. Besides choosing purposeful programs and apps, teachers should learn how and when to use the technology professionally. For example, teachers must elaborately put goals and milestones for individuals using technology so that students stay focused and goal-oriented. For instance, she has weekly goals for students to complete and pass at least two iReady lessons. In this case, it does not matter how much time they spend on the app; they must pass the two lessons. So, slow-paced students do not get stressed by time limitations. Murphy (2016) points to this in his literature review findings that professional training and pedagogy play an essential role in helping transfer the motivation behind the use of technology to the students.

Meanwhile, when teachers can monitor students' performance live during drills and practice, they can help them stay on task and engaged. Besides SPED classes, this benefits all students who need more support to stay on task. For example, NetRef is such technology that allows teachers to monitor students' activity live. As a result, Mrs. S understands the student's level of engagement by checking the amount of time they spend on one question. She even monitors her students' activities in their general ed. classes and gives extra support to other teachers. Mrs. S emphasizes that technology implication must be a part of a good, student-oriented pedagogy as a tool to facilitate teaching and learning.

**Immediate Feedback to Students and Teachers**

Mrs. S believes that access to immediate feedback in apps like iReady increases students' focus and desire to learn as they practice. Students feel more in charge of their learning when interacting with such apps, and it increases their autonomy. Meanwhile, in games such as

Blooket and Kahoot, the live statistical feedback enables teachers to find more about learners' areas of strength or weakness. For example, a low percentage of correct answers on a specific concept tells her that the concept needs clarification, review, or more practice. I have personal experience with this as a para-educator. Monitoring students' live performance allows me to check on them as needed and utilize support. I refer to Ran et al. (2022) here that what influences learners' progress is not analysis that provides information to teachers but how teachers follow up and address students' difficulties.

### **Facilitates Teaching**

According to Mrs. S, some educational technology tools also facilitate teaching during instruction. For example, she uses an overhead projector to project the content from a piece of paper on the wall. So she can walk students through the instruction step by step. Besides, she believes technology allows sharing of supportive educational videos from other professionals. For example, she shares Khan Academy videos after she teaches a lesson. Her experience shows that this method increases students' learning, mainly when students engage in constructive conversation to relate the lesson to the video. She also links videos or educational clips to CANVAS, the course app and students refer to the material during independent practice or when they work at home.

### **Who Benefits More**

When I asked Mrs. S which age group benefits more from technology implementation, she said it all depends on the pedagogy, teacher, type of technology, and content. However, summing up her experience as a mother of two young boys and a teacher who worked in both primary and middle school grades, she believed elementary students show more interest in math games and don't lose interest. The increased connectivity could be due to the interesting game-

like features that are more apparent in apps targeting elementary students. For example, she sees her own kids using the apps even at home after completing assigned lessons. In contrast, her middle school students generally do not engage with educational apps more than what they need for assignments. Li and Ma's (2010) also found that, by a small magnitude, elementary students benefitted slightly more than secondary students with technology application in math classes ( $SD = 0.22$ ).

### **Findings and Discussion**

Nusir et al. (2012) suggest that students must get actively engaged to improve the learning process. The activity theoretical framework stresses the active engagement between the subject and the object through the tool or the mediator. For example, in his literature review about the effects of integrating iPad on students' knowledge construction in Geometry class, Murphy (2016) reports that students' simultaneous access to the instructed information through iPad could be the reason for increased attention. Mrs. S. also sees the opportunity of simultaneous and direct access to information as an advantage for teaching and learning.

As Jackson et al. (2013) mentioned, according to social constructivism, learning is inherently social, and through social interaction in a computer-mediated communication environment, learning is facilitated. Ren et al. (2022) stated that computer applications provide collaborative and communicative settings. This characteristic aligns with social perspective learning theories, believing that learning is a process of knowledge construction through social interactions between peers, like group work and student-teacher interactions. It provides better opportunities for teachers' continuous interaction and quick feedback than traditional classroom communication methods. (Ran et al., 2022). For example, as we saw, the elements in Lopez-Morteo and Lopez's (2007) research also aimed to support the interaction between learner and

learning, learner and learner, and learner and workspace. Their IIRM model considers adopting a constructivist problem-oriented approach. This is precisely aligned with the activity theoretical framework and anchored instruction theory.

Research evidence showed a higher rate of self-efficacy reported by students using educational technology. For example, Kaczorowski et al. (2019) case participants reported satisfactory accomplishment and self-efficacy regardless of their level and tier criteria. Meanwhile, Murphy's (2016) report also confirmed students reported higher self-efficacy when using the iPad. Mrs. S. believes that the embedded educational features in apps like iReady increase students' self-efficacy as they become more active in their learning.

Li and Ma (2010) discussed in their article that professional training and the right pedagogy are necessary with technology integration to result in positive effects. Training could include tips for choosing the right program based on grade level, proper implementation methods, and management strategies. In Murphy's (2016) literature review, researchers reported behavioral concerns regarding the students using iPad with non-academic activities in the experimental group. Mrs. S. also emphasized teachers' training to utilize the effect of technology in the classroom as leaders. Training reinforces the objectives. For example, the finding showed that the teacher and the assistant in Kaczorowski et al. (2019) study continuously encouraged students to use the embedded supporting features before asking for the teacher's assistance.

Researchers reached different results regarding the technology implementation period to increase the influence. For example, Li and Ma (2010) and Ran et al. (2022) claim that shorter-period interventions have better student learning results. However, Murphy's (2016) report on 606 Algebra 2 students over two years significantly impacted learning. Besides, the interview with my community research partner confirmed that students continuously benefitted from

intervention regardless of the duration. From my personal experience, as Mrs. S. verified, depending on what technology is used for and how it is integrated, the system could still keep students engaged in the long and short term.

### **Conclusion**

With the forced shift to online and hybrid teaching during the recent pandemic, the essentiality of expanding research on the purposeful application of technology in education caught researchers' attention. Today, more than ever in our educational history, the technology we use crawled into our classrooms. However, some math teachers still refuse to open up to this idea. As Nusir et al. (2012) mentioned, some even believe that technology integration might lead to learners' ignorance of helpful content and instruction if they are not visually appealing like the ones in multimedia. Analyzing a wide range of data that I collected from the literature review and my interview with the community research partner, based on the active theoretical framework, anchored instruction theory, and self-study framework, it is concluded that technology integration in math classes facilitates teaching and learning. It is confirmed that technology could help math learners stay engaged with a higher interest rate, increase their self-efficacy, and support teachers on different levels.

A simple review of Piaget's and Vygotsky's theories shows the importance of game and play in human learning and cognitive development. Integration of serious games will positively affect students' learning by increasing engagement and interest as they immerse in the game with purposeful real educational objectives (Jagust et al., 2018). Meanwhile, in teaching math, multi-modal instruction is an advantage compared to single-modal (Nusir et al.) As Ran et al. (2022) verify, one characteristic of educational technology is that one technology might be used for different purposes based on specific needs or goals. This is aligned with activity theory and

confirms that we can use technology as a mediator to facilitate teaching and learning based on planned objectives.

I firmly stand with the National Council of Teachers of Mathematics (2015) and believe that using technology strategically and thoughtfully supports every student's learning of mathematical concepts and procedures. However, there are two main points to emphasize for the education world. First, we must consider that the primary goal is not to capture students' interest or entertain them but to teach particular mathematical facts, concepts, and principles. So, educators must invest effort in choosing and implementing gaming tools with educational or pedagogical goals. Second, the aim is to benefit education, and technology is just a method to assist with implementing some aspects to reach academic goals. Meanwhile, it is essential to consider the learner's needs and the educational context when choosing interactive multimedia. (Nu sir et al., 2012). For example, considering fundamental principles such as students' age group and grades help us to provide learners with the most productive tools (Ran et al., 2022).

### **Implications and Recommendations**

In this research, we answered the critical question of how integrating technology in math class benefits teaching and learning. Findings from the literature review and the community research partner highlighted that learners become more interested and actively engage in technology-rich mathematics classes than in traditional math classrooms. Meanwhile, technology integration facilitates teaching while promoting students' self-efficacy. However, this research also brought new questions into perspective. For example, Murphy (2016) concludes that educational technology integration supports students in gaining higher-order thinking skills that can help students even beyond the classroom. Higher-order thinking skills allow students to analyze and synthesize their learning in school and beyond it. We know that based on anchored

instruction theory, context application helps students' cognition. So, maybe this bridge that connects the context to the learning is a two-way channel, and students can also apply the skills they learn in the context and the math class to their real lives. We might need further research on educational technology's role as a two-way education channel.

Some people like Jackson et al. (2013) warn about the small sample size of some research that confirms technology efficacy. They report that while numerous studies prove the effectiveness of educational technology applications, most rely on self-report data. The lack of adequate pretest performance data causes doubt for some to see the benefits compared to the costs associated with technology implementation. Besides, this paper did not cover the grade-related benefits of different types of technology. Such concerns convince me that my research just removed the tip of an iceberg, and more precise data and analysis are needed to recognize the best type of technology based on grade level and favorable implication methods.



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**APPENDIX A****Sample Questions for the Community Partner**

Due to confidentiality matters, I address this community partner as Mrs. S throughout this paper.

1. What is the effect of technology integration on student's attention and engagement?
2. Do you see students' behavior as a challenge when using technology? What are your suggestions for teachers on this?
3. Does the technology lose its efficiency? For example, do you plan a specific duration for a specific intervention?
4. Do students lose interest when in a long period with one specific app?
5. What do you think about student's self-efficiency when working with apps?
6. What software features you find really helpful in math? For example, story context, color pads, visuals?
7. When we are in general ed. classes, I sometimes see our students with IPE showing preference for working with paper and pencil. Specially when we need to make diagrams and lables in science. Does this happen in your math class?
8. How does technology increase collaboration in math classes?
9. What is technology" s effects on communication and interaction?
10. What is teacher's role in regards with technology implementation, their pedagogy, theory, and methods.
11. Is tchnology effective in instruction or only as a practice and review tool?
12. Could technology compete with good teaching?

13. You worked in elementary and I know that you have two kids still in elementary. How do you compare the benefits of educational technology in math based on grade level?
14. How does technology help you as a teacher in class?
15. How do you see it as a tool for personalizing Education for students?
16. Does immediate feedback facilitate teaching and learning? How? ( I saw you in class checking students' work and correcting them). Do students respond to the app feedback too, or you see your follow up necessary?
17. What are the obstacles and challenges that some teachers avoid using technology?
18. I know that in your math class, you are willing to try different educational technology. Is it the same in the general ed. that you coteach?