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Approaches to Educational Research | Literature Review

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Do 'Smart' Technologies Affect Academic Achievement in the Mathematics Classroom?

Introduction

The Focus of this literature review is on mathematics achievement and 'Smart Technologies.'

My question of focus is:

"Does the introduction of smart technologies affect academic achievement in the Mathematics Classroom?"

The question arose from the perspective of being an educator in the 21st century and understanding the importance of the 4th industrial revolution and the effect it will have on education; more specifically how students learn. For this literature review, I define 'Smart Technology' as any technology that requires a digital interface and the ability to respond to direct interaction from the user. These include devices such as Ipads, Smartphones, Interactive Whiteboards and specific software or applications that can be downloaded to a computer. Since the introduction of the Smart Board in 1991, many teachers and students have perhaps come across one in their classrooms. I had a smartboard in my classroom that I never used. The technology seemed outdated, and I was skeptical about how this tool could be used in education effectively. Perhaps a general upgrade was needed, but the current school that I work for could not justify the expenses that a smart projector or board would incur on their fiscal budget, without knowing the implications of its usage. Thus begins my literary review of 'smart' technologies and their effect on mathematical achievement. Emerging technologies have been the core of the 4th industrial revolution; I would like to determine the best way Smart Technologies or Smart Learning tools can be utilized in the mathematics classroom and review studies that support specific claims that are in favor of its usage. If the studies are convincingly evident and consistent in support of these technologies, then it provides reasoning to request smart boards, Epson Smart projectors or any other smart device that can support growth in the classroom and ensure positive matriculation into the workforce or higher education for secondary aged students. For the sake of my study, I focused on research that were quasi-experiments and observational studies, with the exception of one case study, so that proper conclusions could be drawn. Majority of the journals come from educational research libraries such as Eric and JSTOR or known Educational Journals.

Evidence of Increasing Achievement

With a focus on interactive whiteboard technologies, international studies have shown that they can be used as a tool to accommodate teachers in differentiating instruction. An experiment that was conducted in the Netherlands by Sofie J, Cabus, Carla Haelermans, and Sonha Franken found that when comparing students pre and post-test scores, the 'efficient use of the SMARTboard as a way to differentiate instruction, significantly increased math proficiency' by 0.25 points when compared to student results when taught in a traditional classroom. (Cabus, et al., 2015). These results are not necessarily limited to middle school-aged students. A study that was conducted in Turkey that regarded 18 - 20-year-old high school graduates and their performance on a college mathematics entrance exam garnered similar results. Led by a team of technological researchers in conjunction with the Department of Mathematics Education of a Turkiyan University, the study found students 'rate of increase' in their pretest to posttest scores higher when taught in a technology supported environment (this included computers and an IWB display) compared to students taught in a more traditional classroom (Erbas et. al, 2015). With the usage of the whiteboards, studies have also been able to pinpoint where students are achieving success. More specifically, in the study conducted by Wu Yuin Hwang, Nian-Shing Chen, and Rueng-Leung Hsu, Chinese 6th-grade students learned mathematical fraction division with the support of a multimedia whiteboard system (Hwang et al., 2009). In this system, they were able to use the voice features to give oral explanations of their process. Although female students in this particular experiment outperformed the males in this aspect (oral explanation of a math problem), further analysis found that some students could do the correct arithmetic but not provide correct oral explanation, thus the benefit of the oral explanations allows teachers to address whether students truly 'understand the meaning of their solution' (Erbas et al., p. 16). Not only does the effect of the interactive whiteboards or smart technologies increase academic achievement but it also has positive effects on the enrollment of students in preparing them for the STEM fields. From an observational study conducted by Ahleal Lee supported by Xavier University, evidence was found that students who experienced high levels of engagement with computer-based learning activities in their mathematics classrooms positively affected their choice in STEM major selection more so than lecture-based learning or individual learning activities (Lee, 2015). Although 'computer-based' is a broad terminology used in this particular study, we can safely assume that the activities such as interactive whiteboards and smart technologies such as iPhones and iPads would be considered computer based. Lastly, a large experiment with over 16,000 students K - 5th-grade classrooms, conducted by The University of Southern Mississippi wished to find a causal relationship between electronic whiteboards in the classroom and student 'success'. Quantitative results found that subjects such as mathematics found statistically significant differences with student success when using interactive whiteboards when compared with the control group that used more traditional teaching methods (Mundy, 2012).

At What Point Does The Learning Happen?

So where do we go from here? From the previous section, we can be convinced that in a Smart learning environment, achievement does increase in the mathematics classroom, however, when and where do these learning moments occur? As mentioned in the study conducted by Wu Yuin Hwang, teachers found that the voice application of the interactive whiteboard system to be advantageous of understanding if a student indeed conceives of a topic (Hwang et al., 2009). If we compare this with other findings, we can identify when and where and what aspects of the whiteboard or smart technologies produce the most insight to student learning. In a previous case study conducted by the same lead researcher Wu -Yuin Hwang in 2004, the focus of the research was the usage of virtual manipulative whiteboard technologies in a geometry class. This prior study also focused on learning moments and student perception of the technology. Students ranked the usefulness of the platform and ease of use of the system which was all found to be significantly positive. The 3D interface allowed students to use a ‘multi-representational construction model’ to organize their thought process with symbols (Hwang et al., 2006). It supported the constructivist theory on learning and found that aspects such as ‘stacking’ (stacking blocks to build 3D models) and the ‘partition’ function (breaking larger items into smaller groups thus turning complicated problems into smaller components) were utilized the most to produce student solutions. (Hwang et al., 2006). This study gives insight into how the students are learning. This 3D virtual environment allowed for the manipulation of objects that could not have been easily replicated in the general classroom. On the contrary, the introduction of new technology in the classroom could introduce bias since the student may show a positive interest merely because it is new. Thus a study conducted in 2011 led by Catherine Bruce and Richard McPherson of Trent University wished to hone in on where these significant learning moments occur with students who had at least one year prior experience in a smart learning environment (i.e., interactive whiteboards, etc.). After establishing the criteria for what is considered a 'significant learning moment' students showed greater moments in preserving their mathematical reasoning, conveying their ideas, and an increase in greater student interaction was observed. Therefore much like the results from the study conducted by Hwang et al., 2009, there were positive effects on student communication and reasoning (Bruce, 2011). Similarly, in a recent observational study involving Algebra 2 students studying trigonometric functions conducted by Anne DeJarnette from the University of Cincinnati, the programming environment (ETOYS) was used to determine where student conception occurred. The results showed that students mostly struggled with covariate reasoning and the symbolic conception of the problem itself (DeJarnette, 2018). The environment forced the students to rely and focus on empirical feedback rather than the more traditional symbolic constructions which they may have carried on from prior knowledge of Sine and Cosine. So, since we've addressed that the learning is happening and we can identify what aspects of these smart environments are producing these learning moments, what could inhibit students from interacting and participating? An observational study was conducted in 2011 by Angie Olsen who wished to determine the relationship between student participation and self-efficacy in middle school mathematics. Students who rated themselves with a high self-efficacy showed a statistically significant difference in the willingness to solve more difficult problems on the IWB. (Olsen, 2011). Students also showed statistically more significant effects of anxiety when working on more difficult issues on the interactive whiteboard. Furthermore, it was found that students who felt that their peers were not supportive were also not comfortable participating in IWB experiences. Thus, even though an interactive whiteboard could produce significant learning moments, student participation is not necessarily a given when introducing these new technologies in the classroom.

One Interactive Smart Technology Or Many?

The next question is, now that we are ready to adopt smart technologies in our classrooms, are 1:1 environments of smart technologies a necessity to see high levels of student achievement and engagement? Contrary to our belief it may not be necessary to introduce one to one smart technologies in the classroom to increase academic performance in the mathematics classroom. In a case study conducted in 2010 titled Project K-Next, students were provided with smartphones in an attempt to improve student skills in the STEM field (Davis, 2010). The results of the case study were indeed positive; however, the results can only be generalized to the observed sample. Thus in a more detailed comparative quasi-experiment conducted in 2012, students were given 1:1 Ipads in a classroom to support their mathematics instruction and compared against a control group that received regular instruction. The findings of the study were that there was not a statistically significant difference in the achievements of the 5th graders who received or did not receive 1:1 iPads for supplements with their instruction. The pre-test and post-test averages were compared. Minimal differences were observed, however, the difference was not enough to reject the null hypothesis (assuming that there is no difference in mathematics achievement) (Carr, 2012).

Supporting Special Groups

Studies have shown that smart technologies not only have a positive effect on achievement for the general student but that they also support student achievement in our special populations. When comparing the use of Ipads vs. traditional worksheets on math skills with high school aged students who have been identified as having emotional disturbance, the research team from the University of Kansas found that of the three subjects who identified as having emotional disorders, performed more accurately (correct responses per minute was highest) during the iPad condition. Furthermore, all three students showed lower levels of engagement under the worksheet condition. Lastly, the researchers found that during the iPad condition, the teacher had more time to walk around and answer questions, than during the worksheet condition (Hayden, 2012). Similarly, in a quasi-experiment conducted in 2009, the focus was closing the gap in academic achievement between ELL's (English Language Learners) and regular students with the usage of the IWB. The study found strong results indicating that the IWBs can increase achievement thus, therefore, closing the achievement gap between ELL students and non-ELL students (Lopez, 2009).

Implications for Preparing Teachers

So how can teachers prepare to adopt this new technology in the classroom? Most studies reviewed showed pedagogical implications for teachers for fostering these digital and smart learning environments in their classrooms to ensure success. Teachers from all different backgrounds come into the profession with varying levels of experience with smart technologies and their benefits to the classroom. In 2016, engineering academics (teachers) were observed using their own or institutionally provided devices in an observational study led by Riyukta Raghunath. The study indicated that they were primarily used to communicate with students, create materials, and coordinate their work. (Raghunath et al. , 2016).

Multiple problems arose in this study that suggests that for teachers to adapt to using these technologies to enhance student learning, they must first understand how these same technologies can be used to improve their personal usage. Alternatively, in a study that wished to observe how creatively teachers were using the IWB to enhance student learning, it was found that who controls the environment and design of the teaching experience is ultimately the teacher. Thus teachers could be controlled by the design of the software of ready-made resources, and not the sought after contrary of producing their own to enhance the IWB experience for the students ultimately (Wood, 2007). Both of these studies indicate that without proper training, academic adoption of smart technologies for educational practice and a clear infrastructure to ensure connectivity and accessibility, the enhancement of teaching and sought after increase in academic achievement will not and cannot occur.

Conclusion

It is clear that academic achievement can occur in the mathematics classroom with the introduction of smart technologies. The performance happens with student engagement with the platform and produces more empirical understandings and processes of mathematical concepts and problem-solving. Not only do regular students benefit from this smart learning environment, but our special populations' performance also sees improvement, which could improve the achievement gap between the two groups. The teacher, however, must understand the technologies on a personal level and also receive proper training and understanding of when to use the technologies in an educational setting, such as TPACK. Lastly, the school must provide an environment and infrastructure in which these technologies can have optimal performance.

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