

The Effect of an Augmented Reality Enhanced Mathematics Lesson on Student Achievement and Motivation

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Abstract

The purpose of this study was to assess student achievement and motivation during a high school augmented reality mathematics activity focused on dimensional analysis. Included in this study is a review of the literature on the use of augmented reality in mathematics and the combination of print with augmented reality, also known as interactive print. The design and development process of the interactive print document is described in detail. Participants in the quasi-experimental study included 61 students and measures included the IMMS Survey as well as pre-, post-, and delayed-post-achievement tests. Findings support claims that technology use within a mathematics lesson increases student achievement, and augmented reality enhances student motivation to learn mathematics. However, analyzing the impact of technology use on student conceptual and technical use of mathematics shows varying outcomes emphasizing the need for continued exploration to determine the impact of technology use not only on overall mathematical achievement, but also on the specific type of mathematical activity, technical or conceptual.

Highlights

- Technology use within a mathematics lesson increases student achievement.
- Augmented reality enhances student motivation to learn mathematics.
- Technology, including augmented reality, supports student conceptual understanding of new mathematical concepts.
- Technology use has different impacts on student technical as compared to conceptual understanding.

Keywords

interactive learning environments; media in education; secondary education; simulations; teaching/learning strategies

1. Introduction

The use of augmented reality (AR) in combination with print resources, also known as interactive print, in educational contexts has gained popularity in research literature and the business industry. However, advances in technology and ubiquitous access to mobile devices have increased the popularity of AR in recent years. By combining books or printed documents with immersive technology, teachers are able to provide students with access to digital content and extend learning in a 3D space. In addition, teachers can provide students with individualized instruction and situate learning outside of the classroom walls.

Mathematics instruction is a natural fit for AR with benefits in manipulation, visualization, and authentic contexts. In this study, we developed a high school mathematics activity exploring the use of dimensional analysis within real-life examples. Students navigated a spring break trip to Mexico calculating multi-step problems focused on unit conversion and dimensional analysis. The print documents were enhanced with AR, including online resources and on-demand information. Using a quasi-experimental design, we examined student achievement and motivation when participating in an interactive print document enhanced with AR. We analyzed data to answer the following research questions: (1) What impact, if any, does the use of AR have on student mathematical achievement? and (2) Does student motivation increase after completing an AR-enhanced mathematics activity?

2. Theoretical Background

2.1. Theoretical Perspective

In order to align the research questions with the affordances of AR within the mathematics classroom, the situative perspective was used to frame the literature review and research design. (Brown, Collins, & Duguid, 1989; Greeno, Collins, & Resnick, 1996; Putnam & Borko, 2000). Situative theorists draw attention to the social nature of learning and the central role that communities of practice play in determining what and how people learn (Greeno, 1997). Situative theorists argue that the contexts

and activities in which individuals learn are fundamental to what they learn (Greeno, Collins, & Resnick, 1996). Therefore, we gained a perspective that allowed for analysis of learning within not only a social context (Lave & Wenger, 1991) but also powerful classroom activities utilizing tools such as discourse, technology, and AR (Putnam & Borko, 2000). Specifically, we sought to determine the impact AR has on student learning and motivation while focusing on conceptual and technical math activities to ultimately understand the potential of AR within mathematics classrooms.

2.2 Technology in mathematics teaching and learning

The National Council of Teachers of Mathematics (NCTM) provides a vision for technology implementation in the mathematics classroom centered on the notion that technology has the potential to enhance mathematics learning, support effective mathematics teaching, and influence what mathematics is taught (NCTM 2008). A recent NCTM Technology Statement (2008) cited:

With guidance from effective mathematics teachers, students at different levels can use these tools to support and extend mathematical reasoning and sense making, gain access to mathematical content and problem-solving contexts, and enhance computational fluency. In a well-articulated mathematics program, students can use these tools for computation, construction, and representation as they explore problems. The use of technology also contributes to mathematical reflection, problem identification, and decision-making. (p. 1)

This vision is further supported by the research literature. A 2013 meta-analysis (Cheung & Slavin) spanning the past 30 years determined that technology use in the math classroom does make an impact on achievement, varied by contexts such as duration of use, type of software, and student age. With an increasing amount of digital applications and Web 2.0 tools readily available, technology has a key role in the 21st century classroom (Purcell, Heaps, Buchanan, & Friedrich, 2013).

Although the use of technology for student achievement is increasing, the role of technology in the

mathematics classroom requires careful “distinction between two different kinds of mathematical activity: technical and conceptual” (Zbiek, Heid, & Bloom, 2007, p. 1170). As defined within the *Second Handbook of Research on Teaching and Learning Mathematics* (2007), technical mathematics includes procedures and representations where conceptual mathematics involves understanding, communicating, and applying mathematics. Kaput (1992) reported that the use of technology in mathematics could compact technical activity while also providing opportunity for enhanced conceptual activity. Therefore, the use of technology can assist students in learning, exploring, and representing mathematics; however, research is needed to go beyond overall understanding of technology-enhanced mathematics and into the benefits specific to each kind of mathematical activity, technical and conceptual, within and across mathematical content areas.

2.3. Augmented reality and interactive print in mathematics

Research indicates that AR environments can help learners develop skills and knowledge in a more effective way (Dunser, Walker, Horner, & Bentall, 2012). For the purposes of this paper, AR will refer to a “technology that creates a reality that is enhanced and augmented” (Wu, Lee, Chang, & Liang, 2013). Creating environments with enhanced and augmented reality can increase students’ motivation and interest, further resulting in more effective and deeper understanding of content learning (Wu et al., 2013). Therefore, implementation of AR within mathematics instruction has the potential to enhance both kinds of mathematical activity, technical and conceptual, along with student motivation.

The use of AR is aligned with effective instructional practices in the following five ways: 1) engagement in learning (Di Serio, Ibáñez, & Kloos, 2013; Dunleavy, Dede, & Mitchell, 2009), 2) immersion and presence in content (Lee, 2012), 3) situate learning to a location or context (Dunleavy, Dede, & Mitchell, 2009; Kamarainen et al., 2013), 4) authenticate the content (Wu, Wen-Yu, Chang, & Liang, 2013), and 5) build community (e.g. collaboration, competition) (Dunleavy, Dede, & Mitchell, 2009). For example, Alien Contact (Dunleavy, Dede, &

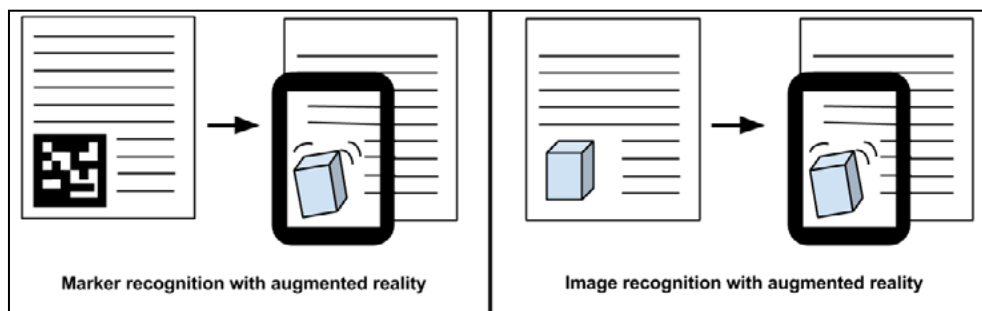


Figure 1. Augmented reality with the use of a marker and image recognition.

Mitchell, 2009) was a mobile app where students were given clues to a mystery in different physical locations. Results from the study revealed that students were engaged and motivated, while some students became competitive in teams. Researchers also found that the technology can become a barrier to learning, as well as the amount of information presented to students.

Although research on the integration of digital objects within print materials spans 15 years (Billinghurst, Kato, Poupyrev, 2001), rapid advances in mobile technology and AR software programs have led to an increase in availability and access in educational contexts. These blended systems are more recently referred to as interactive print. For example, the MagicBook project required users to hold a glasses-like display connected to a computer to interpret a graphic marker (Billinghurst, et al. 2001), while more recent studies used tablets and mobile devices as the computer interface. Until recently, the markers such as QR codes have been an essential part of the interactive print system as a mediator between the user and the content. This extra step in the process has been shown to negatively impact the user experience (Chen, Teng, & Lee, 2011). New software applications on mobile devices no longer need markers to activate content, but instead recognize the layout and design of the page as a whole to identify an interactive document. For example, instead of embedding a square marker on a page, the students can point the mobile device at that page and the AR content will instantly appear (Figure 1).

In addition to markers, few studies have utilized comparison groups in data collection. Dunser, Walker, Horner, & Bentall (2012) show gains in achievement and

motivation when comparing books designed with AR and traditional print books. This result can be misleading, as the literature is clear that the use of technology in itself is highly motivating to students. In order to bring forward the evidence for the use of AR in education, studies should “focus on whether students are actually acquiring knowledge and to what extent their knowledge of the concepts and processes presented in AR environments is increased.” (Wojciechowski, & Cellary, 2013).

Within mathematics research, AR is in its early stages (Table 1), but shows powerful results. For example, research at the secondary level examined a student activity centered on the concept of scale using paper markers and a webcam. The study determined that students using AR demonstrated collaborative teamwork and problem solving (Sollervall, 2012). At the primary level, students used paper, QR codes, and a document camera to explore quadrilaterals, the protractor, and angles. Results indicated that the younger students were highly engaged in the activity and collaborated in teams (Bonnard, Verma, Kaplan, & Dillenbourg, 2012).

Existing research on AR and interactive print within mathematics has primarily conceptualized manipulatives (Bujak, et al., 2013), basic computation (Lee & Lee, 2008), and geometry content to have the greatest potential to enhance student learning. For example, two math-focused mobile applications developed by PBS Kids allow young students to move shapes (CyberChase Patch the Path) and practice addition and subtraction (Fetch Lunch Rush). Although these uses match the affordances of AR, this is a narrow view focused only on one kind of

Search Term	Google Scholar	ERIC	EBSCO
“Mathematics instruction”	1,420,000	44,066	11,455
“Augmented reality”	85,900	81	1,292
“‘Augmented reality’ in ‘mathematics’”	18,700	6	2
“Mathematics instruction” and “augmented reality”	7,790	1	0

Table 1. Keyword search counts within the research literature

Group	Math Content	(N)	8, 9, 10 Grade	11,12 Grade
Class 1 – Comparison	Algebra	17	6	11
Class 2 – Comparison	Geometry	10	6	4
Class 3 – Treatment	Algebra	11	7	4
Class 4 – Treatment	Geometry	23	22	1

Table 2. Experimental Groups.

mathematical activity, technical. There is a need for a closer examination of mathematical learning through AR and broadening applications in the classroom.

Researchers have just begun envisioning how interactive print and other AR experiences can address learning needs. This study adds to the foundational literature by examining student achievement and motivation in an interactive print activity. To determine the impact AR has on student learning and motivation we sought to answer the following research questions: (1) What impact, if any, does the use of AR have on student mathematical achievement? And (2) Does student motivation increase after completing an AR-enhanced mathematics activity?

3. Materials and Methods

3.1. The context and participants

Data was collected within one comprehensive high school in rural Iowa. One math instructor taught students in two geometry and two algebra classes. From these classes, sixty-one students participated in the study, with 56% female students.

3.2. The experimental design

Using a quasi-experimental design, both algebra and geometry classes were randomly assigned to treatment groups, resulting in the following two groups: (1) website interaction (i.e. comparison) and (2) AR interaction (i.e. treatment). Contextual information for each group is represented in Table 2 above.

3.3 The system architecture and system procedures

The system within this study included the development of three items for a student activity: (1) print document, (2) AR enhancements for the document, and (3) companion website. First, the research team and the high school math teacher developed a print handout consisting of six different problems that focused on unit conversions with the use of dimensional analysis. The high school math teacher selected the specific concept of dimensional analysis due to a lack of student understanding across his multiple mathematics classes. Further, he reported that a science teacher colleague also reports a need to re-teach this concept to students. Therefore, a mathematical

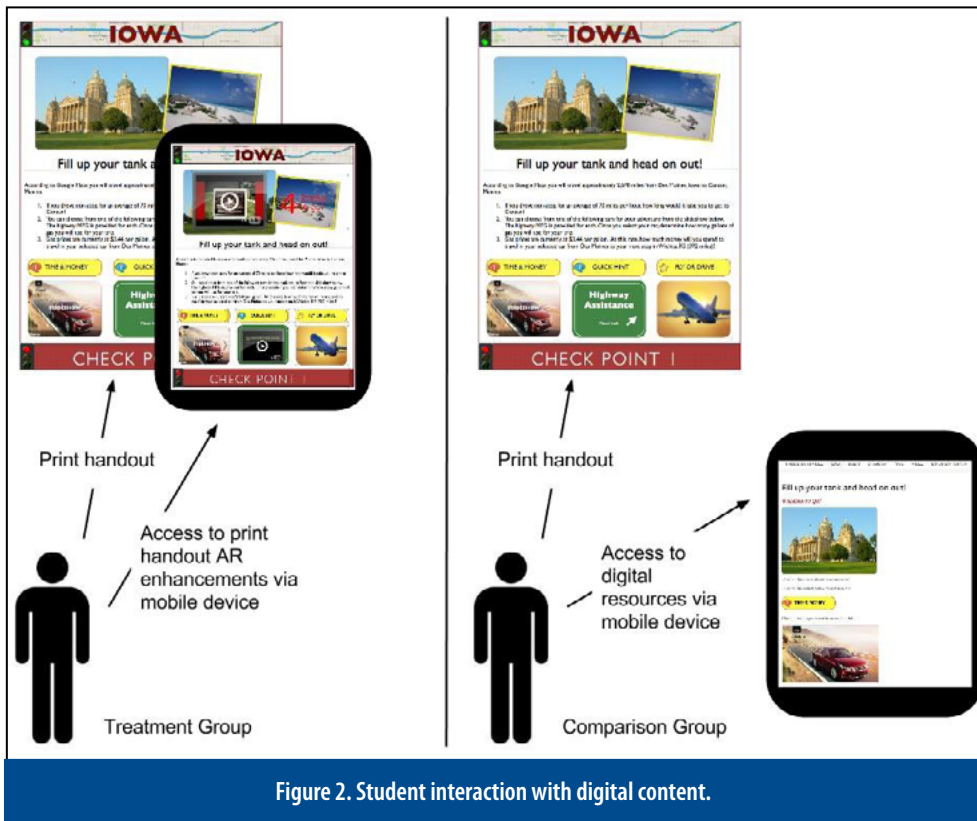


Figure 2. Student interaction with digital content.

activity focused on dimensional analysis provided an opportunity to support instructional needs within several areas of study. The specific problems were connected with one unifying theme, a spring break road trip from Iowa to Cancun, Mexico. Along the way, students encounter challenges and issues that must be resolved to reach the destination. We intentionally selected a theme that was relevant to secondary education students and included real-life math problems following best practices for effective mathematical tasks provided by Hiebert et. al (1997). For example, one problem read:

You have arrived in Wichita, Kansas that is approximately 390 miles from your beginning location. You noticed that one of your friends enjoys eating beef jerky. As a best guess, you assume he is eating one oz. of jerky about every 3/4 hour.

1. If a bag of beef jerky has 10 oz. of jerky, how long does it take him to finish a bag?
2. How many miles will a bag of jerky last your friend if he continues eating at this rate? Assume you are driving on the highway at 70 miles per hour.

3. How many pounds of beef jerky will he consume for the rest of the trip?

The AR environment was developed using the Layar Creator (www.layar.com) software and an associated mobile application. Videos, websites, audio, and images were added to augment the print document. A simple website was also created to mimic the resources for the comparison group (Figure 2).

For example, a student in the treatment group placed the mobile device over the handout. Videos, audio, and links physically appeared on the page. A student in the comparison group used the handout independently on the mobile device. The handout provided information while a website pulled up on the mobile device presented video, audio, and links in a linear fashion. For both groups, the resources were selected intentionally to support student learning (Figure 3) and averaged between 7-9 items on each page. For example, the "Quick Hint" was designed to provide a quick tip to students who are having difficulty with the mathematics. In contrast, the "Highway



Figure 3. Sample page with AR interaction.

Assistance” area presented images of a similar problem being solved by the instructor.

Students all began the activity in Iowa, which was the starting location for their spring break trip to Mexico. To begin the activity students selected a vehicle to travel in and calculated projected statistics for the trip (i.e., gallons of gas needed for entire trip). Using the provided information and tool specific for each group, students problem-solved through mathematical questions and challenges provided within and across the states of travel (Iowa, Kansas, Oklahoma, and Texas) until their final destination of Mexico was reached.

Before implementation of the activity, the mobile devices at the school (i.e. iPads) were checked to make sure students would be able to access the digital videos and resources. Then, students within the treatment and comparison groups participated in the activity following the same format as provided below in Table 3.

3.4. Instruments

3.4.1. Achievement test

The pre-test, post-test, and delayed post-test consisted of ten questions focused on assessment of technical and conceptual understanding. We defined technical to be the accuracy of a procedure (i.e. the correct calculation) and conceptual as understanding or use of a mathematical process (i.e. use of a strategy) for dimensional analysis as they solved unit conversion problems. To improve reliability and validity within and across measures, researchers selected test questions from instruments with commonly known valid questions. These included released items from the Program for International Student Assessment (PISA), ACT, and California Standards Test (CST). Although the reliability and validity of these instruments do not transfer to individual questions, each question has been extensively tested on a national or global scale for accuracy.

For example, one of the included PISA (<http://www.oecd.org/pisa/38709418.pdf>) questions read:

Mei-Ling from Singapore was preparing to go to South Africa for 3 months as an exchange student. She needed to change some Singapore dollars (SGD) into South African rand (ZAR).

- Mei-Ling found out that the exchange rate between Singapore dollars and South African rand was: 1 SGD = 4.2 ZAR. Mei-Ling changed 3000 Singapore dollars into South African rand at this exchange rate. How much money in South African rand did Mei-Ling get?
- On returning to Singapore after 3 months, Mei-Ling had 3900 ZAR left. She changed this back to Singapore dollars, noting that the exchange rate had changed to: 1 SGD = 4.0 ZAR. How much money in Singapore dollars did Mei-Ling get?

In addition to these instruments, the classroom teacher created questions and adapted questions from a regional Texas district assessment.

Students were asked to use dimensional analysis to solve the problems and to show all their work. The test was worth a total of 20 points. Questions were scored using a 2-point system with 1 point earned for use of a dimensional analysis strategy (conceptual mathematics) and another for accuracy of an answer (technical mathematics). This resulted in three scores for each student: a total test score out of 20 which included 10 points each for conceptual mathematics and technical mathematics described above.

3.4.2. Survey

The Instructional Materials Motivation Survey (IMMS) is an instrument to examine the motivational impact of tasks and instructional materials. Conceptualized by Keller as the ARCS Model (attention, relevance, confidence, satisfaction), this framework pulls together psychological and educational research on motivation and learning (Keller, 1987). Several studies have verified the validity of the IMMS (Keller, 2010). This study implemented the 20 question modified version for computer-based

Day 1	Day 2	Day 3	Day 4	Day 5	One month later
Pre-test	Introduction to dimensional analysis concepts prepared and enacted by classroom teacher	Spring break activity: Provide overview of the activity format and begin solving problems	Complete spring break activity	Post-test and motivational survey	Delayed post-test

Table 3. Overview of the activity implementation for both groups.

settings with an overall reliability of .85 (Huang, Huang, Diefes Dux, & Imbrie, 2006). The survey questions were randomized for students and can be found in Appendix A. Overall, Chronbach's Alpha calculated in this study for all survey questions was .913.

The survey also included one open-ended question to elicit student reflection on the overall learning experience. The text was quantitatively analyzed for frequency using the Text Analysis Portal for Researchers (TAPoR) software (Rockwell, 2006). Common words, symbols, and numbers were excluded using a modified Glasgow stopword list during text analysis. Words with a frequency of five or more were retained and then reviewed to eliminate additional words not significant in describing the learning experience (e.g. thought).

4. Results

4.1. Achievement Tests

Researchers analyzed the data using a repeated measures analysis of variance to determine the differences between the two groups over time, particularly through the performance on the pre-test, post-test, and delayed post-test. Because of a compressed scale and small sample size not all assumptions were met within these tests, but significant results are reported below. With respect to the total scores, the main effect of time showed a statistically significant difference in scores at the different time points, $F(2, 104) = 516.446, p < .001$ partial $\eta^2 = .540$. The main effect of group showed that there was not a statistically significant difference between intervention groups $F(1, 52) = 1.521, p = .223$, partial $\eta^2 = .028$. There was an overall increase in scores between the pre-test and post-test, then a decrease between the post-test and delayed post-test (Figure 4). The delayed post-test showed a statistically significant increase compared to the pre-test, $t(59) = 7.50, p < .001$.

We plotted means in order to explore the possible differences between conceptual and technical use of dimensional analysis within and between groups. The mean for technical (accuracy) mathematical activity (Figure 5) shows that students within the comparison group had a slight, yet steady, increase. However, students in the treatment group using AR experienced a decrease of less than one point in their accuracy on the post-test, but gained this back for the delayed post-test with a similar mean to that on the pre-test.

Calculated means for the conceptual (use of a dimensional strategy) indicate that both groups experienced gain from the pre-test to the post-test. A decrease occurred from the post-test to the delayed post-test; however, scores within each group ended higher when compared to the pre-test as shown in Figure 6.

4.2 Motivation Survey

A Mann-Whitney analysis was run to determine if

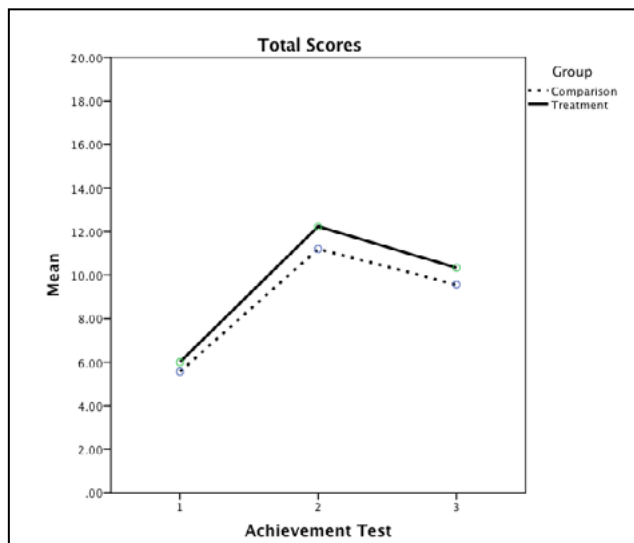


Figure 4. Total mean scores for pre-test, post-test, and delayed post-test.

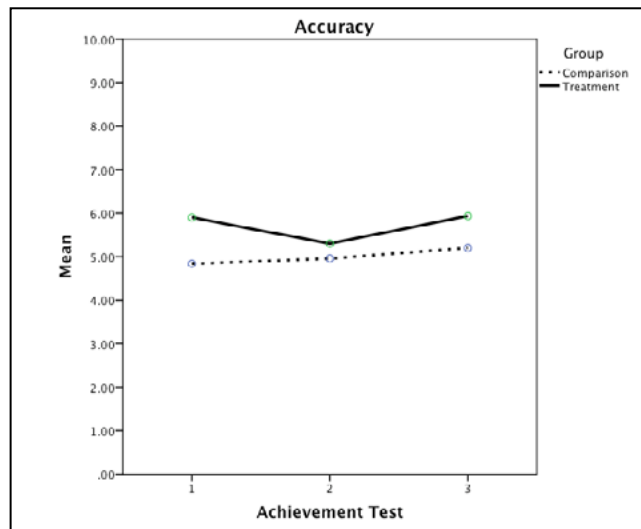


Figure 5. Technical mathematics mean scores for pre-test, post-test, and delayed post-test.

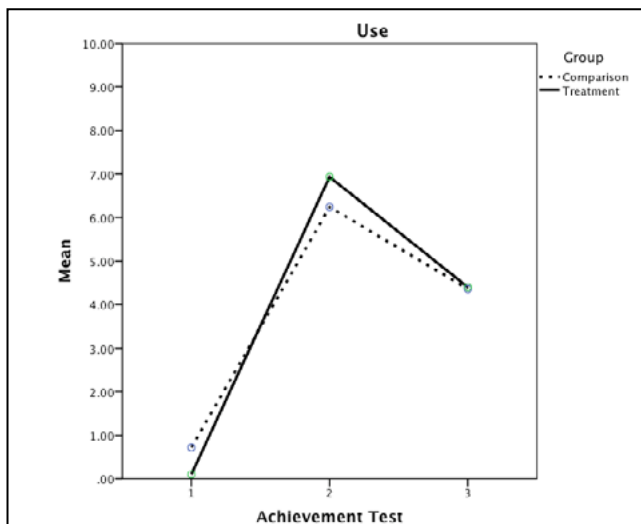


Figure 6. Conceptual mathematics mean scores for pre-test, post-test, and delayed post-test.

Question	Median website	Median Layar	Mann-Whitney U	Z	Asymp. Sig. (2-tailed)	
1	Attention getting	6.0	6.5	531.50	1.065	.287
2	Eye catching	5.0	8.0	705.50	3.620	.001
3	Quality of writing	6.0	6.5	500.00	0.605	.545
4	Arrangement	5.0	7.0	582.00	1.806	.071
5	Curiosity	5.0	7.0	595.00	1.994	.046
6	Keep my attention	5.0	6.5	578.50	1.761	.078
7	Relate to my life	6.0	6.0	541.50	-0.110	.913
8	Like to know more	4.0	5.0	625.50	2.454	.014
9	Enjoyed learning	5.0	6.0	570.50	1.639	.101
10	Feel rewarded for effort	5.0	5.0	494.50	0.522	.602
11	Pleasure to work	5.0	6.0	538.00	1.170	.242
12	Relates to class	6.0	6.0	448.00	-0.162	.871
13	Activity could be important	5.0	7.0	567.50	1.596	.110
14	Content useful	6.0	6.0	517.50	0.863	.388
15	Not too abstract*	6.0	6.5	483.50	0.360	.719
16	Not too difficult*	6.0	4.0	401.00	-0.855	.393
17	Not too much information*	6.0	4.5	308.00	-2.221	.026
18	Confident to pass a test	5.0	5.0	478.00	0.278	.781
19	Could understand*	5.0	5.0	451.50	-.110	.912
20	Not bored*	5.0	5.0	505.50	0.681	.496

*Scale reversed from original questions for direct comparison

Table 4. Mann-Whitney table.

Word	Layar Count	Website Count
like	12	10
learn	10	5
hard	5	7
good		6
fun	9	
interesting	7	
cool	5	

Table 5. Text Analysis.

there were differences in engagement scores between the treatment and comparison groups (Table 4). Engagement scores were statistically significantly between the two groups ($p < 0.05$) for questions 2, 5, 8, and 17. Therefore, the group using an AR lesson more positively agreed that the lesson was eye-catching, instilled curiosity, and would like to know more about the lesson. These three questions are identified as “attention” in the ARCS model. The AR group also significantly reported one negative, that there was too much information in the activity. This question is

identified with the “confidence” category.

4.3 Open-ended Question

Students were asked to reflect on their “overall impression of the activity.” For text analysis, 25 student comments were randomly selected in each group, for a total of 50 out of 61 student comments. Both groups “liked” the activity and “learned,” but commented it was “hard.” In addition, the website group used the word “good” to describe the activity, while the Layar group used the words “fun,” “cool,” and “interesting” (Table 5).

These results are further evidenced in the student

comments reported within the open-ended questions. First, students in the Layar treatment group stated:

I think it was pretty cool. I think that the app was *cool* because there were a lot of things that you could do to make the assignment *interesting*. I feel like some of the questions were challenging but, the help on the app helped. So, overall I think it was interesting.

I liked this activity. I thought that this activity was very *fun*. It was *cool* to be able to interact with math through technology.

Students in the Website control group stated:

It was nice to have an activity instead of just tests to show what we learned. Being able to be with partners was good as well. It was a *good* way to learn.

I *liked* it but some problems were confusing and *hard*.

5. Discussion and Implications

5.1 Technology supports student mathematical learning

Results show both types of conditions lead to overall achievement with respect to mathematical learning of dimensional analysis. The gains were not maintained across

a 1-month period, but the delayed post-test results were significantly higher than pre-test results. Therefore, our results are consistent with previous findings in that the implementation and enactment of AR in high school settings increased, then decreased over time (Dunser, Walker, Horner, & Bentall, 2012).

5.2 Augmented reality enhances student motivation

Students were clearly motivated by the activity, both in the AR and website version. There were several significant differences between the groups on the survey items, showing that AR did capture the attention of the students to a greater degree than the website only group. This result supports prior research showing that the use of AR in classroom contexts can increase motivation. Interestingly, students using the augmented document reported that there were too many items on the page, possibly leading to distraction. Results would recommend that future developers take this finding into consideration when creating the materials that blend digital and print resources, aiming to be below the 7-9 items per page presented in this activity.

5.3 Technology use has different impacts on technical and conceptual mathematical understanding

Results indicate that the activity increased student conceptual understanding of dimensional analysis. Through participation in the activity, students were exposed to examples and situations where dimensional analysis is appropriate. By participating in the activity, students gained exposure and experience with dimensional analysis that allowed the use of similar methods on future post-tests and delayed post-tests. However, further research is needed to indicate the depth and duration of opportunities needed to have a significant impact, not only on the conceptual understanding, but also on the technical use of mathematical concepts. It is important that future research look at both types of mathematical activity, technical and conceptual, due to the fact that one does not warrant the other. For example, one can have technical understanding of a mathematical concept to compute the right answer, but not have conceptual understanding for how or why the computation works. Technology can provide teachers and students with opportunities to engage in both types of mathematical learning. Further research focused on how the design of instruction with interactive print, such as optimal items on a page, impacts or hinders student learning is needed as we seek to implement more AR-enhanced lessons in classrooms.

6. Conclusions

Augmented reality within and across content ar-

eas has the potential to produce interactive, real-world learning opportunities for students. Through the use of such innovative learning platforms, students are provided relevant experiences that extend outside of the classroom walls to ensure student motivation and learning is supported with the use of technology. Of particular note is that students in both versions of the digital activity increased their overall achievement, while the AR group demonstrated higher motivation. When achievement scores were closely examined for gain in technical and conceptual mathematics, there was a striking difference in overall learning gains for both groups. Although our study was limited by a small sample size and data sources were restricted to a survey and test format, promising results concluded that there is a need for future research studies to explore the optimal amount of information presented through AR, as well as examination of the methods to increase both technical and conceptual understanding of mathematics through technology.

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Appendix A

How much do you agree with the below statements about the “Spring Break” interactive activity? (Sliding scale 1-9; absolutely not true, not true, true, absolutely true)

1. There was something interesting at the beginning of this activity that got my attention.
2. The document and links are eye catching.
3. The quality of the writing in this activity holds my attention.
4. The way the information is arranged on the pages helped keep my attention.
5. This activity has things that stimulated my curiosity.
6. The variety of reading passages, tasks, illustrations, etc., helped keep my attention on the activity.
7. I could relate the content of the activity to things I have seen, done or thought about in my own life.
8. I enjoyed this activity so much that I would like to know more about it.
9. I really enjoyed learning with this activity.
10. The feedback and/or links to go back and review material after the exercises made me feel rewarded for my effort.
11. It was a pleasure to work on this activity.
12. It is clear to me how the content of this activity relate to this class.
13. There are sufficient diagrams and examples that showed me how this activity could be important to some people who are learning about unit conversions.
14. The content of the activity will be useful to me in terms of learning math effectively.
15. This activity was so abstract that is was hard to keep my attention on it.
16. The exercises in the activity were too difficult.
17. Many of the pages contained so much information that it was hard to pick out and remember the important points.
18. After working with this activity for a while, I was confident that I would be able to pass a test on unit conversions.
19. I could not really understand quite a bit of the material in this activity.
20. The amount of repetition in this activity caused me to be bored sometimes.