Engaging the 21st-Century Learner: Using Augmented Reality to Increase Student Engagement and Student Achievement in an Inquiry-Based Learning Environment

By: Roxanne Hibberd, Alton Johnson, David To and Swati Vora-Patel

Introduction

Sutton Public School is a rural school located in the northern York Region community of Sutton, Ontario. The school has a population of 283 students, of which 17 students will be entering Grade 6 in September 2012 (York Region District School Board, 2011). The school was selected for the Future Navigators project because of its EQAO performance. According to the Fraser Institute, Sutton Public School ranked last amongst all other schools within the York Region District School Board when it came to the Grade 3 and Grade 6 provincial assessments (The Fraser Institute, 2012). The social and emotional aim of the four-week Future Navigators project was to provide additional resources and support to help engage the students of Sutton Public School, while the academic aim was to increase student achievement. Both project priorities fall under the Board’s Equity and Inclusive Education policy (York Region District School Board, 2011).

Our project team decided to work with students who will be entering Grade 6 in order to help prepare them for the upcoming EQAO assessments in Spring 2013. Our team has worked on numerous student engagement and technology projects and we embarked on Future Navigators in order to answer the following questions:

1. Can the use of iPad-enabled augmented reality increase student engagement?

2. Can the use of iPad-enabled augmented reality increase student achievement?

While four weeks is generally not sufficient to draw any significant conclusions about future EQAO performance, the methodology and research findings can assist educators in planning ahead and making decisions throughout the school year to work towards increased student achievement. This mixed-method study combines qualitative assessment tools, such as observation, culminating tasks and focus groups, with quantitative tools such as surveys, pre-project diagnostic assessments and post-project formative assessments in order to provide an accurate picture of student engagement and student achievement.

Background on Augmented Reality

Augmented reality (AR) is a type of technology where virtual images, 3D objects and other multimedia are overlaid on top of a real-world environment such as the classroom. The physical environment is real but AR virtually extends the environment by providing additional information and input opportunities for the user. Essentially, AR seamlessly bridges the gap that exists between what is virtual and what is real, allowing the environment to come to life (Lee, 2012).
AR is utilized in a variety of different settings such as business marketing, tourism, gaming, the training of doctors, military personnel, and more recently in K-12 education (Lee, 2012). For example, the Royal Ontario Museum has adopted AR for its dinosaur exhibit, allowing visitors with smart phones and Apple iPads to experience how dinosaurs would look like, move and behave if they were alive today (Baker, 2012). While the use of AR in Ontario and North American K-12 schools has been rather limited, AR has seen widespread implementation in European schools over the past several years. For example, in Lithuania, AR pilot projects in several K-12 schools show significant increases in student engagement and student achievement, especially amongst students with special education needs. (Vilkonienë, Lamanuskas, & Vilkonis, 2008).

AR also has an additional advantage when it comes to documenting and presenting student work throughout the school year. Since AR enables educators to create a malleable learning environment, student work can be collected, manipulated and displayed for an infinite number of days, weeks, months and years. Unlike traditional showcases of student work where previous work needs to be removed before new work can be displayed, AR allows educators to digitally view, update and rotate between all of the work that a student has completed from the beginning of the year. This “black box” of data provides educators with a snapshot of student achievement at various intervals, allowing them to gauge a student’s most consistent level of achievement throughout the school year. This complies with the assessment and evaluation guidelines outlined in Growing Success (Ontario Ministry of Education, 2011).

For our Future Navigators project, AR is implemented through the Apple iPad and its built-in camera. As students point their iPad camera towards digital learning walls in the classroom and specially-marked AR cards, various images, 3D objects and multimedia appear on the iPad screen. For example, as shown in the Future Navigators book, student work, videos, images and 3D models appear on their iPads when students target specific areas of the classroom. These additional pieces of information appear over top of what the student is pointing at, allowing them to interact with this information by tapping, dragging and manipulating what they see. This provides students with an opportunity to engage with what they are learning in auditory, visual and kinesthetic ways.

**Review of Technology in K-12 Education**

It is no surprise that today’s students are in fact 21st-century learners who are immersed in a world of 24/7 technology. With over 60% of Grade 6 to 8 students in North America possessing laptops and over 51% possessing a mobile device such as a smart phone, students are increasingly utilizing technology to stay connected, informed and entertained (Franklin, 2011). In fact, based on 2010-2011 EQAO survey data for Sutton Public School, over 60% of Grade 3 students and over 55% of Grade 6 students indicated that they played video games and utilized the internet outside of school hours (Queen's Printer for Ontario, 2012). In our study group, all 16 students indicated that they are daily internet users and all participate in at least one form of online gaming.
Given the important role that technology plays in students’ lives, it is important for educators to embrace and integrate technology into their teaching practices. Although some educators ban or restrict technology in the classroom because they feel that it is a distraction, the opposite is actually true. In the study conducted by Vilkonienė et al. (2008), students exhibiting behavioural issues in a traditional “paper and pencil” learning environment became more engaged and more motivated to learn when the teacher began using AR in science classes to demonstrate abstract concepts. Thus, educators should not fear technology but rather harness its capabilities to provide an engaging learning environment for their students.

When it comes to technological integration in the K-12 classroom, the Apple iPad is certainly no stranger to both students and educators. Many schools in North America, Europe and Asia have adopted the iPad for their classrooms with varying degrees of success. A study conducted by the Auburn School Department in Maine, which involved 266 kindergarten students, indicated that using the Apple iPad in classroom instruction contributed to a 2.1 point increase in standardized early literacy assessment scores (Bebell, Dorris, & Muir, 2012). In another study, one that was conducted by the University of Calgary, data showed that while elementary and middle school students were highly receptive to school-issued iPad devices, secondary students had difficulty finding specific uses for these devices in school (Crichton, Pegler, & White, 2012).

However, the strongest positive benefits derived from using the Apple iPad were often seen in studies involving students with special needs. For example, a fifth grade student with attention deficit hyperactivity disorder, or ADHD, and reading at the third grade level was equipped with an Apple iPad and paired with a special education resource teacher who utilized interactive eBooks on the device to help strengthen his reading skills. After several months of the iPad intervention, the teacher administered an informal reading inventory, IRI, that showed a significant increase in the student’s word recognition and reading comprehension up to the fourth grade level (McClanahan, Williams, Kennedy, & Tate, 2012).

The Future Navigators project utilizes the knowledge obtained from these previous studies and combines it with the utility of AR to create an effective learning environment that increases student engagement and student achievement over the four-week summer program.

**The Power of Inquiry-Based Learning**

There has been a recent push for educators to move away from traditional teacher-directed instruction to student-centred learning using an inquiry-based approach. Simply put, inquiry-based learning is a process where educators create guiding questions about a particular topic and students take the initiative to collect and analyze various sources of data that may help answer the guiding questions. Students then synthesize and organize this data into useable information that they summarize and communicate to both their teacher and their peers (Queen’s University, 2011). Unlike teacher-directed instruction, where teachers provide students with all of the facts and information as part of their lesson, inquiry-based learning encourages students to take responsibility for their own learning and to discover the facts for themselves while continuing ongoing dialogue and conferencing with the teacher.
Inquiry-based learning offers many advantages including, but not limited to:

- Engaging students to solve real-world problems that are of interest to them.
- Encouraging student collaboration and cooperation.
- Developing students’ critical thinking and transfer of knowledge to new contexts.
- Supporting teacher assessment of both process and product.
- Strengthening digital literacy skills to prepare students for the 21st-century.

Source: (Ontario School Library Association, 2010).

For the Future Navigators project, our team utilized the Apple iPad and its AR capabilities to support an inquiry-based learning environment that was based on the Grade 6 flight and space curriculum. Students used AR tools to discover and explore the history and theory of flight, technological advances in aviation, space flight and pathways to different careers in aviation and space.

**Program Development and Implementation**

Our project team followed a six-step approach to designing and implementing the Future Navigators Program for determining the impact of AR in increasing student engagement and student achievement:

1. **Student Selection** – All 17 students who would be entering Grade 6 in September 2012 were invited to participate in the four-week summer learning program. Of the 17 students invited, only 16 were able to attend, a balance of nine males and seven females. These students were selected because they would be writing the Grade 6 EQAO assessment in Spring 2013.

2. **Focus on Strengths and Areas for Improvement** – Using EQAO data from the previous five years, we were able to identify areas for improvement in order to structure the curriculum aspect of the program. For example, the five-year trend indicates that students would require additional practice in skills such as understanding implicitly-stated information, making connections and language conventions. From the math curriculum, the measurement and data management strands were of particular concern (Queen’s Printer for Ontario, 2012).

3. **Classroom Design** – Empirical research has shown that the learning environment plays a significant role in student engagement, particularly when it comes to designing a space that permits meaningful student interaction on a regular basis (Fredricks, et al., 2011). As such, regular student desks were replaced with interconnected guided reading tables where students sat together side-by-side. Digital banners and posters were placed on
classroom walls and AR technology was utilized to bring these walls to life on students’ Apple iPad devices.

4. Use of the inquiry-based learning model – Each week was divided into themes: history and theory of flight, mechanics of flight, Earth and space, and careers in aviation. Our project team adopted the inquiry-based learning model, as empirical research has shown that it is effective in increasing student engagement through self and peer-directed learning. The digital literacy teacher used the four stages of the inquiry learning process by:

   a. Establishing **focus** by utilizing guiding questions for whole class discussions.
   
   b. Allowing students to use AR to **explore** various flight and space concepts.
   
   c. Asking students to use AR and iPad tools to **analyze** their exploration findings.
   
   d. Providing students with the opportunity to **share** their learning with peers.


5. Community Partnerships – To support the exploration phase of the inquiry learning model, students were given the opportunity to visit various destinations related to flight and space, such as innovation centres, airports, hangars and flight training centres, to name a few. These experiential learning opportunities, in conjunction with AR, allowed students to make connections between what they were learning in the classroom and the real world.

6. Formative Assessments – At the beginning of the four-week program, students were asked to respond directly to 15 EQAO questions using their iPads, as a pre-program diagnostic. These questions were randomly taken from previous EQAO assessments, five from each subject, and were chosen based on the areas for improvement. Throughout the program, students were assigned additional formative assessments, one of which was a weekly culminating task that was part of the inquiry learning process, such as creating a 3D flying machine or an environmentally-friendly passenger jet, using the knowledge that they had acquired during the week. In addition, the digital literacy teacher utilized the iPad to administer flight and space trivia questions that were customized and modeled after EQAO questions from previous years. At the conclusion of the program, students were asked to respond directly to another set of 15 EQAO questions using their iPad, with these results being compared to the initial assessment.

**Research Methodology and Results**

**Does iPad-Enabled Augmented Reality Increase Student Engagement?**

Our team utilized classroom observation, focus groups and surveys to gauge the level of student engagement at Future Navigators. Overall, the 16 students responded positively to the uniquely-designed augmented learning environment, which indicates a high level of student engagement.
For example, survey data revealed that:

- 90% of students found that the iPad-enabled AR tools were fun and easy to use.
- 80% of students felt that the iPad-enabled AR tools helped them strengthen their reading, writing and math skills.
- 75% of students indicated that they would like their day school classroom to follow the Future Navigators design and format.

Student feedback from the focus groups also supports an increase in student engagement. Sample responses from four students are transcribed below:

- Student #1: “The iPad made it fun and easy for me to learn language and math.”
- Student #2: “I really liked reading on the iPad because the characters in the story jump out at you and you can make them do actions.”
- Student #3: “I learned new ways of solving math problems on the iPad. It's easier than paper because I can experiment and move stuff around until I get the right answer.”
- Student #4: “It was fun to play with a 3D plane on the iPad and then be able to sit in a real plane on the field trips we went to.”

The Digital Literacy Teacher also observed noticeable improvements in student behavior as students progressed through the inquiry-based program. For the majority of the program, students stayed on task, worked cooperatively with peers and demonstrated active learning through class participation. These act as positive indicators of increased student engagement.

**Does iPad-Enabled Augmented Reality Increase Student Achievement?**

Due to the relatively short timeframe of four weeks, it is difficult to accurately determine whether iPad-enabled augment reality, as modeled in Future Navigators, would lead to increased student achievement. However, our team did make an attempt to gauge possible changes in student achievement by administering a pre-program assessment and a post-program assessment in which the results were analyzed and compared.

Both assessments contained 15 EQAO questions, five from each assessment category – reading, writing and mathematics. Questions were randomly selected based on the Profiles of Strengths and Areas for Improvement for Sutton Public School and students responded to these questions individually on their iPads in a simulated EQAO setting. This set up allowed us to maintain the integrity of the summer program while allowing us to explore possible impacts on student achievement.
As shown in Table 1, there is an average net increase in post-program scores of approximately 4.25%. A paired samples test was conducted to determine correlation and statistical significance between the pre-program and post-program results.

**Table 1 - Paired Samples Statistics**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
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</thead>
<tbody>
<tr>
<td>Pre-Program Assessment</td>
<td>64.50</td>
<td>16</td>
<td>12.089</td>
<td>3.022</td>
</tr>
<tr>
<td>Post-Program Assessment</td>
<td>68.75</td>
<td>16</td>
<td>13.204</td>
<td>3.301</td>
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</table>

The positive linear correlation shown in Table 2 provides evidence that we were testing the same students pre-program and post-program since those that did well in the beginning also did well at the end.

**Table 2 - Paired Samples Correlations**

<table>
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<th></th>
<th>N</th>
<th>Correlation</th>
<th>Sig.</th>
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<tbody>
<tr>
<td>Pre-Program Assessment &amp; Post-Program Assessment</td>
<td>16</td>
<td>.873</td>
<td>.000</td>
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</table>

In the paired samples test shown in Table 3, we can infer that there is statistically significant evidence to indicate that iPad-enabled augmented reality has the potential to increase student achievement; t(15) = -2.634, p=0.019.

**Table 3 - Paired Samples Test**

<table>
<thead>
<tr>
<th></th>
<th>Paired Differences</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
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</thead>
<tbody>
<tr>
<td>Mean</td>
<td>Std. Deviation</td>
<td>Std. Error Mean</td>
<td>Lower</td>
<td>Upper</td>
<td></td>
</tr>
<tr>
<td>Pre-Program Assessment – Post-Program Assessment</td>
<td>-4.250</td>
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<td>-0.810</td>
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Discussion of Results

The Future Navigators project highlights how important it is for educators to create 21st-century learning environments that are interactive, malleable and inquiry-driven. Through iPad-enabled AR, we were able to see a positive increase in student engagement and student motivation towards learning. In addition, our statistical analysis indicates that it is possible to increase student achievement with iPad-enabled AR.

To obtain a definitive conclusion on student achievement, further studies will need to be conducted, especially during the school year where learning takes place over a consecutive ten-month period. In these further studies, it will be important to involve students and teachers from multiple schools in order to provide adequate comparative data. Qualitative data collection in these studies would be more thorough and widespread, allowing us to gauge the level of student engagement across the region. Quantitative data collection would allow us to gauge the impact that iPad-enabled AR has on student achievement across schools. We would be able to apply techniques such as the analysis of variance (ANOVA) and the analysis of covariance (ANCOVA) to statistically compare results between schools and to determine how different variables may influence student achievement in the long run.
REFERENCES


