Using Mobile Applications as a Supplement to Sustainability Education in Pennsylvania Middle Schools and High Schools

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Abstract

Well-known organizations, such as the Environmental Protection Agency, Center for Green Schools, and U.S. Green Building Council, have been calling for an implementation of sustainability education in United States schools since 1994. Having heard this call and understanding that technology has promoted the spread and successfulness of the “green” age, this thesis is intended to introduce a mobile application that can be used by United States schools in order to teach fifth through twelfth grade students about sustainability. In this report, the mobile application’s programming process and design are described in detail, and explanations are given as to why certain qualities were incorporated into the final product. Ideas for future work concerning the advancement of this project are also laid out. The ultimate goal is to release this application to be used in schools as an educational tool once it is polished and finalized.

Hypothesis

Technology has advanced to such a degree in recent years that most people have constant access to the Internet and, therefore, a lot of information. Why not use this trend to an educational advantage? The use of a mobile application by middle and high school students in the classroom is believed to be able to enhance their learning about sustainable materials and environmental awareness. Because of its interactive nature and constant accessibility, its use may be more effective in making middle and high school students more environmentally conscious compared to traditional forms of teaching and learning (ex: lectures). This assumption does not go unsupported. Although there are many cautions against using technology as a teaching supplement, there is also a lot of support for using such techniques. The warnings mentioned in research can be used to the advantage of teachers and developers to try to avoid such problems that have come up in the past when using technology in the classroom. The fact that this application can be used outside the classroom is just the beginning to a solution. The hope to make it more interactive-almost like a game-is what will help students to learn without realizing that they are learning.

Literature Review

Overview

A growing concern in the United States is environmental awareness and friendliness. More and more companies are incorporating "green" initiatives into their businesses and sustainability is becoming a key focus for families and businesses. One potential way to enhance sustainability and, therefore, environmental awareness, is to incorporate relevant classes into school curricula. Furthermore, with the increase of technology use in everyday life, a mobile application may be created to allow easier access to and more interactive learning of sustainability information. Sustainability endeavors and education, successful incorporation of technology into education, concerns of incorporating technology into education, the most effective ways to combat those concerns, and examples of successful sustainability applications are the themes reviewed here.

Sustainability Endeavors

"Green" initiatives have taken to the forefront of American concerns over the course of the past several years. Recycling can be dated back before 1775, but the word was not coined until the 1920s by workers in the petroleum industry. Even then, however, recycling was not something people did because they were concerned for the environment (Zimring, 2005). Now, entire cities are taking on the challenge of making the world a better place (Birch & Watchter, 2008). Not only are cities "going green", but also individuals using modern technology are helping to improve sustainability whether they know it or not. The information age is a large proponent to the "green" age (Mol, 2008).

Sustainability Education

The Environmental Protection Agency's (EPA) called for an increase of sustainability education in United States Schools (Environmental Protection Agency, 1994). The EPA started to make recommendations back in 1994 on how institutions can teach sustainability in schools. Today, the Center for Green Schools and the U.S. Green Building Council are building their own recommendations on how sustainability can be taught in schools. It is their hope that, by 2040, every school in the United States will require each student to graduate with an understanding of sustainability (Long, 2014). Amaya Alvarez and Judy Rodgers (2006), in their article “Going ‘Out There’: Learning About Sustainability in Place,” make it a point to discuss the fact that sustainability can be taught and understood in multiple ways. For instance, Jeffrey Smith, Christine Rechenberg, Larry Cruey, Sue Magness, and Peggy Sandman (1997) performed a study which determined that private school students in grades five and six had the most positive changes compared to students in grades three and four in the observed categories of attitudes, behaviors, and thoughts on being environmentally friendly after undergoing a brief course covering such topics. The students who underwent the classroom presentation portion of the course ended with a greater knowledge about recycling compared to the group that went on a field trip to a landfill to learn about the same matters. The latter group ended with better recycling behaviors compared to the first group (Smith et al., 1997). With the goal of the thesis in mind, it would be best to target the final application toward fifth and sixth graders (at the lower end of the grade spectrum) with a focus on interactive learning by having them perform certain activities for positive reinforcement. On the other hand, the United Nations Educational, Scientific and Cultural Organization believes that the earlier students are exposed to sustainability education, the earlier and more effectively they will be instilled with environmentally friendly habits and opinions (Samuelsson & Kaga (Eds.), 2008). This might be worth considering in the future.

Successfully Incorporating Technology into Education

Positive results regarding the use of technology to enhance educational goals have been reported. Drew Harnish, Chen Ling, and Randa Shehab (2012) performed a study that confirmed technology’s usefulness in education. After taking a test, students’ scores were tallied and those who used technology with the professor’s guidance got an overall score that was 16% better than the control group who did not use such support (Harnish et al., 2012). It was also found that students appreciated the level of access they had to course material, their ability to take a device anywhere because of the convenient size, and being able to organize everything in one place and work almost anywhere, even outside of class (Lunau, 2012; Nortcliffe & Middleton, 2013). Even just the experience of being allowed to use mobile phones in the classroom seems to result in positive outcomes according to students and teachers (Monguillot Hernando et al., 2014; Thiele et al, 2014). Other advantages perceived by students included: better and faster interaction with teachers, easier collaboration among students, easier completion of assignments, more efficiency and success with work, easier learning of class material, and more motivation in class. “The advantages gained by using educational technologies outweigh the disadvantages” (Thiele et al., 2014). The best way to ensure that the benefits outweigh the drawbacks is to simply use technology to support what is being taught in the classroom rather than use it as a complete substitute (McMahon & Walker, 2014; Pegrum et al., 2013).

Concerns of Incorporating Technology into Education

Although there is plenty of support for the use of technology in the classroom, there are also some concerns. (Note that although this section discusses the use of almost any kind of technology in the classroom, similar trends can be found just with the use of mobile phones and applications in the classroom, even when guided by a teacher.) One of the common concerns involved students distracting other students-and even themselves-with the use of technology in class (The Teaching Center, 2014; Fang, 2009; Chen, 2013). Now, most studies that found this were not targeting students whose teachers utilized technology as part of the curriculum, but rather who, for example, simply allowed students the use of computers to take notes (The Teaching Center, 2014; Fang, 2009; Chen, 2013). Nevertheless, this can still become a problem if teachers were to incorporate technology to aid with instruction. For instance, students can still get distracted on their own device by switching out of the application being used in class to browse the Internet and social media sites. Another concern is the lack of know-how possessed by the teachers attempting to effectively incorporate technology into education (McMahon & Walker, 2014; Chen, 2013; Pegrum et al., 2013). There are also concerns about students' dependence on and their lack of imagination as a result of technology. Dependence is a concern because of technology's unreliability (Bowers, 2000).

Even if technology were to be incorporated into education, what about the students in areas with less money to spend on such investments? Some students may end up being at a greater disadvantage just because of the area in which they live. For example, in 2013, one school district of 650,000 students in Los Angeles, California intended to spend about $1 billion on a 1-to-1 iPad initiative in which one iPad would be bought and used by each student in the district. Although it would not be kept by each student, and they would be able to be reused each year, this is still a large sum of money to spend and became a big concern for families with children going to school in the district (Herald, 2013). Students (not whole districts) from lower-income households, however, would not be a problem, as a 2010 Pew study showed that students from lower-income households are more likely to go online via smartphones than students living in higher-income households (Lunau, 2012). One final concern is the negative effect on GPA. One study performed on University of Central Florida students revealed that students who used their phones (or other small mobile devices) for academic reasons actually had a less positive resulting GPA than students who did not. One issue with this study, however, is that it did not specify how the students were using their phones academically. For instance, it was not specified if their teachers were using technology such as mobile applications to aid their instruction (Chen, 2013). Therefore, the results may not be valid to consider for this thesis, but it is still important to at least mention as further research may be needed in this area.

Ways to Combat the Concerns of Incorporating Technology into Education

One way to make sure that technology is used effectively in a classroom is only using it as a supplement to the material taught rather than having the students teach themselves using technology or having the teacher completely depending on it (McMahon & Walker, 2014). Another way is teaching the teachers effective ways to incorporate the technology into their lesson plans (McMahon & Walker 2014; Pegrum, 2013). Additional suggestions on effective teaching with technology include using them as interaction assistants where students can send questions or comments to the teacher and having a designated "technology-free" zone in class so as not to distract students who prefer to use the pen-and-paper method to take notes (The Teaching Center, 2014; Fang, 2009; Chen, 2013; Lunau, 2012). However, before any of these initiatives are put into place, Bowers (2000) warns that everyone should be educated on the potential risks that come with using technology to the point of dependency. Of course, this way, then, users might make it a point to avoid dependency and gear technological use towards supplication of learning instead.

Examples of Successful Sustainability Applications

Some examples of sustainability applications include: Children of the Element, Recycle Hero, Sustainaville, Enercities, Sustainable U, and Emrals (Global Footprint Network, 2012;

Tablets for Schools, n.d.; Sakai, 2014; DWN TWN BRKLYN, 2014). A couple main themes throughout these applications include: story lines, cause-and-effect relationships, and gaming aspects with various rewards. Children of the Element uses a story line-style game in order to make it more enjoyable for children (Global Footprint Network, 2012). Sustainable U uses the player's surroundings as a basis for their desire to learn and make environmentally friendly decisions (Sakai, 2014). Similar cause-and-effect simulations are the basis for kid-friendly games such as Sustainaville and Enercities (Tablets for Schools, n.d.). Finally, one major undertaking is the use of digital currency in the Emrals application. According to the CEO of Emrals, the company is trying to advance the game in a way that allows the Emrals to benefit charities and volunteers (DWN TWN BRKLYN, 2014).

Mobile Application

Programming Process

The application started as a simple project for a class. As it was determined that the quiz should be the focus for this thesis, that part started to build in complexity. The planning and programming portion took approximately 30 weeks to build the application to its current state. The hardware used was a Macintosh computer equipped with XCode software (Objective-C programming), which allowed for iOS development (accessible to iPhones, iPads, etc.). Alpha testing was performed using the simulation component of the XCode software to make sure all functions were working properly before being passed on as the final project for the 2014-2015 school year. This testing consisted of examining each question-answer combination to confirm selected answers were appropriately marked correct or incorrect. It was also ensured that every question could be easily and entirely viewed by the user during run time. Map locations were also checked for visibility, calculations were re-evaluated for correctness, and all textboxes were realigned and/or resized as needed so that the finished application looked presentable.

Design

This application consists of five major functions and screens: a welcome/home screen, a materials list and material details screen, a green locator or map, a Footprint Points counter, and a quiz. Each of these plays a significant role in the bigger picture of the Sustainability application, as explained in the next few sections.

Welcome/Home Screen

The application framework includes various screens. The introductory screen seen in Figure 1 explains the application and its various parts. A bar at the bottom of this screen takes the user to a list of everyday recyclable materials, a map, a point counter, and a quiz. These screens do not have to be traversed in any order, but, rather, can be accessed at any time from any screen with this same bar at the bottom.

Materials List and List Details

The information to compile the list of everyday recyclable materials is referenced from CES Edupack, a Granta Design product used by all engineering majors at Robert Morris University to learn

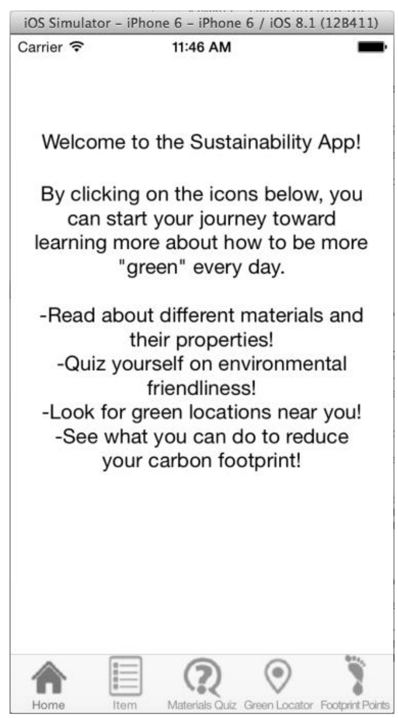

Figure 1: Welcome/Home Screen

about a large number of materials (Granta Material Intelligence, 2013). The list shows a picture of each material and its name as well as the category of material into which it can be classified (see Figure 2). All of the materials listed are recyclable materials and are items that most people will see in their everyday lives in some form or another. The hope with this section of the application is that children will, after exploring this list, be able to identify various recyclable materials and will be able to distinguish recyclable products from non-recyclable products.

When an individual material is selected by the user, another screen appears which gives the user more details about its cost per unit, common uses, date of first use, and CO_2 emissions, as shown in Figure 3. This is for the more curious user. The most pertinent part of this screen is the common uses section. It is something that most kids will be able to relate to and, again, will help them to determine for themselves which products they see around them are recyclable or not. This is anticipated to promote positive recycling behaviors in the sense that users will be able to recall which materials and products were listed in this application. If they are not able to recall by themselves, they will have this application available to them so that they can make sure they are making the best environmentally friendly decision possible.

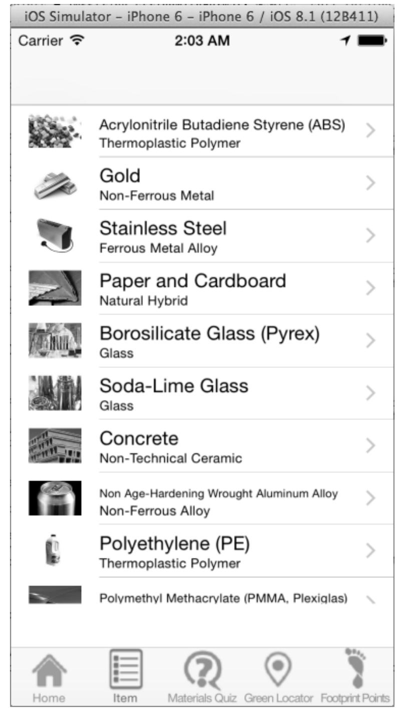

Figure 2: Materials List

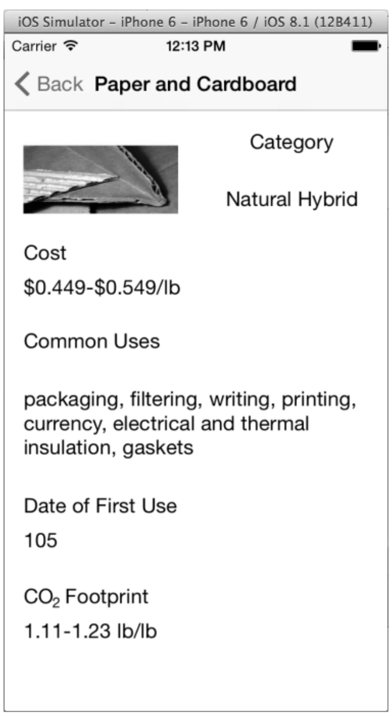

Figure 3: Material Details

As is indicated by the “<Back” arrow next to the name of the material on this screen, the user can simply hit the top banner, and they will be taken back to the previous Materials List screen. From there, they can again choose another material to explore or an entirely different screen to migrate to, as was mentioned in the “Welcome/Home Screen” section of this paper.

Green Locator

The application’s map illustrates ten locations in the Pittsburgh area that are known as “green” buildings and what makes them so notable. As of right now, the application cannot display how a person can get to those buildings from his or her current location. Figure 4 shows the opening screen after the user allows for his or her location to be used by the application. The user’s simulated location was determined by the coordinates for downtown Pittsburgh: 40.4397° N, -79.9764° W, which were provided by a simple Google search. These coordinates were put into the computer as the starting location. When the application is completed, this will not be necessary, as it will be determined by GPS location services. It is only for the sake of testing that simulated coordinates were needed.

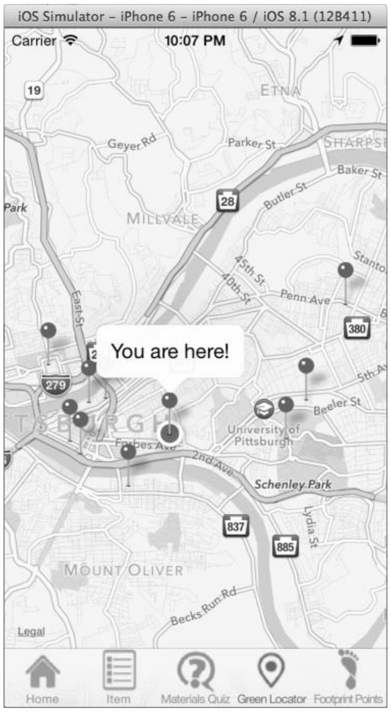

Figure 4: Opening Green Locator Screen with Current Location Pin Selected

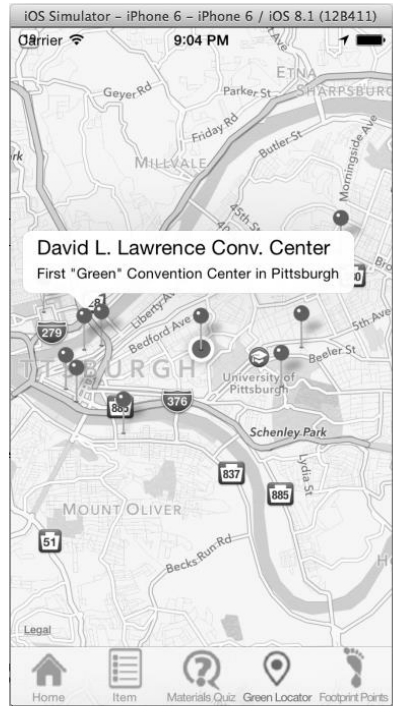

Figure 5: "David L. Lawrence Conv. Center" Pin Selected

If the user were to click on any other pins available, he or she would be able to see which building the selected pin represents. Figure 5 gives an example of this with the David L. Lawrence Convention Center, the first "green" convention center in Pittsburgh.

As of right now, the pins represent these additional locations: the PNC Firstside Center, the first "green" financial institution; the Children's Museum of Pittsburgh, the first "green" children's museum; the Point Park University Dance Complex, the first "green" university dance studio; the Phipps Conservatory Welcome Center, the first "green" public garden welcome center; the Senator John Heinz History Center, the first "green" Smithsonian property; the WYEP Radio Station, the first "green" radio station; the Greater Pittsburgh Food Bank, the first "green" food bank; the Carnegie Mellon University Stever House, the first "green" university dormitory; and the Pittsburgh Glass Center, the first "green" public arts facility (Green Building Alliance, 2015).

Footprint Points

The point counter (see Figure 6 for the opening screen) shows how many "Footprint Points" a user has depending on his or her environmental friendliness. The greater number of points a user has, the more environmentally friendly he or she is. He or she can add or subtract points on a separate screen by clicking the "Add Points" button.

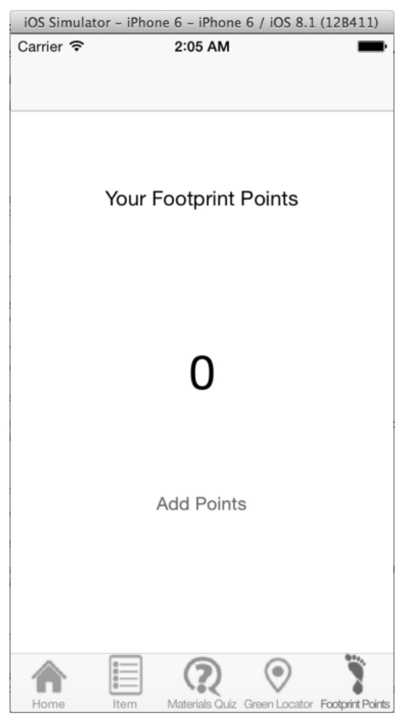

Figure 6: Opening Footprint Points Screen

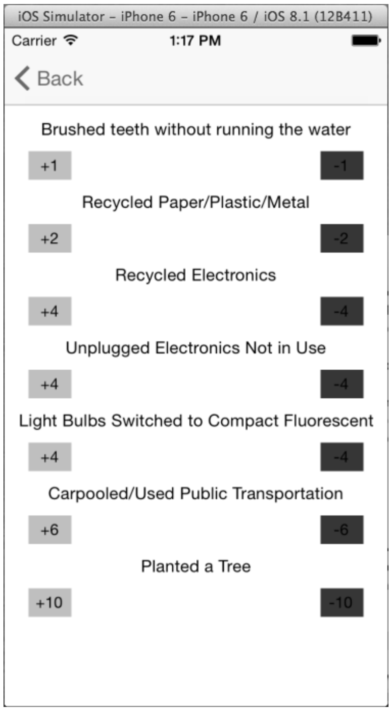

Figure 7: Selected "Green" Activities Affecting Total Footprint Points

At the start of the user's exploratory journey, the points are equal to 0. Green buttons on the left add points, and red buttons on the right subtract points for the activities listed in Figure 7. These activities include brushing teeth without running water the entire time, recycling various objects, and planting trees. For example, if a child recycles a plastic bottle, he or she can add four points, but if he or she throws it in the trash, the four points can be subtracted. This is an easy, interactive, direct way to show how environmentally conscious the users are and how they can improve. The idea of positive reinforcement (points) is intended to encourage users to be more environmentally friendly. It is taken from the association that other successful applications have included some form of rewards in their applications. Ideally, the users' ability to see their progress in terms of high positive points or negative points will encourage users to keep up their normal activities (in the case of the former) or change themselves around to be more "green" (in the case of the latter).

Quiz

The quiz is the main focus of this thesis. It is a compilation of thirty-five questions ranging from "What do the three R's mean?" to "Why are trees good for the environment?" (A full list of each question, its choices, answer, and explanation can be found in Appendix A.) The screen that the user first sees is shown in Figure 8. The user must press the only visible button ("Press to Show First Question") in order to start viewing questions.

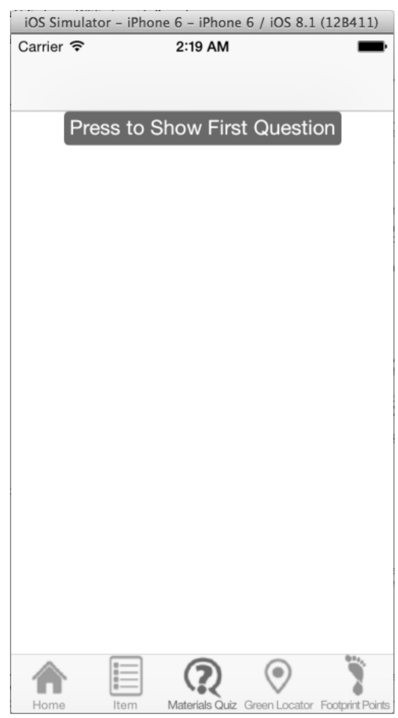

Figure 8: Quiz Introductory Screen

When the button is selected, a question is revealed and the "Press to Show First Question" button changes to read "Next Question." Each question is multiple-choice, and is paired with four possible answers. These questions are randomized so that each time the user pulls up the quiz, question one will not always be the same, for example. This is the same for the possible answers A. through D. This prevents students from memorizing which number question has which letter answer. In addition to randomizing the questions and their respective possible answers, the code was written to ensure that questions are not repeated. Before this function was incorporated into the application, the same question could have appeared three times in a row. This would be expected to get boring and annoying to users, so this issue had to be overcome. An example of the first appearing question is shown in Figure 9.

When a selection is made, all other choices disappear except for the one chosen and the correct answer (if the latter is different from the former). The buttons for the possible selections are disabled. These functions prevent students from being able to change their answers. If they were able to do so, they could continuously guess, which would defeat the purpose of the quiz. At the bottom of the screen, the user can see if the answer is correct or incorrect. The coloring of the chosen answer also indicates if it is the correct choice (green text) or incorrect choice (red text). Examples of incorrect and correct answers can be found in Figures 10 and 11, respectively.

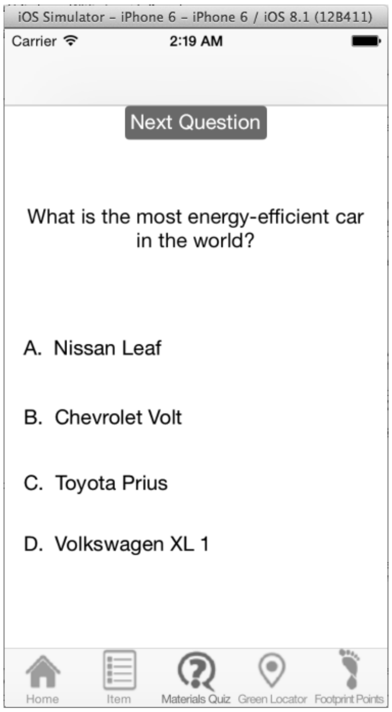

Figure 9: Question Example

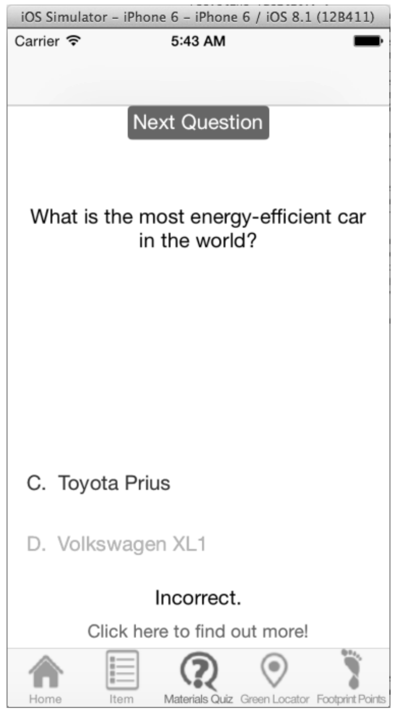

Figure 10: Incorrect Selection Example (Answer C. was chosen by the user.)

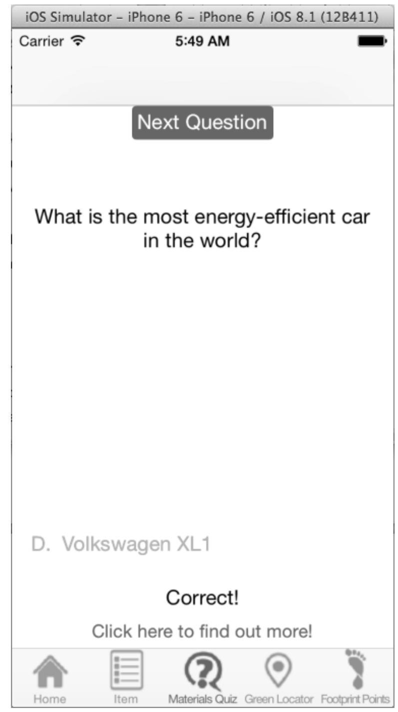

Figure 11: Correct Selection Example (Answer D. was chosen by the user.)

Regardless of if the user got the question right or wrong, he or she will be able to click on a button ("Click here to find out more!") which will take him or her to another screen to give an explanation of why the answer is right or wrong or offer more details relevant to the answer (for an example, see Figure 12). This encourages students not just to guess and get lucky, memorize, or learn simple answers, but also to understand detailed explanations.

Because there are only so many questions, and those questions do not repeat, the user is intended to eventually reach the end of the bank of questions. When this happens, a message appears to the user telling them so, as can be seen in Figure 13.

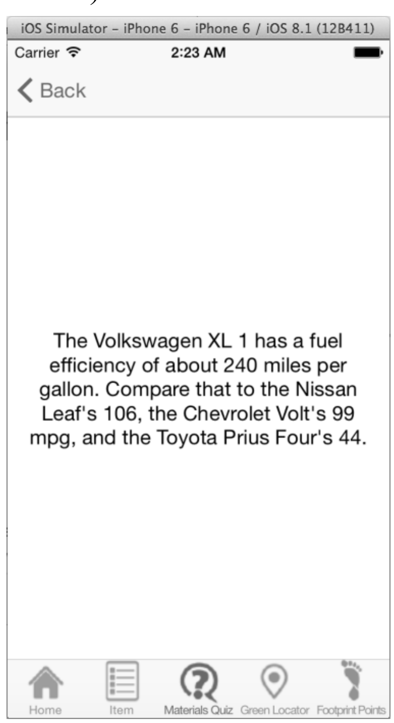

Figure 13: Explanation of Question's Answer

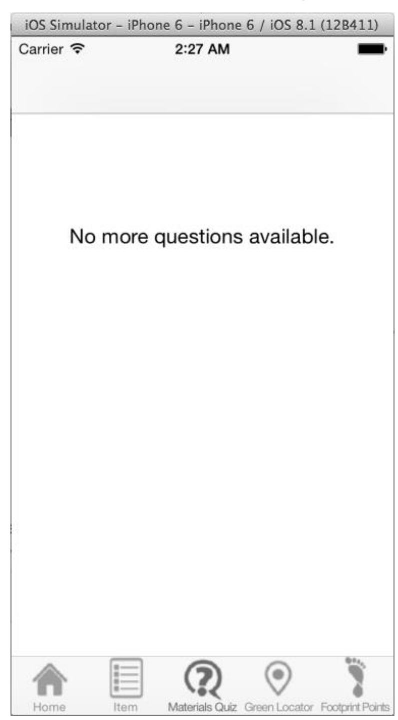

Figure 12: End of Available Questions

Challenges and Lessons Learned

Perhaps the most difficult challenge that was faced throughout this process was handling information that had to be transferred among screens. In particular, the calculations that had to be passed back and forth between the Footprint Points initial screen and the addition or subtraction points screen. This is still a problem and will, unfortunately, be passed down to the next programmers who decide to take this on as a project. The reason it is an issue is because when passing information was taught as a topic in a class taken by the original application developer, information was only passed from the initial screen to the second screen. Here, information is being passed from the second screen to the initial screen. Again, this is something that must be fixed before the application is passed on as a final product. Perhaps the new developers can determine another way to display the total points correctly. The only hope is that the total points are displayed on a separate screen from the activities that adjust the points up or down.

Another major challenge faced, which proved to be quite the learning experience, was the need to update the map portion of the application. This application was started in the Fall 2014 semester and was updated in the Spring 2015 semester. In the former time frame, the map was working very well and without any problems. Sometime between the two semesters, the XCode software was updated. After the update, it was required for users to allow applications to use their current locations (found using location services) before anything like a map could successfully run. Having to find out exactly what to incorporate into the code in order to avoid any runtime errors was the problem the original developer was having. After multiple Google searches and an endless number of tests, the map finally started to work again. It was not until this occurrence that the true effects of software updates were made apparent to the first application developer.

Other than these issues, the entire programming and application design process was very enjoyable to the application's first programmer. Trying different programming techniques and seeing (almost) everything work as it was intended felt like a great accomplishment.

Opportunities for Future Work

There is a lot of work yet to be completed on this application before it can be passed on to schools to be implemented in an educational sense. It is intended that within the next few years, other interested, well-informed students will develop the application. As of right now, these students are intended to be software engineering students. However, any student interested in programming can decide to further develop this application.

A grant is in the process of being requested so that the engineering department might have access to its own Macintosh computer and XCode software for application development and iPhone for testing. If the grant is accepted and offered to the engineering department, then future developers will have easier access to the necessary materials to continue working on the application.

Some improvements and changes that are intended to be made are as follows: a further extension of the list of sustainable materials, a further extension of the list of "green" locations, a determination of distance from current location to aforementioned "green" locations, a further extension of the questions posed to students, a separation of questions based on grade level, a separate screen to reveal the grade from the quizzes, a further extension of the Footprint Points idea, an adaptation of the existing mobile application to other formats, and a provision of the application to local schools for Beta testing and use in classes.

The list of sustainable materials can be obtained from further exploration of the Granta Design Edupack database found on Robert Morris University computers. If the developers at the time feel that this list is not comprehensive enough, of course, they may use the Internet and find an additional, suitable, and appropriate source.

The list of "green" locations is up to the discretion of the future developers. Ideally, this list will be extended to outside of the Pittsburgh area so that even further in the future, students across the nation will be able to use this application and realistically apply what they learn. Local community websites can be used to find locations of recycling facilities and other "green" locations in order to expand these lists.

Questions that can be posed to students can be found online, in educational materials, and the like. These questions can be separated by grade level through this research and through observation of educational standards.

A separate screen to reveal results of the quizzes is simply an extension of the application, and its appearance is up to the discretion of the future developers. It should act similarly to the Footprint Points screens. Another option is to have the final quiz grade appear when it is revealed that no more questions are available. Perhaps the grades for the quizzes can affect the Footprint Points in the future.

A further extension of the Footprint Points section can include more activities worthy of points. It can also include a delegation of appropriate activities based on grade level and/or number of Footprint Points. For instance, at a certain level, students can "unlock" new "green" activities after they have become "proficient" in the current ones of which they are aware. It was also considered that the Footprint Points idea can be turned into a list concept so that more activities can be included on the respective screen. This will involve more "passing" of information between screens, but it can be done.

The mobile application described in this report was written using XCode software (Objective-C programming), which is used for iPhone applications. If future developers so desire, they can adapt the program to work on Android phones as well. More versions in the form of interactive games with characters and story lines could be made in the future. These may prove more effective when it comes to educating children, as is proven by past research described in the Literature Review section of this report.

Beta testing can be performed, as was stated earlier, at local grade schools and high schools. The new developers will need Institutional Review Board (IRB) approval for this testing. The approval process has already been started. Relevant documents can be found in Appendix B. These documents were written with the intent to survey college students eighteen years of age or older. Therefore, the new application submitted will need to be modified for surveying of students under the age of eighteen. This process should be started as soon as possible so that, if any improvements need to be made to the proposal, they can be made in a timely manner for an early final approval. This would then give the new developers enough time to enact the study to obtain results and feedback which can be used to improve the application. The mobile application, after IRB approval is given for the testing process, will be put on the Apple store for the express purpose of this testing. After being downloaded, the students who are a part of this testing will be asked their opinion on the application: if they enjoyed using it, what they liked the most, what they did not like, etc. This feedback will then be used to enhance the application even further. When the application is sufficiently improved, it will be released on the Apple store for use in schools as an educational supplement, not just to be tested.

In the future, students in educational programs can develop a curriculum for sustainability education which incorporates the use of this application. Perhaps then, more detailed lessons can be added on to the application as a separate section of screens, again depending on the grade of the user.

Conclusion

Sustainability has become quite the hot topic over the past few years. Many prestigious organizations, such as the Environmental Protection Agency, Center for Green Schools, and U.S. Green Building Council have called for the United States education system to start implementing sustainability into its curriculum. With technology on the rise, and it seeming to have more of an advantage than disadvantage in the classroom, creating an interactive, rewarding, and informative mobile application to aid in this endeavor is a logical answer to these calls. Because children are noted to learn more the earlier that they are introduced to information, aiming this proposed mobile application toward the younger children would be the best way to approach such a challenge. Ideally, this mobile application described in this thesis will be the beginning of successfully incorporating sustainability education into every United States school.

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Appendix A

The following is the full list of questions, respective possible answers, and explanatory information provided to the user in the quiz portion of the mobile application. The first answer (a.) is the correct answer with the explanatory information provided as "i."

1. What percent of worldwide energy usage does the United States claim?
   a. 18%
      i. According to the U.S. Energy Information Administration, the United States contributed to 18% of the total primary energy consumption in 2012. Total Energy Consumption = 529 British thermal units; U.S. Energy Consumption = 95 British thermal units (U.S. Energy Information Administration, 2015)
   b. 57%
   c. 6%
   d. 21%
2. If you replace one regular light bulb with a compact fluorescent one, what is the equivalent in cars taken off of the road?
   a. 1.3 million (1,300,000)
      i. Compact fluorescent light bulbs use 75% to 80% less energy than a normal light bulb. A single light bulb replacement is equal to taking 1.3 million cars off the road. That same amount of energy can power all the houses in Delaware and Rhode Island (Fishman, 2006).
   b. 2.2 billion (2,200,000,000)
   c. 56 thousand (56,000)
   d. 800 thousand (800,000)
3. About how much water is conserved per household per year if you do not pre-rinse your dishes before putting them in the dishwasher?
   a. 6,000 gallons
      i. If you still insist on wanting to wash dishes before putting them in the dishwasher, use the "Rinse and Hold" option if there is one. Also be sure to keep all dishes unobscured so that water can easily get to them and you won't have to rewash them after once cycle (Consumer Reports, 2012).
   b. 530 gallons
   c. 100 gallons
   d. 42,000 gallons
4. Which of the following is NOT one of the three R's of sustainability?
   a. Refine
      i. Reduce: Use less things that produce waste; Reuse: Use things more than once; Recycle: Use a special container for all your used, recyclable materials to be taken to a local recycling facility (National Institute of Environmental Health Sciences, n.d.).
   b. Reduce
   c. Reuse
   d. Recycle
5. How does planting trees help the environment?
   a. All of these are correct

        i. Trees not only combat the greenhouse effect, clean the air, and naturally cool their surroundings (which reduces the need for excessive energy use), but they also improve water quality, reduce noise, provide living places for many animals, and decrease the amount of maintenance required for pavement upkeep. (United States Environmental Protection Agency, 2013).
    b. Combat the greenhouse effect
    c. Clean the air
    d. Naturally cool their surroundings
6. What is the most energy-efficient car in the world?
    a. Volkswagen XL1
        i. The Volkswagen XL 1 has a fuel efficiency of about 313 miles per gallon. Compare that to the Nissan Leaf's 106 mpg, the Chevrolet Volt's 99 mpg, and the Toyota Prius Four's 44 mpg (Volkswagen, 2015; Consumer Reports, 2015).
    b. Chevrolet Volt
    c. Toyota Prius
    d. Nissan Leaf
7. What is the most environmentally friendly company in the United States?
    a. Allergan
        i. Allergan is a pharmaceutical company, primarily known for its product Botox. The company is a member of the United Nations Global Compact, which promotes a sustainable culture among its members. Allergan reduced its energy consumption by 11%/square meter simply by installing solar panels at its California headquarters (Newsweek, 2014).
    b. International Business Machines (IBM) Corporation
    c. Apple
    d. Hershey
8. What is the certification a building, home, and/or neighborhood can receive for being “green?”
    a. LEED
        i. In order to qualify for LEED certification, a company, home, or neighborhood must meet certain requirements and receive a given number of points based on the level of certification that is being requested (U.S. Green Building Council, 2015).
    b. GREEN
    c. Sustainability Certification
    d. Environmental Awareness Certification
9. What does LEED mean?
    a. Leadership in Energy and Environmental Design
        i. From the LEED website: "LEED certified buildings save money and resources and have a positive impact on the health of occupants, while promoting renewable, clean energy” (U.S. Green Building Council, 2015).
    b. Lessening Energy and Environmental Damage
    c. Little Energy Expended for Destruction
    d. Lessening Each Environmental Detriment

10. What is the most environmentally friendly country?
    a. Switzerland
        i. Switzerland, over the past several years, has introduced five national parks and reduced its carbon footprint (Ross, 2014).
    b. United States
    c. Germany
    d. China
11. How can you find your local recycling facility?
    a. Look it up online
        i. You must separate recycling from the trash, and it is not guaranteed that the trash men will not just throw the recycling out if it is on the curb when they come to pick up the trash. Driving around town could waste a lot of gas, and emit a lot of carbon dioxide into the air, hurting the environment. It is best to look up your local recycling facility online using www.recyclerfinder.com (Recycler Finder, 2012)!
    b. No need to-just put the recycling out with the trash
    c. Drive around town
    d. Throw everything in the trash. It can be separated later.
12. “Carbon footprint” is defined as: “the amount of ______________ and specifically carbon dioxide emitted by something (as a person’s activities or product’s manufacture and transport) during a given period.”
    a. Greenhouse gases
        i. Carbon dioxide makes up 82% of greenhouse gas emissions as of 2013. As its namesake suggests, the amount of carbon dioxide you release into the environment is known as your "carbon footprint" (Merriam-Webster, 2015; United States Environmental Protection Agency, 2015).
    b. Smog
    c. Carbon
    d. Oxygen compounds
13. About what percent of American waste is recyclable?
    a. 75%
        i. 75% of American waste is recyclable-and we only actually recycle about 30% of it (Do Something, n.d.)!
    b. 25%
    c. 100%
    d. 50%
14. If you were to recycle one aluminum can, how much energy would be saved?
    a. Enough to listen to a full album on a multimedia device
        i. If you were to recycle 100 aluminum cans, enough energy would be saved to power your bedroom for two weeks (Do Something, n.d.).
    b. Enough to keep my room lit for the day
    c. Enough to run a train for five minutes
    d. Enough to power a computer for two weeks
15. How long does it take for an aluminum can to go from a recycling facility back to a local grocery store shelf?
    a. 2 months

        i. A recycled glass container can be processed and placed back on store shelves in as few as 30 days (Do Something, n.d.; Conserve Energy Future, 2015)!
    b. 2 weeks
    c. 4 days
    d. 1 year
16. What was the first company to use recycled material in their products (after use by their customers)?
    a. Patagonia
        i. Patagonia started this material reuse process in 1993. All of this company's products are 100% recyclable and each of their clothing pieces contains 54% recycled polyester (Manohar, 2011).
    b. Timberland
    c. L. L. Bean
    d. The North Face
17. What is the most abundant material in the Earth's crust?
    a. Aluminum
        i. This probably explains why Aluminum is the most recycled material (at least in the United States) (Conserve Energy Future, 2015; Granta Design, Limited, 2014)!
    b. Gold
    c. Silver
    d. Nickel
18. How does the United States rate in the following categories: ecological footprint and gross domestic product (GDP)?
    a. High ecological footprint, High GDP
        i. The United States is rated higher than Germany, China, and Switzerland in both categories. The only countries to exceed the United States in both categories are Denmark and Luxembourg. This all means that the United States produces a lot of products, but also has a large carbon footprint. It would be difficult to achieve a high GDP but low carbon footprint (Granta Design, Limited, 2014).
    b. High ecological footprint, Low GDP
    c. Low ecological footprint, High GDP
    d. Low ecological footprint, Low GDP
19. How many trees are needed to produce the Sunday newspapers each week?
    a. 500,000 trees
        i. BUT! If everyone were to recycle the Sunday newspaper one week, that would save 75,000 trees! If all newspapers were recycled for the year, 250 million trees could be saved (Conserve Energy Future, 2015)!
    b. 500 trees
    c. 5 trees
    d. 5,000 trees
20. Design for _______________ is a way that the environmental impact of a product (for its entire life) can be reduced significantly-or even eliminated.
    a. Environment

        i. This method can result in lower costs and higher quality, too! There are so many benefits to its implementation. Ultimate goals should include: simplifying the manufacturing process, using less raw materials, reducing scrap, increase efficiency, and eliminate toxins (Manohar, 2011).
    b. Sustainability
    c. Impact
    d. Energy
21. Which of these is an effect of the amount of carbon dioxide being released into the air everyday?
    a. All of these are correct
        i. There is less of a variety of animal and plant species (biodiversity reduction) and less protection of the Earth from UV rays (ozone depletion). Our water and air is being polluted, land is being torn up, resources are being lost, landfills are being filled, and global warming is heating the Earth significantly (Manohar, 2011).
    b. Biodiversity reduction
    c. Ozone depletion
    d. Water pollution
22. Glass is ____ recyclable.
    a. 100%
        i. A glass bottle can take up to 4000 years to decompose (more if it is just sitting in a landfill)! When glass is recycled, it must be separated by color because the color remains even after being recycled (Conserve Energy Future, 2015).
    b. 60%
    c. 55%
    d. 30%
23. By about how much (degrees Fahrenheit) is the Earth's average temperature rising per decade?
    a. 32
        i. The surface temperature has been rising this way for the past 50 years. It is twice as fast as the 50 years before that! That's pretty dangerous (Manohar, 2011)!
    b. 16
    c. 1
    d. 25
24. There are three categories that define Designing for Disposability. Which of the following is not one of these categories?
    a. All of these are part of Designing for Disposability
        i. "Green" products are those that can, at the end of their life, be reused and decomposed with little to no harm to the environment. "Clean" processes result in very few byproducts and little to no toxins released into the environment. "Eco-factories" have recycling capabilities and make use of as few natural resources as possible (Manohar, 2001).
    b. "Green" products
    c. "Clean" processes

    d. “Eco-factories”
25. List the following demanufacturing issues from greatest to least waste reduction: Remanufacturing, Reuse, and Recovery.
    a. Reuse, Remanufacturing, Recovery
        i. Reuse: requires the entire product; Remanufacturing: requires only scrap pieces of a product; Recovery: requires only very specific (usually small amounts) of materials from a product (Manohar, 2001)
    b. Remanufacturing, Recovery, Reuse
    c. Recovery, Reuse, Remanufacturing
    d. Recovery, Remanufacturing, Reuse
26. What is NOT involved in the demanufacturing process?
    a. Each of these is used
        i. Demanufacturing is, essentially, the disassembly of a product so that the parts can be reused later. The whole process involves retrieval, separation, disassembly, sorting, storage, transportation, identification, testing, reprocessing, and remarking (Manohar, 2001).
    b. Retrieval
    c. Separation
    d. Testing
27. What is the difference between being “green” and being sustainable?
    a. All of these answers define the difference
        i. Being "green" describes items on a smaller scale and in a shorter term. Sustainability is all-encompassing and long-lasting (Yanarella, Levine, & Lancaster, 2009).
    b. “Green”: only individual products or components are involved
    c. Sustainable: an entire system is involved
    d. “Green”: quicker (not as long-lasting) and cheaper
28. What is another environmentally friendly end-of-life potential (aside from being recycled) for materials after they are used?
    a. All of these are potentials
        i. A material that is down-cycled is used for a lower-quality purpose. A material that is biodegraded is composted and can be used as fertilizer for the Earth. A material that is controllably combusted can be used to provide energy for various means. A material can also be thrown into a landfill if it will not have a contaminating effect on its surroundings (Manohar, 2001).
    b. Being down-cycled
    c. Being biodegraded
    d. Being controllably combusted
29. What companies have to abide by particular “green” engineering standards?
    a. All companies
        i. There are international standards that all companies must follow. International Organization for Standardization (ISO) 14001 can help any company fulfill these standards by outlining a relatively universal environmental management system. Most users of this outline found it useful when attempting to meet legal requirements (Manohar, 2001; International Organization for Standardization, n.d.).

    b. Only companies in certain countries
    c. No companies
    d. Only the companies that are a part of the Green Alliance

30. What reasons might make a company want to partake in "green" engineering?
    a. Greater profit
        i. Creating "green" products actually increase the differentiability of one company's products from those of another, making the more varied products more desirable to consumers. Going "green" can have a higher cost, but is also a very complex process. Despite these costs, a "green" company can end up getting more of a profit from being environmentally conscious. Consumers tend to like products that have a positive impact on the environment and can be willing to pay more for such products (Manohar, 2001).
    b. Less differentiability
    c. Higher cost
    d. Less complexity

31. What was the first year in the United States when more paper was recycled than thrown away?
    a. 1993
        i. 1993 was the first year that the United States recorded that more paper was recycled than thrown into landfills. If one person recycled all his or her paper in that year, it would have equaled about 700 pounds of paper and would have saved 465 trees (Greencyclopedia & Eco Endeavors, 2013).
    b. This has not happened yet
    c. 1950
    d. 2000

32. Which of these items cannot be reused?
    a. All of these can be reused!
        i. Old cell phones can have the zinc extracted from them, which can then be used to help build ships. Clothes can be donated to other kids who need them. Cloth bags can be used instead of plastic bags when going to the grocery store. Additionally, old video game consoles have gold in them, which can be used to make gold jewelry (Greencyclopedia & Eco Endeavors, 2013).
    b. Older cell phones
    c. Clothes
    d. Cloth bags

33. Which of these is the best substitute for plastic bags?
    a. Cloth bags
        i. Only 1% of plastic bags are recycled. When they are thrown into landfills, they tend to blow in the wind and get caught in trees and the ocean, negatively affecting the animals that live there. Paper bags and cardboard boxes require trees to make them. Cloth bags can be reused multiple times because they are very durable (Greencyclopedia & Eco Endeavors, 2013).
    b. Paper bags

c. Cardboard boxes
d. None of these-plastic bags are the best option

34. Which of the following statements is false?
    a. 1.2 million people do not have enough to eat
        i. 1 BILLION people do not have enough to eat. The other statements are true. A lot of people also do not have access to clean drinking water. Being conscious of your daily habits may not help directly affect these people, but it will surely reduce daily waste (Greencyclopedia & Eco Endeavors, 2013).
    b. 1.6 billion people do not have access to electricity
    c. 2.5 billion people do not have access to proper sanitation
    d. All of these statements are false

35. Which of the following can be composted?
    a. Leaves and flowers
        i. There are very many more things that can be composted. Most of these involve natural materials (such as flowers and leaves) because composted material goes back into the soil. Although newspapers can be composted, magazines cannot be because of the way they are printed with coatings and chemicals. Meat, fat, and bones can attract unwanted pests. Sawdust can be composted, but only if you know for sure that it came from untreated wood. Otherwise, this is another chance for chemicals to contaminate the soil (Eartheasy, 2014; Baskind, 2010).
    b. Magazines
    c. Meat, fat, and bones
    d. Sawdust

Appendix B

The following information was used to fill out the online IRB approval application (found at https://rmuirb.com/) for IRB case number 2015011780:

Project title: "Using Mobile Applications as a Supplement to Sustainability Education in Pennsylvania Middle Schools" ("and High Schools" added onto the end of the title exceeded the allotted character length)

1. Co-Investigators: none
2. Research Information
    - 2a. The study is being conducted as part of: Honors or Individual Problems Project
    - 2b. N/A
    - 2c. What is the research intended to accomplish?: Ideally, a mobile application will be designed and created for the use of students in grades five through twelve. This mobile application will teach users about the essence of sustainability, sustainable materials found in everyday life, and environmentally friendly actions in a gaming format. Additionally, the use of the application will turn the young audience into better citizens who are aware of how their actions affect the environment and encourage the students to enroll and work in STEM (science, technology, engineering, and mathematics) related fields.
    - 2d. What previous research has been done? (Please supply a brief literature review): see the Literature Review section of this report
    - 2e. Please check the types of measures to be used: Focus Groups
    - 2f. N/A
    - 2g. Please select the type of data to be collected: Qualitative
    - 2h. Please provide a description of your research design and procedures (may need more detail regarding the focus group and feedback process): The main approach to this thesis is to read and understand how Apple mobile application development works and the types of processes and conventions used by developers. This can be found on the Apple developer website. I will also learn and understand what makes mobile applications fun, appealing, and educational using some of the sources I found throughout the course of the Honors: Research Methods class. Using the Board of Education requirements regarding environmental science and sustainability, I will lay out a plan for what the application will cover in terms of educational content. Using software such as CES EduPack and its supplemental card game, I will find information on sustainable materials that I can use and incorporate into the mobile application. After finding this information, I will sit down with my thesis advisor, Dr. Priyadarshan Manohar, and create a potential storyboard for the application. I will then coordinate a focus group of Robert Morris University students (pending IRB approval) to get constructive feedback on the storyboard. After this, I will take the finalized storyboard and turn it into a preliminary program. Once I have tested the program to make sure it works properly, I will coordinate another focus group to ask how the program itself might be improved. I will do my best to improve the program further based on the critiques I receive after the second focus group providing there is enough time to do so. This will all culminate in my presenting the final product as part of my Honors Thesis independent study class (HNRS 4912).

3. N/A
4. Researching in an Organization
    4a. The research will be conducted at a particular organization (workplace, school, military base, retail outlet, etc.) If the research takes place at RMU, NO letter of support is needed: No letter provided since research was intended to be performed at RMU
5. Financial Support
    5a. Please select the type of funding being used: Unfunded (The grant, if accepted, may need to be mentioned in the future.)
    5b. Please select the source of financial support: None (Again, the grant source may need to be included here.)
6. Participation Information
    6a. Number of Participants: 25 (probably will end up being greater)
    6b. Participant Age Range: Ages 18 and Older (for Beta testing, future developers will want to test with students under the age of 18)
    6c. Gender: Both (Male and Female)
    6d. Vulnerable subjects (pregnant women, infants, prisoners, individuals with compromised mental status, or children): No (Depending on the age of children studied, future developers may need to check "Yes" for this.)
7. Risk Factors
    7a. Discuss the direct and indirect risks to participants and how any risks will be managed: N/A
    Please specify: No foreseeable risks, direct or indirect, will result from the focus groups.
    7b. If deception is involved, please explain: N/A
    Please specify: N/A
    7c. *Indicate the degree of physical or psychological risk you believe the research poses to human subjects: Minimal Risk: the probability and magnitude of harm or discomfort anticipated in the proposed research are not greater than those ordinarily encountered in daily life or during the performance of routine physical or psychological tests or examinations.
8. N/A
9. CITI Program (required for all students)
    9a. Have you completed the CITI (Collaborative Institutional Training Initiative) Program training?: Yes (Future developers will need to complete this training and upload proof of completion. The link to the program is provided in the online IRB form.)
10. Additional IRB Approval
    10a. Do you have an additional outside (other than Robert Morris University) IRB approval?: No
11. Recruitment Information
    11a. Select the levels of recruitment being used: Other
    11b. Please specify: I will obtain approval from a Robert Morris University professor to introduce my idea to his/her class so that I might use his/her students as my focus group. (Change to target study towards middle and high school students.)

12. Consent Form, Script with IRB Contact Information and any Relevant Data (i.e., survey, interview questions, etc.)
    - 12a. Please include a copy of the consent form, script with IRB contact information and any relevant data gathering instrument (i.e., survey, interview questions, etc.). Please merge all files into one .pdf document and upload it below. (See uploaded form at the end of this Appendix. It is recommended that the IRB phone number be included as a point of contact in the form should those involved in the study have any questions.)
13. Participant Compensation and Costs
    - 13a. There is no compensation for this study
14. Confidentiality and Data Security
    - 14a. Personal identifiers, recordings, files, and any other material used in the study will be held in a secured location.
15. Conflict of Interest
    - 15a. Do you or any individual who is associated with or responsible for the design, the conduct of, or the reporting of this research have an economic or financial interest in, or act as an officer or director for any outside entity whose interests could reasonably appear to be affected by this research project?: No

Robert Morris University
Institutional Review Board
Approval Date:
Renewal Date:
IRB Number:

Principal Investigator: Brittany Palac
bapst11@mail.rmu.edu
(610)547-2668
RMU Mailbox Number 123
Advisor: Dr. Priyadarshan Manohar

Using Mobile Applications as a Supplement to Sustainability Education in Pennsylvania Middle Schools and High Schools

Focus Group Consent and Release Form

By signing this waiver, you are agreeing to participate in the aforementioned study. The goal of this project is to develop a mobile application for middle school and high school students so that they may learn more about sustainability and environmentally friendly activities. Through this medium, these students might grow to be more outstanding citizens and enroll and work in STEM (science, technology, engineering, and mathematics) related fields.

Throughout this study, in the form of a focus group, you will be shown layouts for a proposed mobile application as well as the preliminary and final versions of the application in order to provide constructive feedback to the Principal Investigator listed above. It is requested that you offer honest feedback so that the Principal Investigator can tailor the final product to its audience as best as possible.

There are no risks or benefits that you will incur due to this focus group activity. Nor will you be required to pay or be compensated for your participation. No personal information will be obtained from you and the responses and feedback that you offer will be kept anonymous.

Furthermore, you may opt out of this study at any time.

Should you have any questions about the study or further feedback on what is presented to you, please contact the Principal Investigator whose contact information is listed above.

I have read and understand the above statements and agree to voluntarily participate in the focus group. I understand that I may withdraw from the study at any time without penalty. I understand that I may contact the Principal Investigator should I have any questions after the completion of this study.

Participant Name (print): ____

Participant Name (sign): ____ Date: __________

Person Obtaining Consent (sign): ____ Date: __________