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Augmented Reality Technology Used To Enhance Informal Science Learning

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Introduction

There is a need for education to address the unique scientific literacy demands of the 21st century. With science advancements ever-changing and an increased use of multimedia to display information to the public, science literacy and critical thinking skills are important for the public to keep up to date. Students will need to know how to interpret science information they are faced with throughout their lives to make decisions and critique scientific arguments (Squire & Mingfong, 2007). Civic science literacy has been defined in many ways but generally encompasses the ideas that citizens are able to understand science concepts, inquiry and comprehend up to date science information and research that is presented to the public via newspapers, magazines and television series. It is also important for citizens to understand local and global environmental problems and how they can impact their life, the economy and the role of technology. Students should be engaging in activities that involve these issues in their science classes, so that as citizens they can actively participate in finding solutions (Marino & Hayes, 2012).

Science education reform is becoming more focused on incorporating science practices with the use of tools and processes to enhance learning. An authentic learning experience can be described as experiencing real problems and consequences in context (Rosenbaum et al., 2007). The skills learned in an authentic learning environment will be vital to success in 21st century work and citizenship. Technology can help create an authentic experience by incorporating the use of scientific skills needed to address scientific concerns (Rosenbaum et al., 2007). Specifically, augmented reality technology can be used to create authentic learning experiences

as it allows for many unique affordances in the field such as place based learning context, personal embodiment of a role, and solving a problem modeling real life science research.

This paper will examine augmented reality technology in science education and the pedagogical support behind this technique. Authentic learning experiences such as place based learning, participatory roles, and games can all be provided with the use of augmented reality technology. Other pedagogical theories and practices such as inquiry based learning and differentiation can be supported by augmented reality technology. The paper will also discuss some of the principles of design and characteristics that make augmented reality apps successful in science education.

Authentic Learning Experiences

1) Situated or Place Based Learning

A place can hold many different meanings to individuals. They may have visited this place or have an attachment to a place which may stem from nature or culture (Semken, 2009). Place based pedagogy approaches focus on the importance of situating learning in a meaningful context. Place based learning tries to connect personal and social experiences, history, and culture to content based learning (Squire et al., 2007). These situated learning experiences are specifically important to new science standards focusing on authentic scientific practices with context in the community to help create meaningful connections and learning experiences (Kamarainen et al., 2013). Many areas of natural science can be taught using place-based learning to help provide context to enrich learning and engagement (Semken, 2009). Learning environment and context can enhance and support learning especially in understanding

ecosystems and interactions in nature. These situated learning experiences may also help in future learning and connecting ideas about school-learned skills in the real world (Kamarainen et al., 2013). Place based pedagogy can allow for profound learning since it can be relevant, promote agency and address current global concerns (Martin et al., 2014).

2) Participatory roles

Simulations are a form of technology, which provide an authentic experience by allowing participants to manipulate their environment and make observations on the outcome. Participatory simulations can be used to demonstrate the nature of complex systems. Students can participate in investigations at a specific geographic location with simulated information, modify a system, and observe the outcomes in a real life space with context. Students' ability to walk around and interact in a physical and spatial environment can create an authentic learning experience (Rosenbaum et al., 2007). Collecting data while exploring the outdoors can make the experience more authentic since students are able to do work like a real scientist. Students are also motivated by their identity and role in the game in which they can become an expert in their field (Dunleavy et al., 2009).

Focusing on certain real life aspects can create authentic learning experiences. Students can be given a role or job within a game or simulation (Rosenbaum et al., 2007). Video games and virtual game identities can be used to help activate and nurture a student's identity and promote engagement (Dunleavy et al., 2009). The use of real occupation and feelings of personal embodiment can enhance authenticity (Rosenbaum et al., 2007). As Kamarainen et al (2013) suggests, the use of specific roles and jobs helps to promote students self-efficacy and positively

affects students' attitude and understanding of the topic. Not only can the use of participatory roles benefit learning, it can open up opportunities for students to become interested in different science careers and understand the jobs of scientists (Kamarainen et al., 2013). It is important to introduce students to possible career opportunities associated with STEM. Allowing students to engage in experiences that apply STEM concepts to real life and concrete situations can help motivate students to be interested in STEM classes and careers (Beier et al., 2012).

Students can play games in which they experience "cognitive apprenticeship experiences" (Beier et al., 2012). These role-playing games allow students to simulate the role of a professional in a particular career and think about real-world problems. Ultimately, these experiences can lead students to develop feelings of agency and competence, leading to motivation in science. These experiences lead the student to develop ideas about the scientific *possible self* (Beier et al., 2012). A study done by Beier (2012), measured student's perception of their future careers in science. The research of the case study suggested that science games are successful tools for motivating students in long-term goals and careers in STEM. The games helped develop a sense of agency and self-efficacy and were related to and possibly motivated by the theory of possible selves. These games ultimately help students discover science through the eyes of a scientist.

According to Marino (2012), there has been a positive outcome from the ability of students to create their own character or avatar. Research found that this technique allows students to free themselves of negative feelings about their identity for students who may have a low-self esteem in the classroom (Marino, 2012). A teaching approach based on this idea found that role-playing had a profoundly positive impact on students' learning when allowed to

perceive themselves as investigators (Squire & Mingfong, 2007). Furthermore, these roles can be dependent on one another to promote collaboration, which is seen in real life STEM careers (Rosenbaum et al., 2007).

3) Games

Game technology can be used in education as a tool for problem solving, role playing, creating models or analysis of data. The programs help students experience and build skills necessary for 21st century learning. Games use interactions, rule based systems and roles to help students perform and develop a conceptual understanding of content. Game based teaching differs from traditional teaching of most subjects as it is based around transmitting information, while games use interactions and experiences to build knowledge and skills (Squire et al., 2007).

"Gamification" is applying game play for alternative uses (Farhangi, 2012). Historically, games have been used for entertainment and leisure purposes but educators have been exploring the idea of implementing digital games into their lessons (Liu et al., 2014). This is a useful tool in science education as a majority of students are reported to frequently play games in their spare time. The amount of people playing games and the time spent playing games must be carefully considered when looking for new techniques in teaching (Farhangi, 2012).

In the past, there have been studies looking at video games used in the science classroom, which help promote social, emotional and cognitive development. These contemporary studies also claimed that these games feed into laziness, and failure to learn and pay attention (Marino & Hayes, 2012). New studies suggest that scientific argumentation skills may be fostered and developed with the use of digital games. Practices used in digital games such as data collection, analysis and developing conclusions can be paralleled to scientific literacy skills needed in the

21st century (Squire & Mingfong, 2007). “Serious” video games are used to help encourage global citizenship and civic scientific literacy. In recent years these games have been evolving due to new research in the field. Such games allow participants to act as an active citizen, expose students of all backgrounds to issues that are faced in society such as pollution and disease as well as develop great civic scientific literacy all of which cannot be easily demonstrated in traditional classroom lessons (Marino & Hayes, 2012). This experiential learning provides students with an authentic and applicable way to learn the content. Games can help provide meaningful experiences with the content and can help engage students learning of science (Liu et al., 2014).

3a) Providing a Goal

Most games include basic traits that attract participants including a clear goal, rules and limitations, creativity, feedback and voluntary participation. Games use challenges that are more interesting and rewarding than real life in order to engage the participants. These games also motivate players by creating feelings of satisfaction from completing a task, hope, success, social aspects and being a part of something big. It was found that as long as the participant is positively contributing toward a group goal, the goal does not need to be real in order to have meaning (Farhangi, 2012). Games provide students with a mission that is achievable and satisfying. When compared to science learning, students do not feel as though they have a mission that is achievable as there is no clear set of relevant goals (Farhangi, 2012). Providing students with a goal can also promote authenticity and motivate learning as students become invested in the outcome of the game (Rosenbaum et al., 2007).

3b) Diverse Learners and Games

Video game technology can help connect science to relevant issues in students' lives in a way that is accessible to a variety of students. This technique facilitates teaching scientific ideas to a range of learners. Inclusive classrooms may contain students of differing cultures and differing abilities and these factors must be considered when designing serious science games. These games may help students reading at a lower level to achieve civic scientific literacy. Principles of Universal Design Learning can be applied to video game lessons. One of the principles that videogames support includes presenting information in a variety of ways to allow students to recognize the information. Some video games offer information that is presented as text, text to speech, video, charts, graphics and game play. The use of visuals and imagery helps put the information into context for all students, especially English-language learners, as images are less culturally specific than text (Marino & Hayes, 2012). Additionally, it was found that culture and background can be related to the amount of time spent playing video games. Underrepresented populations in science were found to spend a greater amount of time playing video games than the majority of the population. These populations may be more prevalent in science careers in the future if we find a way to integrate scientific inquiry into these games (Marino & Hayes, 2012).

Science videogames can offer the ultimate form of scaffolding for lessons. If the game contains multiple levels, students must first master the lower levels to get to more advanced material and ideas. These games can also help with scaffolding by providing hints to students

who need them, and varying difficulty levels and feedback on performance (Marino & Hayes, 2012).

3c) Civic Duty:

Another important aspect of games is contribution to a group goal. Participants feel a sense of purpose by contributing to a goal and having a specific role or purpose. This tool of engagement can be used in the science classroom by having students collaborate and contribute to complete a task or goal. It is important that the goal is oriented toward betterment of society, science or the world. Many students and gamers already have strong skills in collaboration from experience in video games, so teachers must use this knowledge to help create valuable science lessons. Teachers can also inspire students to contribute to innovations in science by using science games in the classroom. Students and gamers feel accomplished by contributing to the betterment of society and solving problems. Students can participate in different projects that involve citizens to make findings in science based on game outcomes (Farhangi, 2012). Scientific discovery games are valuable tools not only for teachers and students, but for all of society. These games can be used to get citizens involved in science. Scientists have developed games around very complex problems and participants have contributed to solving these problems. These games can be more engaging as students feel they are contributing to actual research and the greater good of society rather than a simulation. These games also offer the opportunity to make advances in science research and science knowledge (Magnussen et al., 2013). An online game called “Foldit” used knowledge and trials from the public to help

scientists determine a complex retroviral protease involved in the spread of AIDS (Marino & Hayes, 2012).

Findings from a scientific discovery game researched by Magnussen et al (2013) suggested that students were motivated by this activity as they felt like they were making a difference in the world by participating in real research. Teachers found that this game helped to provide context and tangibility to a complex and theoretical idea. These discovery games provide students with an experience that could not be provided otherwise in the classroom (Magnussen et al., 2013). This approach to learning and exploration in science can offer many new perspectives from a diverse group of participants to help reach solutions to real world problems (Farhangi, 2012).

The focuses of scientific discovery games are not only to help researchers come up with answers to complex questions but also to help students become producers of knowledge. Often times in traditional classrooms students are conditioned to believe that that are consumers of knowledge and that there is a concrete set of information to learn rather than using experimentation to create new knowledge (Magnussen et al., 2013). Creating new knowledge and coming up with answers to problems are both very important skills that students will need in future careers.

As students are becoming more and more technology oriented, teachers must take the time to gain new skills and learn new instructional techniques to teach using technology in the classroom. As videogames are more popular among students than movies, games are an important tool for engaging students in their interests. These tools are also important for bridging student's lives outside of the classroom to their work in the classroom. As of now, there is a need

for the federal government to drive research in the field of serious video games, as private companies do not have incentive. This leaves teachers as an important resource in the development of these games. Serious video games allow for students to experience things that they would not normally be able to in a normal classroom setting and learn many valuable skills that are aligned with science standards and their future (Annetta et al., 2013). Additionally, these games can be used in the classroom to promote inquiry learning and cooperative learning. Videogames can also be combined with regular classroom activities such as discussions, laboratories, worksheets and investigations. These games also allow students to work collaboratively to engage in solving problems (Marino & Hayes, 2012). Students will be able to learn content through a variety of different media and collaborate with students to investigate and inquire (Annetta et al., 2013). Many student gamers would claim that they are not science minded, while many science teachers would claim that they are not gamers, but there must be an intersect between the two (Farhangi, 2012).

Technology

There is a lack of current student interest in STEM programs in the United States. The NGSS is looking to transform science education and introduce STEM practices into the science curriculum. Students in the 21st century will need skills that are fundamental to science learning such as inquiry, critical thinking, model making, collaborating, and communicating, all of which can be facilitated through technology. Not only is technology important for science skills, it is fundamental for observing phenomena that are too small, fast or far to see (Delello, 2014).

Schools are dealing with a shift seen in culture as technology progresses. This technology has started to shape users learning styles and preferences in innovative ways. (Dunleavy et al.,

2009). The widespread use of technology allows teachers to pair technology with learning. Teaching with technology can create an environment that is not only authentic and engaging, but also fun. The use of technology has led to better academic results. Educators have explored new ways to teach using some of the different formats of technology in education including, computers, multimedia, Internet, e-learning, social web, simulations, mobile devices and games afforded by mobile devices (Nincarean et al., 2013).

The use of technology to teach environmental education has been largely debated in recent years (Anderson, 2015). For instance, many believe technology use should be limited to specific and relevant situations and nature should be left alone as a place to escape and disconnect. However, the use of technology can help students learn abstract concepts and promote awareness of global issues and it can provide students with easy access to information to help facilitate inquiry and critical thinking (Anderson, 2015). The combination of these two factors can provide students with relevant, engaging and meaningful experiences. In order to facilitate the most meaningful aspects of technological experiences, teachers can use web-based tools, apps on mobile devices, self-guided nature walks and field experiments to incorporate technology into their environmental science lessons (Anderson et al., 2015). Electronic devices can provide visuals and text to supplement the experience in the natural environment. Mobile devices can help keep students engaged in learning about their environment with the use of visuals and prompts to help focus the scope of their learning. There was a study done on the use of a site-specific app for nature hikes. The app encouraged students to become engaged with their environment by providing site-specific visuals and access photos and information about different species in the area (Boyce et al., 2014). Anderson et al (2015), also demonstrates how

to use technology to compete for the attention of children and reconnect them to the environment with meaningful lessons. The study specifically aims to implement and reflect on experiences using different mobile technology in a field based environmental science class as well as comparing students learning outcomes between a traditional teaching approach and a traditional-plus technology approach. The traditional-plus technology treatment resulted in students with a greater understanding of ecology. This greater understanding was afforded by the students ability to use technology to blog about their experiences and observations as well as the opportunity to look up any questions they had. Students using technology in the lesson were also more enthusiastic about the lesson, engaged in learning and inspired to share their findings (Anderson, 2015). When the three learning conditions; paper, PC and PDA were compared, it was found that students found learning with PDAs most enjoyable. (Nincarean et al., 2013). Teachers can enhance instead of degrade the environmental learning experience with the use of technology if implemented appropriately.

As students are continuously stimulated by technology, the incorporation of virtual tools can help foster students interest in science. The use of technology in science learning can help to involve underrepresented students in science learning and enhance their experience with the natural world to ultimately inspire an interest in science (Boyce et al., 2014). As Boyce et al., (2014) suggests, students became more comfortable in nature with the use of technology and their new knowledge. This helped to promote more scientific observations. The accessibility of this technology makes it a useful instrument for field based learning to enhance science learning outcomes.

Urban school districts suffer from a lack of funding and support for teachers and insufficient materials, which often leads to science programs becoming compromised. Students in urban school districts also often feel that science is not relevant to their lives. Environmental education in particular is a subject in which students from urban districts feel they cannot connect with, as there is very little they can do to help improve their environment. Urban communities suffer from pollution and environmental degradation and many students are not exposed to nature to gain an appreciation for it. Traditional science practices do not promote a sense of stewardship for the environment. Engaging students in their local environment has been found to increase student interest in science (Barnett et al., 2006). Experiences outdoors can help students gain a sense of relevance and give them a real world context.

Urban school districts are often comprised of a high proportion of low income and minority students. In the field of science there is a great need to increase diversity of students and professionals in this field. These groups are often extremely underrepresented in STEM (Nam et al., 2013). The study by Barnett et al., (2006) looked at the impact of an urban ecology program on student interest in science. During the first year of the study, the researchers found that at the end of the year, the experimental group scored significantly higher in areas of the scale that measured interest in future science careers, science methodology and the ecological mindset scale and environmental stewardship. The study found that this program helped students become interested in urban ecology by experiencing real life science and environmental stewardship. Reform taking place in education focuses on inspiring students to become involved in STEM courses and careers. These authentic investigations using technology not only help increase

interest in the content and ultimately help to increase test scores, but they will also have a lasting impact on the health of us and our environment.

Informal learning environments are powerful tools to help engage students in science learning. They can provide an opportunity to explore and discuss science in an environment that promotes a positive attitude toward science. These experiences can also help learners apply classroom concepts to the real world. Groups of students underrepresented in science may gain an interest in STEM with the use of technology integrated into an informal learning experience. Informal science experiences with technology can be very successful in engaging students with minimal experience in nature to science learning (Boyce et al., 2014).

Handheld devices provide educational affordances like portability, social interaction, context of location, environment and time, connectivity of a shared environment and individuality for customized scaffolding. The combination of technology situated in specific place-based learning environments can help to combat the lack of student interest and many of the issues science educators are facing in their classroom by making the learning experience more meaningful and relevant to their lives.

Augmented Reality Technology

Advances in technology offer a promising future for education reform. Researchers have been studying student-learning outcomes to determine effectiveness of the use of technology in new learning techniques. Recent developments in technology include augmented reality, which has historically been used in military and other advanced technology fields. The use of this technology in science education has only been used since the 2010's. There has been evidence of

these types of tools affecting motivation and cognitive learning. Although augmented reality provides the ability to enrich real world phenomena using images and sounds, it is surprisingly still only used minimally in education (Salmi et al., 2012).

Augmented reality has been defined in many ways. Some simply define it as overlaying virtual information onto a real world situation, while others mention the specific merging of images and videos onto real scenes to provide information missing in the environment. Augmented reality exists in a spectrum ranging from reality to a completely virtual environment, which can be measured using the Milgram Reality-Virtuality Continuum (Nincarean et al., 2013). Mixed reality exists between the virtual environment and the real environment and is the space in which the two environments are blending. This can consist of augmented reality, which combines the real world with a small amount of virtual overlay or augmented virtuality, which is primarily digital data containing elements of reality (Nincarean et al., 2013). There are two types of augmented reality; location based augmented reality and vision based augmented reality. Location based augmented reality allows the user to move through an environment using GPS. Vision based augmented reality uses a camera in a mobile device to view an object. Vision based augmented reality can also include tools like QR codes. Both of these types immerse the learner in their environment to provide context to the learning experience (Dunleavy, 2014). In any case, augmented reality can be used to support science learning by overlaying virtual elements onto the real world environment and allow students to perceive a combination of virtual and real world information in a new way. (Yoon, 2016)

Students' prior experiences and background may lead them to form scientific misconceptions on various challenging concepts. A study by Yoon et al.,(2016) addressed this by

using Augmented Reality technology to help scaffold informal science learning in a museum. Augmented reality devices can be particularly helpful in teaching complicated, counterintuitive and abstract ideas and principles as it can provide digital displays to help students visualize and comprehend these difficult concepts. The ability of augmented reality to display complex relationships in science that otherwise we would not be able to demonstrate deems it as a successful scaffolding tool to provide students with visuals and information that may be hidden in the real world (Yoon et al, 2016).

1) Augmented Reality and Diverse Learners

Augmented reality is a tool that can be used to help meet the needs of diverse learners. These tools can be used to reach a variety of learners by differentiating learning for gifted students, special needs and students with low motivation (Salmi et al., 2012). Multiple layers of an augmented reality game allow for differentiation and can offer a challenge to students and provide the opportunity for the experience to be individualized to each specific student (Dunleavy et al., 2009). Mobile augmented reality games have also proven effective in teaching students with disabilities. A study found that when tested on students with physical disabilities and able-bodied students, both groups had equal success rates. This shows that augmented reality games have the potential for improving the success rates of students with disabilities (Nincarean et. al., 2013). This can also be used for differentiating learning and has the potential to significantly increase learning success for lower achieving students (Delello, 2014). Researchers also found that providing multiple sources for information other than reading could make the game and learning targets available to everyone, especially English-language learners and

students with low levels of literacy. Students can use the technology in new and creative ways to suit their own unique learning style (Perry et al., 2008) Augmented reality can be beneficial for kinesthetic learners by allowing students to view 3D objects from different perspectives and visualize different phenomena. Augmented reality technology has great potential to enhance student learning in a variety of different learners due to its characteristics, which help to merge the real and virtual world (Nincarean et al., 2013).

2) Augmented Reality and Inquiry

Augmented reality opens up a new world of authentic science inquiry. The scaffolding ability of augmented reality tools can greatly benefit students in informal learning settings to acquire accurate knowledge during periods of exploration and inquiry (Yoon et al, 2016). The 5E model of inquiry is supported by the use of augmented reality technology. Students are engaged with objects and questions then explore micro level phenomena along with macro level observations. Students explain their understandings and elaborate by applying concepts to new context to build understanding. The technology can be used to assess and evaluate student learning and understanding (Salmi et al., 2012). Handheld mobile devices accommodate augmented reality technology and have been found to support inquiry based science learning. This learning tool allows for scaffolding and development of a narrative promotes inquiry-based learning that is not easily supported in a typical classroom environment (Squire & Mingfong, 2007). Augmented reality technology can help make data collection in the field more meaningful by providing context and connections to the real world, provide individualized scaffolds and just-in time instruction, and other tools (Kamarainen et al., 2013). Allowing students to explore

their environment with the technology of augmented reality can help students acquire accurate knowledge of concepts through inquiry and collaboration (Yoon et al, 2016).

3) Principles of Augmented Reality

Augmented reality development has been researched by many designers to explore the opportunities and potential in science education afforded by the unique characteristics of this emerging technology. Researchers have studied many augmented reality games to help outline the most successful design practices. Pokémon GO is an app that was developed in 2016 and quickly became one of the most downloaded and used apps (Bartholomew, 2017). The success of this game led researchers to look at its characteristic in terms of integrating it into STEM learning. This app is unique in comparison to other game apps in that the user must be actively moving to participate and succeed. The game also uses GPS and real-world locations. This app has many parallels to science and technology that can be used to incorporate this highly engaging app into lessons on various topics (Bartholomew, 2017).

According to a study done by Dunleavy (2014), there are three major principles of augmented reality that help promote learning (Dunleavy, 2014). The first is “enable and then challenge”. As initial experiments with augmented reality can be frustrating and challenging to learners, participants should be enabled and have access to content and activities before higher level challenges. It can be overwhelming to simultaneously navigate a new complex technology and environment along with content and problems. Scaffolding with this technology allows users to build on their prior experiences. The second principle is “drive by gamified story”, which encompasses the use of interesting narratives to provide a rationale for the experience. The use of

a narrative or an interactive story can help provide context for inquiry and encourages discussion (Squire et al., 2007) The narrative can also provide the user with critical information on history or site background. This structure can create a more meaningful learning experience. The third design principle is “seeing the unseen”, or allowing the user to see invisible parts of the environment with the use of digital media (Dunleavy, 2014). This can allow for the student to view detailed models such as anatomy of animals at the zoo or unseen parts of nature such as bacteria. Additionally, research in this field suggests that other elements of augmented reality games that promote student engagement include; challenge, curiosity, control, fantasy, interaction, communication, mystery, role-playing, representation, goals, sensory stimuli, adaptation and 3D images (Liu et al., 2014). The future of these apps and games and their most beneficial characteristics will require a lot of research and ideas from instructors.

4) Development of Augmented Reality for Science Education

In recent years, mobile technology has revolutionized communication and is finding its way into education in the form of learning tools (Martin et al., 2014). Some of the characteristics that make mobile devices useful for educators include portability, social interactions with data exchange, context sensitivity and individuality to tailor activities to different learners (Perry et al., 2008). Teachers must adjust their methods to embrace the digital world and help prepare students with 21st century skills that will be vital to their future and success (Delello, 2014). Augmented reality in the classroom can be easily afforded and available but is limited by options and ideas related to curriculum. There is a need for new augmented reality resources and once

we have more available programs, these can be used routinely in science education (Salmi et al., 2012).

Augmented Reality and Interactive Storytelling (ARIS) is a platform for educators to design augmented reality tools. ARIS provides an easy and accessible opportunity for users to create augmented reality tools. This technology has encouraged educators to develop their own place-based tools using their own ideas, geography and curriculum to provide context for learning (Martin et al., 2014). The use of general software for augmented reality would allow for easy and cost effective development of games in a wide variety of locations and allow these games to be individualized to meet student's specific needs (Klopfer & Squire, 2008).

5) Pedagogical Benefits of Augmented Reality

Augmented reality is an interface of technology that engages virtual information, with physical landscapes. Compared to other technology interfaces, augmented reality is unique in that it is more connected to the environment, allows for face to face communication of teams and supports kinesthetic learning and sensory of spatial information, all of which can be beneficial to student learning (Dunleavy et al., 2009).

The use of augmented reality was found to be motivating and engaging (Delello, 2014). A study by Dunleavy et al., (2009) found that students were highly engaged and motivated while using the augmented reality technology. Researchers identified that the use of computers and navigation for data collection can be motivating factors in student learning. Other factors of augmented reality that were found to motivate students include the use of handheld computers,

collecting data outside of school, differentiated information, roles in a group and providing instant feedback (Salmi et al., 2012).

According to Dunleavy et al., (2009) when students used augmented reality technology they displayed behavior that indicated engagement, like communicating with others about information to solve the problem. The study also suggests that the collaborative nature of augmented reality games significantly contributes to student engagement. Augmented reality can be used to engage students in a lesson by allowing students to think about content in relation to familiar places from their daily lives (Martin et al., 2014). A study by Perry et al., (2008) looked at a place based augmented reality game; "Zoo Scene Investigators", used in zoos in the United States. This study found that with the use of augmented reality technology, students engaged in exchanging ideas, asking thoughtful questions and requesting confirmation. Augmented reality games have also been found to help student's access prior knowledge, which can help to promote engagement (Nincarean et. al., 2013).

The use of these augmented reality experiences can also help to increase understanding of concepts and promote collaboration and community (Martin et al., 2014). Augmented reality has been shown to promote higher learning and achievement by combining real and virtual environments. Using collaborative exercises afforded by augmented reality, students can develop critical thinking, problem solving and communication skills, which can be used in science learning (Salmi et al., 2012). Although there are limitations to augmented reality tools, like availability of devices and Internet connection, researchers and practitioners found that the benefits outweigh the challenges (Martin et al., 2014).

6) Affordances of Augmented Reality in Science Education

The flexibility of augmented reality technology allows for it to be used in countless ways to facilitate science learning. Place based augmented reality games are used to augment experiences at a real world location and create context for a problem solving experience (Squire & Mingfong, 2007). Location-aware field guides are tools that can be accessed using handheld computers or mobile devices and can provide context sensitive data and information about a location using GPS (Klopfer & Squire, 2008). Augmented reality games can also help support ideas of situated learning theory as learners are immersed in an issue and must use their knowledge to solve it (Martin et al., 2014). Augmented reality games can help immerse learners in a location by playing in the real world. Data about the location of the game can be overlaid using multimedia to manipulate the experience in the real world. Not only can augmented reality tools provide information on a location or landmark, they can outline new experiences, problems and investigations for students (Squire et al., 2007). The construction of knowledge through the use of interactive simulations allows any location to serve as a classroom with the use of location aware handheld computers (Perry et al., 2008). This situated learning experience outside of the classroom has also been found to remove stressful everyday pressures, like grades and exams from the learning experience (Squire & Mingfong, 2007).

Augmented reality can facilitate the transition from instruction to self-instruction and make learning more student-centered by providing context and differentiating learning. This augmented reality technology provides a pupil oriented learning environment and context for building new knowledge (Salmi et al., 2012). In a study done by Kamarainen et al.,(2013) teachers found that the use of the augmented reality on mobile devices promoted student

centered learning and allowed the teacher to act as the facilitator to different groups. The devices also allowed students to work independently at their own pace and provided students a sense of ownership and freedom in the experience. These experiences were motivating to the students and promoted the learning of scientific practices.

Conclusion

As mobile devices become prominent tools in our everyday lives, it is important that educators explore the possibilities for learning afforded by these relevant technological practices (Perry et al., 2008). Augmented reality is used in a variety of science content areas. Augmented reality can be used to facilitate learning in subjects from body systems to the solar system by helping students visualize spatial concepts and unseen phenomena (Delello, 2014). Educational goals for augmented reality games may include observing phenomena, asking questions, engaging in scientific arguments, developing conceptual understanding, and gathering evidence. They can also include roles that are specific to scientific careers for students to explore possible interests (Squire et al., 2007).

The use of these technologies can provide a deeper learning experience and help to determine gaps in students' understanding of content. The use of augmented reality to view non-obvious parts of the environment allows students to think deeper about unseen roles in the environment (Kamarainen et al., 2013). Some of the major overarching themes permeating the area of mobile learning include sociocultural, constructivism, and situated learning theories (Perry et al., 2008)

The strength and efficiency of devices and technology are rapidly increasing as cost is decreasing, making access to technology easy and widely available (Klopfer & Squire, 2008).

Teachers must be aware of these engaging activities that students enjoy and make connections in the classroom to their lives and activities outside of the classroom. Simple adjustments to conventional lessons can be made to increase student engagement if it relates to their interests. Teachers can use their student's current interest to frame lessons and relate the content to science and engineering practices (Bartholomew, 2017).

Project Outline

As discussed previously, the use of technology in science learning will be vital to 21st century skills (Rosenbaum et al., 2007). Augmented reality is a tool that can help students have authentic science learning experience and promote the acquisition of important science skills and knowledge.

My final project will consist of augmented reality apps that can be used in science education in an informal learning environment. The apps will be place based at a local park and will include elements that overlay information about the environment onto the screen. These apps will connect information about the local environment to content from living environment class. Students will be able to use this app prior to taking living environment to gain background information and context for content of the class. They could also use this app as an independent assignment or as a class activity. The app will contain elements of successful augmented reality apps to promote engagement. Some of these characteristics may include a collaboration aspect, game elements, development of a character, providing local history, and guided nature walk aspects.

There are a few platforms that exist for teachers to create augmented reality apps, making this tool easy and affordable (Klopfer & Squire, 2008). The apps will be developed using TaleBlazer or another platform that is available for teachers to create their own augmented reality apps.

In the future, the apps can be used as a tool in my future science classroom and classes of other teachers in the local area. The experience and knowledge gained from developing these apps may lead to the development of more apps in the future.

TaleBlazer Introduction:

The following video gives an overview of the online platform TaleBlazer that was used to create the Augmented Reality science apps and games. The creators of the game discuss some of the learning opportunities afforded by mobile augmented reality apps.

https://www.youtube.com/watch?v=wGiIlaGWAag

Using Tale Blazer: Overview

TaleBlazer is an online platform used to make games and guided tours in a specific setting allowed by it GPS capabilities. There are various terms and basic settings on the platform to learn to help the creator make each game. The image in Figure 1 shows an example of the screen that can be found when creating a game on TaleBlazer. The black arrow points to the different "Agents". The agents are the objects or characters that are visible in the game. These agents can be moved to specific GPS locations on the map and arranged to be seen in a certain order. The red arrow points to the agent's picture. The creator can upload an image for each agent. The pink arrow points to the symbol for the agent that will be seen on the map. This symbol on the map can be moved and this will move the agent to a chosen location on the map. The blue arrow points to the agent description. In this space the creator can write about the character, object or scenario or pose a question. The creator can also use this space to give information about the natural world that can not be seen or explain natural phenomena that may be occurring at that site. The green arrow points to the codes for the game. These codes can be moved over and placed in an order to prepare the game to perform a specific

Figure 1. Image shows a screenshot of the game controls and functions on the TaleBlazer website.

function for that agent. The orange codes represent “controls”, “operators” are green, “game” are yellow, “looks” are purple, “movement” are blue, and “traits” are pink.The orange arrow points to an example of the codes that will cause the agent to pop up at it’s specific GPS location and then disappear or be “excluded from world” and tell the next agent in the order to pop up or be “included in world”. These codes help the player determine where to walk to next to find the next agent and in the correct order until the game is complete.

Pond Ecosystem

Use game code “gvupdjf” to play using TaleBlazer App

The “Pond Ecosystem” game takes place at Cobb’s Hill Park but the GPS points could be moved to any location with a pond. The different colored circles in Figure 2 represent the different agents from the game and their locations around the pond at Cobb’s Hill Park.

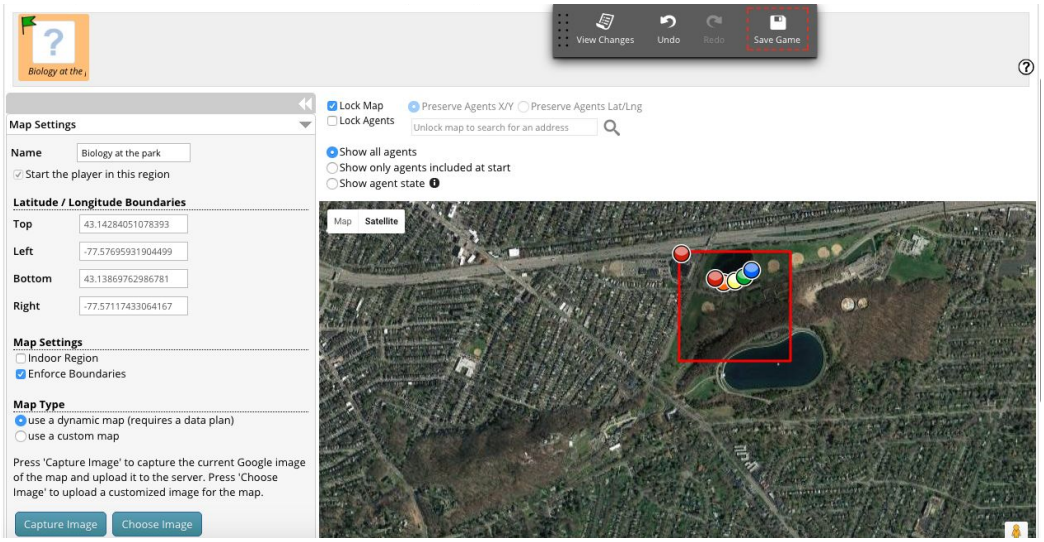

Figure 2. Image shows a screenshot from the TaleBlazer editing website for the GPS location of the game on the map.

The first agent in the “Pond Ecosystem” activity is an image of a food web (Figure 3). The food web shown is representative of one that would be found in the pond. This image helps the student view relationships and interactions occurring in the pond that can not be easily observed. The agent description states “Inside of the pond there exists a very complex food web. This web contains producers and consumer and shows how energy flows through the habitat. In the pond phytoplankton, algae, duckweed and aquatic plants play the role of the primary producers. Next the primary consumers are the herbivores that eat the producers. They include zooplankton, tadpoles, insects and very small fish. The secondary consumers will eat the primary consumers and include bigger fish, frogs, and reptiles. Higher levels of consumers can include even larger fish, waterbirds and hawks. Finally we cannot forget the decomposers! They serve an important role in the food web and break down the dead material into nutrients that can be recycled. They include bacteria, fungi, insects and animal scavengers.”

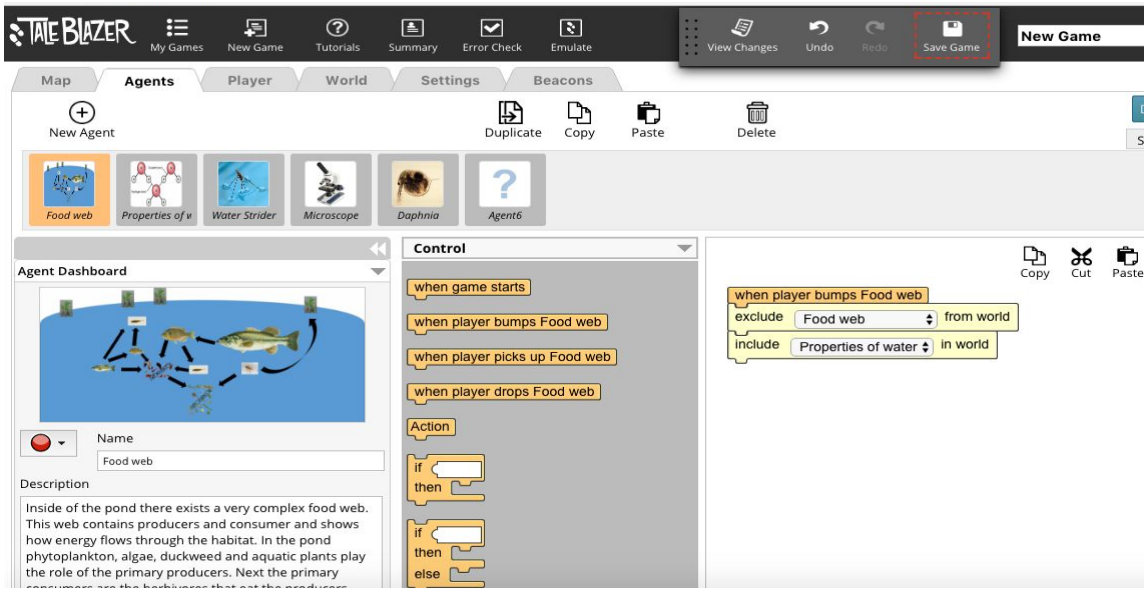

Figure 3. Image shows a screenshot of TaleBlazer editing website for the “Pond Ecosystem” app.

The next agent the student will encounter is the “properties of water” agent. This agent displays a diagram of a water molecule and the types of bonds found in water. This agent helps the learner understand properties of water that can not be observed with the human eye and states “A molecule of water is composed of two hydrogen atoms and one oxygen atom. The molecules of water interact and form hydrogen bonds which give water many unique properties. “ The next agent is a water strider which elaborates on the students understanding of the important properties of water. This agent states “You found a water strider! These insects are attracted to water ripples and feed on insects that have fallen in the water. These water striders are able to glide on the water due to a property that is unique to water due to its strong hydrogen bonds: Surface tension”.

Next, the student will encounter a microscope, an important tool for studying a pond environment as it allows us to see microscopic organisms living in the water. The student then encounters the agent “Daphnia” which is a microscopic organisms typically found in pond water samples. This agent is described; “If you looked at a drop of pond water under a microscope you might find this zooplankton, Daphnia. Daphnia are only about 0.2-5 millimeters in length and filter feed on algae and bacteria. Daphnia serve an important role of primary consumers in the food web”.

Finally, the player encounters a Red Winged Black Bird. This is a species that is part of the pond ecosystem as it is a non-aquatic species typically found in this environment. The agent is described; “Red Winged Blackbirds are a species that can be typically found near ponds or in marsh areas. They use wet vegetation to make their nests and eat seeds and insects, making this the perfect habitat to find this species. Listen to their call!” This agent has a sound clip attached

for the student to listen to and become familiar with sounds typically heard in the pond ecosystem (Figure 4).

After the completion of this activity the student will be able understand the complex interactions and relationships between the biotic and abiotic factors of the pond ecosystem and become more familiar with some of the species that may be found in a pond. The student will also be able to see and understand biological concepts that are occurring but may be unseen.

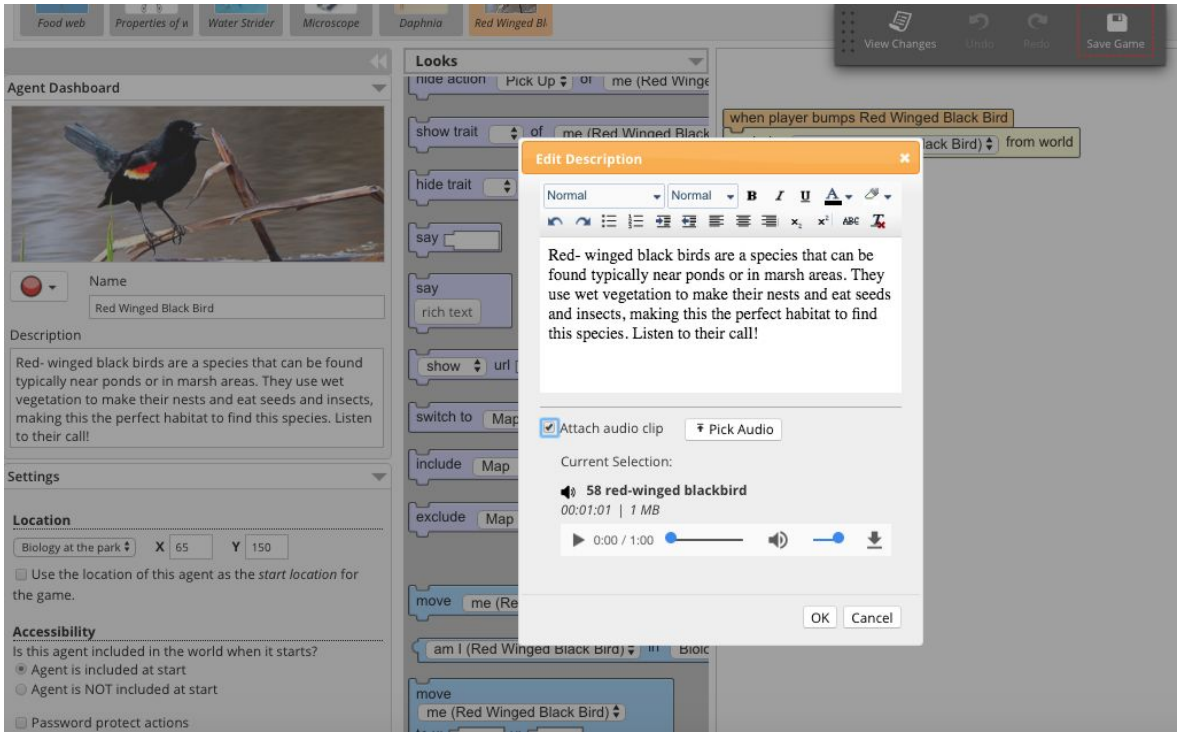

Figure 4. Image shows a screenshot of TaleBlazer editing website for the sound clip function. The function shown is a sound clip of a Red Winged Black Bird that can be played during the game with this particular agent.

Corbett's Glen

Use game code "gaecowg" to play using TaleBlazer App

The app "Corbett's Glen" was made to be used specifically at Corbett's Glen Park. This app explores the land use history and the environmental and ecological impacts on the area. This app discusses concepts such as pollutants in the water and soil, habitat fragmentation, wildlife corridors, farming, deforestation, succession and mature ecosystems; all of which can be observed at this park. The player can follow the trail at the park and use the app to learn about the different uses of the land in the past, while reading about the scientific concepts associated with them and use visuals to guide their learning. The image in Figure 5 shows the website for the app page and the codes that were used throughout the app to allow for the agents to follow the correct order on the trail.

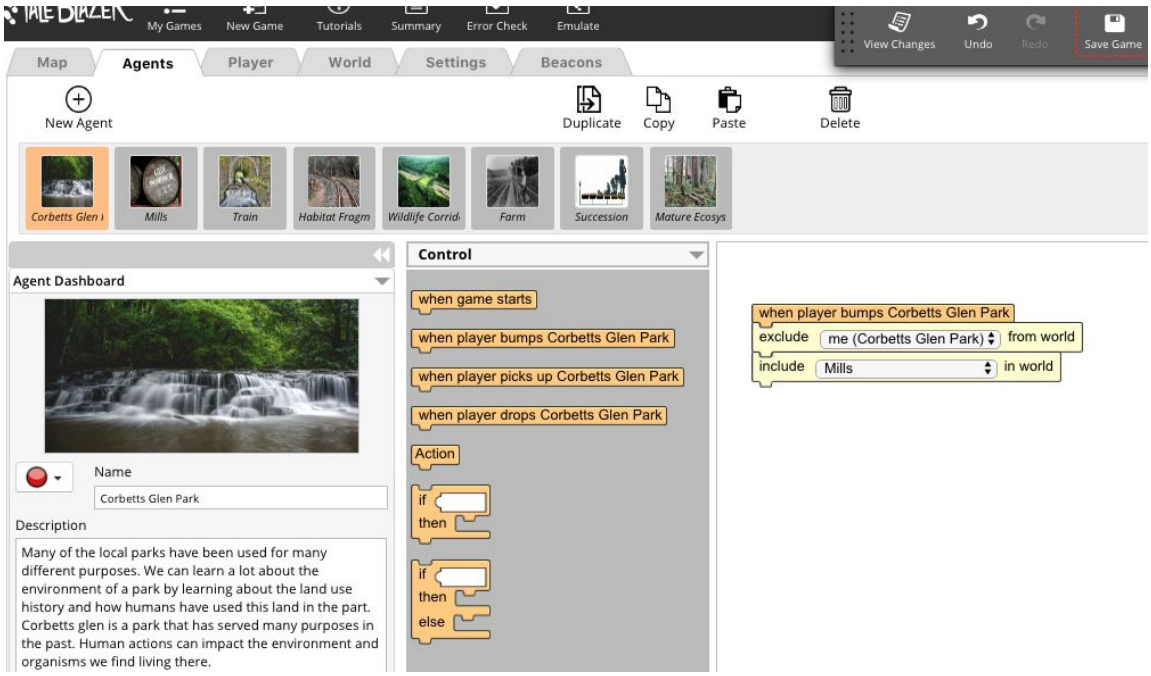

Figure 5. Image shows a screenshot of TaleBlazer editing website and codes used in the "Corbett's Glen" app.

The app includes the following agents with information provided:

Corbett's Glen: "Many of the local parks have been used for many different purposes. We can learn a lot about the environment of a park by learning about the land use history and how humans have used this land in the part. Corbett's glen is a park that has served many purposes in the past. Human actions can impact the environment and organisms we find living there."

Mills: "Corbett's Glen served as the site of a powder mill, producing gunpowder and using the flowing water as an energy source. Not only can the mill have an effect on the environment by releasing pollutants into the air, soil and water, but as you may be able to see here, a large crater was left in the earth at the site from an explosion."

Train: "After the Powdermill at Corbett's Glen, train tracks were soon constructed at this site. You can see here that the railway runs through the forest."

Habitat Fragmentation: "Habitat fragmentation is the loss or dividing of habitats often from human development of an area. This issue can lead to a loss of biodiversity in the area. This park is found alongside a main road as well as a train track. Roadways and railways are major contributors to habitat fragmentation as they act as an obstacle for wildlife dispersal and reproduction of populations."

Wildlife Corridors: "Wildlife corridors can be constructed to help connect populations that may have been separated by roads or trains. These corridors can help increase biodiversity and interbreeding."

Farm: "Soon after the railroad, the land at this site was used for farming. Farming this area led to clearing forests to make the land suitable for agriculture. Deforestation is an issue we see often due to clearing of land for agricultural use. This can lead to a loss of habitat and biodiversity."

Succession: "Succession occurs over time after farmland or other disturbed ecosystems have been left unmanaged or are not in use. The native species from the original community start to recolonize the environment. Secondary succession occurred at this site. The land that was previously used for farm land became a forest again."

Mature Ecosystems: "Mature ecosystems will have rich soil, nutrients and resources and will be more stable and resistant to disturbances and disease. These forests will contain a variety of hardwoods and a high diversity of forest floor plants."

By the end of the activity students should understand the land use history of the park and have a better understanding of how our actions and use of land have an impact on the ecosystem and their community parks.

Tree Identification App

Use game code "gmrvztc" to play using TaleBlazer App

The Tree Identification App was created to be used at Highland Park. This app allows students to explore the trees in the park and observe their characteristics while using a guide to help them identify the trees. The students will use a systematic dichotomous-like key (Figure 7) to determine which tree they are standing in front of and then they will answer identification questions to assess their knowledge. The students will be given feedback for their answer. This app uses a special feature which allows for a new tab (World) to be present on the screen of the game (Figure 6). Under the world tab, there is a tree identification chart. The student can leave the game screen

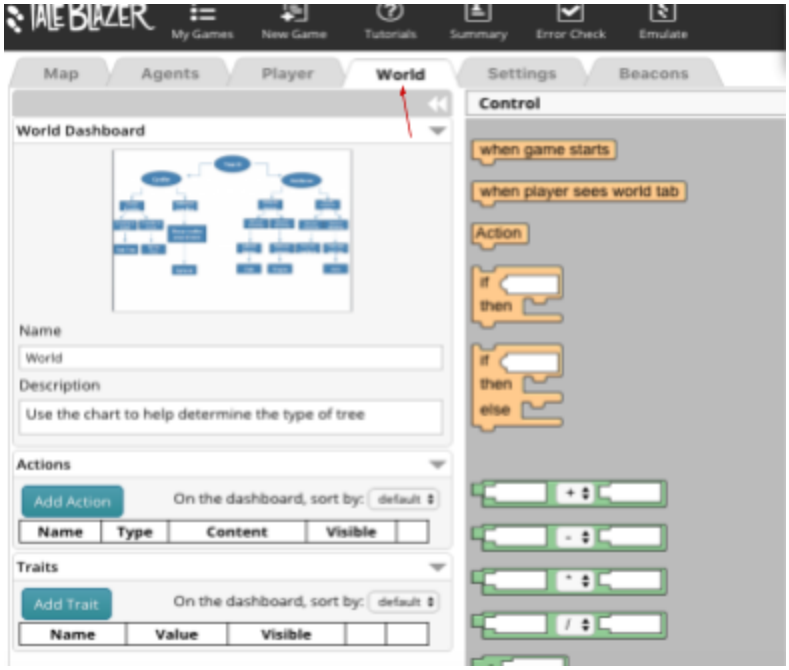

Figure 6. Image shows a screenshot of TaleBlazer editing website for the "World" tab that can be found to add images to the game that can be accessed at any point during gameplay.

and click the world screen tab at any time to use the identification chart. (Figure12).

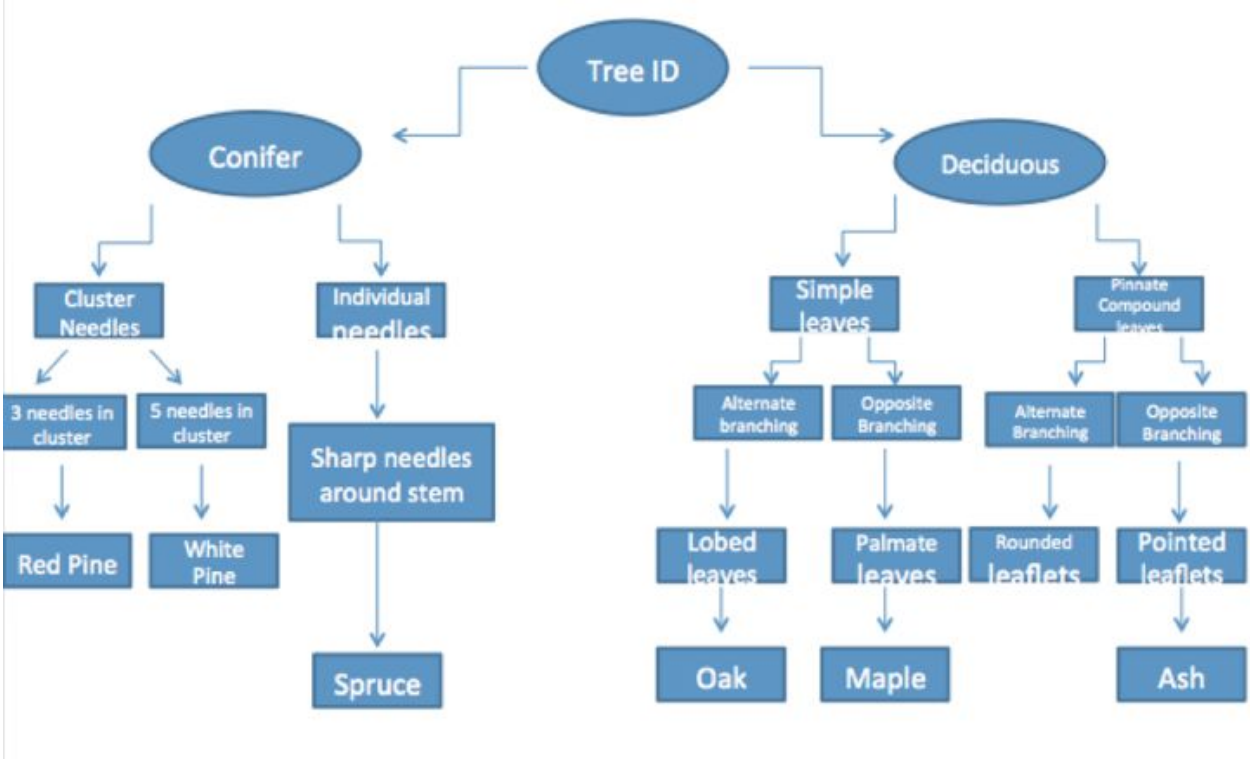

Figure 7. Image shows the “Tree Identification” app key that can be found in the “World” tab of the game. The player can access this key to use any any point throughout gameplay.

The agents for the game are different species of trees. The student is given the following prompt with each agent; “At your current location, find the tree that has characteristics that match this picture. Examine the tree and use the Tree identification key in the "World" tab to help discover which tree this is then place your answer”. The student will choose from 3 different answers and they will be given feedback based on their answer. If the student gives an incorrect answer they will be prompted to try again. If the student gives the correct answer for example a White Pine, the feedback will say “Yes, this tree is a White Pine. It has long needles

in bundles of 5 with a fluffy appearance. This coniferous tree can be remembered since WHITE has 5 letters and the White Pine has 5 needles per bundle.” The image in Figure 9 shows a screenshot of the mobile app page for a locust tree assessment question. The arrow in Figure 8 points to the specific codes used to create the assessment questions and feedback.

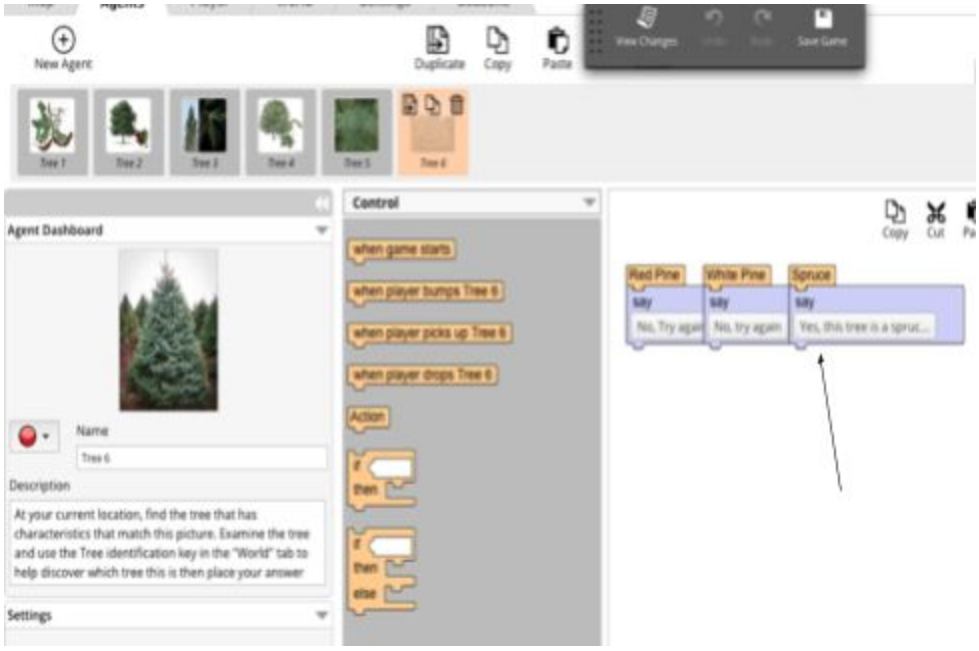

Figure 8. Tree identification assessment questions and feedback screenshot.

Assessment questions can be added to the game using the “Actions” function. The creator can click “Add Action” to create an answer choice for the question and complete the rest of the prompts as shown in Figure 10. Then the creator will move the codes for each action to display the correct order and add feedback using the “looks” code for “say” and add the feedback response (Figure 8).

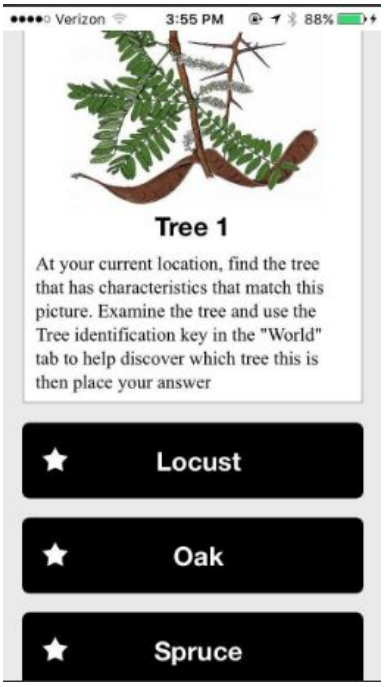

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Figure 9. The image shows a screenshot of the screen that would be seen while using the "Tree Identification" mobile app assessment question.

Figure 10. Image shows a screenshot of TaleBlazer editing website for the option to create questions with feedback under the "Add Action" function.

The image in Figure 11 shows a view of the screen that would be shown on a portable device or cell phone while using the app. The figure shows the map of points throughout the park in which specific trees are located for the activity. The image in Figure 12 shows the tree identification key under the "World" tab, in which students can access this tool at any time during the game.

Figure 11. The image shows a screenshot of the screen for the map used in the "Tree Identification" mobile map. The map shows the placement of the different agents that are available at the park.

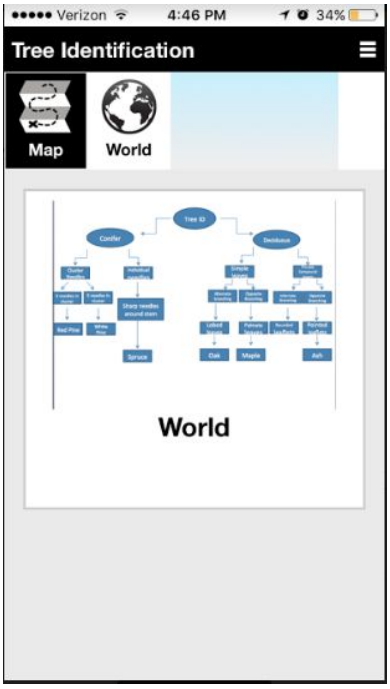

Figure 12. The image shows a screenshot of the screen of the "World" tab while using the mobile app. The "World" tab allows the player to access resources at any point during the game.

Invasive Species App

Use game code "gssbbex" to play using TaleBlazer App

The Invasive Species game or role playing scenario could be played at any outdoor location, as it is not specific to the attributes of a particular park in the area and uses hypothetical creatures and scenarios to help the player understand the concept of invasive species. The GPS points could be set to any park location as well as a school yard. This roleplaying game involves the player acting as a park staff member dealing with the health of the park. The staff member is

posed with a problem and must gather evidence at the park through observations of nature and interviews with park visitors to determine the problem and how to fix the problem to help the park return to a healthy state.

The arrow in Figure 13 shows the codes that are necessary for the role playing scenario game. The codes allow for the game player to encounter the different agents in a specific order. The player takes the role of the “Park Staff” and is first provided with the scenario, “You have noticed a decline in the population of the Red Puff Berry trees that are native in your area. The park once contained 50 Red Puff Berry trees and you now only count 30 that are alive. This tree feeds the Red Puff Birds that are native to the area and you are worried that they will not have enough food to survive. Would you investigate the possible causes of the decline of healthy Red Puff Trees to help us keep our park ecosystem healthy?”. The student then encounters the agent entitled “Purple Leaf Bug” and is provided with the following scenario “You have come across a new species of insect that you have never seen in the park before. After investigating this insect you come to find that it is a species of insect not native to the area- Purple Leaf Bug.” The player will then encounter a park visitor for an interview and gathers the information; "I have noticed that the leaves of the Red Puff Trees seem to be filled with bites and there are purple insects all over the leaves". The player then encounters a species of bird that relies on the Red Puff Berry Tree and finds out the following information “ My diet consists solely of the berries from the Red Puff Berry Tree and it is becoming harder and harder to find food to eat now that all of the trees are dying.” The player is then left to think about all of the data and new information that they collected and they are presented with the following task “Now that you have found out that the Purple Leaf Bug is invasive and causing the trees to die, you must come up with a solution to

eradicate the bug from the area in order to keep the rest of the ecosystem healthy and maintain biodiversity.”

Figure 13. Image shows a screenshot of TaleBlazer editing website the Invasive Species app. The arrow highlights the codes that are used in this app.

The player is then faced with a final decision question asking “What do you think? How should the park manage the invasive species problem?”. The player is also given four options to choose from. The imagine in Figure 14 shows the codes used to create a decision making question to provide options and feedback for each option. The student is provided with the following options and feedback with each answer;

1. Introduce a natural predator of the purple leaf bug: Introducing a natural predator of the purple leaf bug is considered a biological control of an invasive species. This technique can work successfully but we must also consider the possible consequences of this.

Perhaps the new predator in which we introduce has no other natural predators and the population starts to grow and disrupt other populations in the ecosystem

2. Use chemicals to kill the purple leaf bug:Chemicals can be an effective way to kill a nuisance species that is not native to an area but there are many things to consider. Families that enjoy the park may be concerned about pesticides used to kill the bugs. The chemicals may also harm other insects that are important to the ecosystem. Chemicals may also end up in places that they were not intended for such as water supply and may harm other species.
3. Inform the public about the issues with invasive species in the park: Public awareness of issues like invasive species is very important. Many invasive species can travel with humans over long distances and end up destroying a population or even an ecosystem. People must also be aware of different invasive species that may be in the area so thy know what to look out for! This can also help to prevent the introduction of new invasive species in the future!
4. Mechanically catch and remove all individual purple leaf bugs from the area: Mechanical control of an invasive species can be an effective yet difficult way to remove a species. This method may be time consuming and costly as it will take a lot resources and man hours to remove all of the individuals in a population. If a plant is invasive, they can be mechanically removed by mowing or cutting to reduce seed production.

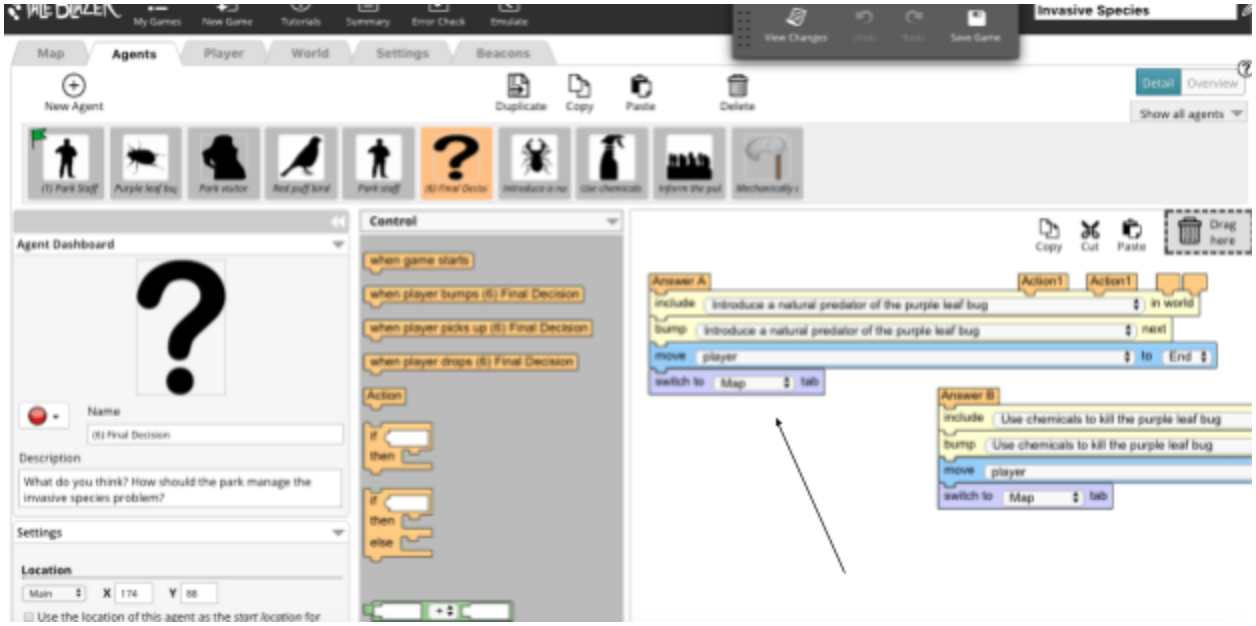

Figure 14. Image shows a screenshot of TaleBlazer editing website for the Invasive species app. The arrow highlights the codes used to create the final question.

After the completion of the activity, the student should have an understanding of the devastation an invasive species can cause to the environment and the different organisms inhabiting the area. The player should also have an understanding of different methods that are used to deal with invasive species and the positive and negative consequences associated with these.

Adaptations at the park

Use game code "gtrjhjb" to play using TaleBlazer App

"Adaptations at the park" is an app in which students are able to explore different adaptations of common organisms they might see at a park. The app uses photos and descriptions of the adaptations, the purpose of this adaptation and benefits for the organism's' survival. The

player is also asked questions to assess their understanding of the adaptations. The image in Figure 15 shows an example from the app about tree adaptations and provides the following description, “Trees have adaptations that help them live in their environment. When you look at the leaf on a tree you may notice it looks shiny or waxy. This is called the cuticle of the leaf and it is an adaptation that trees have to conserve water when it is hot. Without the cuticle of the leaf, water can be lost through the leaves on a hot or dry day.“ Once students observe the species in real life at the park with the additional support and information from the app they can answer questions to apply the new information they have learned. The codes for the assessment questions are shown in Figure 16. The game also includes the chance to learn about water adaptations found in ducks and fish, various adaptations found in birds, and camouflage and defense adaptations in insects.

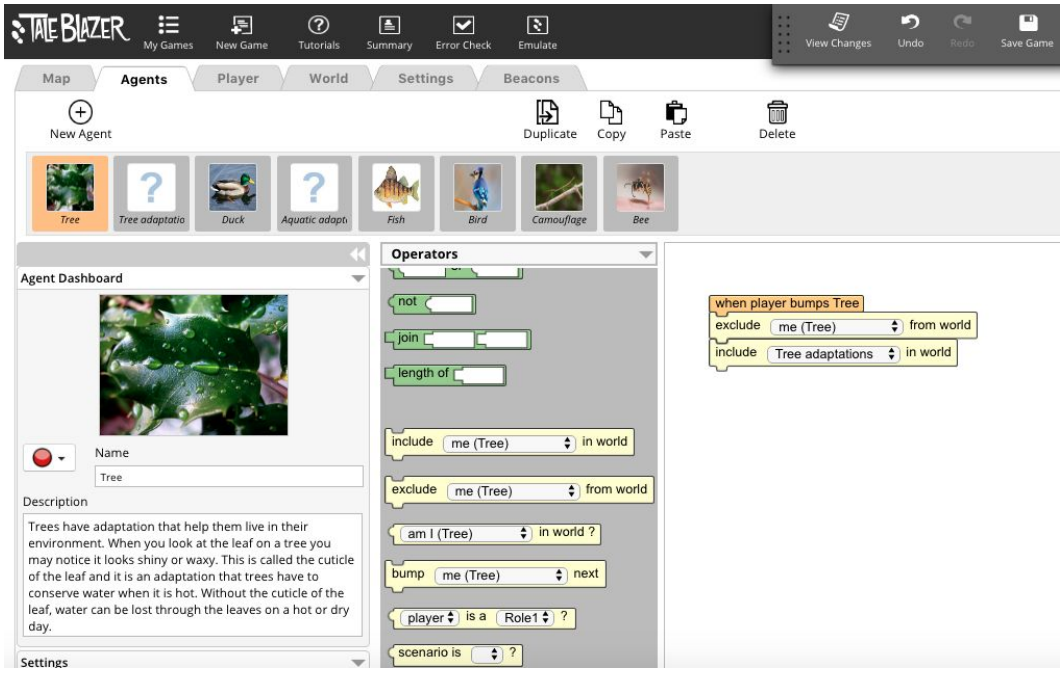

Figure 15. Image shows a screenshot of the TaleBlazer editing website for the“Adaptations at the park” app and the “tree” agent.

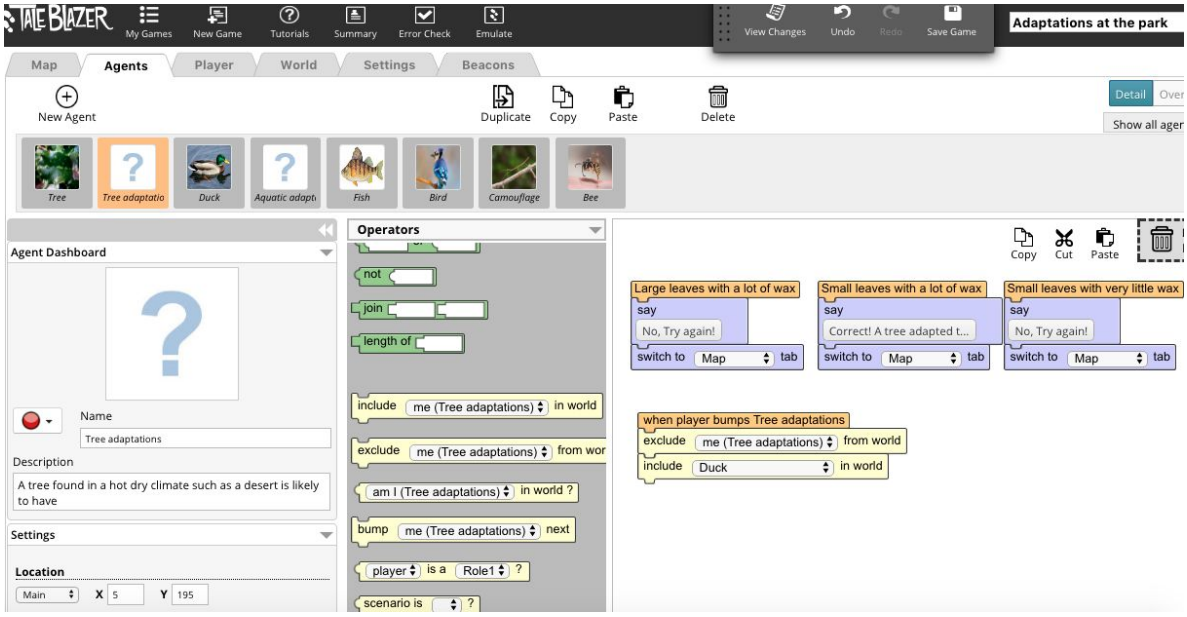

Figure 16. Image shows a screenshot of TaleBlazer editing website and the codes needed to create assessment question for the app, "Adaptations at the park"

What happened to the creek?: Oatka Creek

Use game code "gptusli" to play using TaleBlazer App

The game "What happened to the creek?" is set to take place at Oatka Creek Park, but the GPS points could be moved to other parks in the area that are a part of the Genesee River Watershed. The game starts off with a background and importance of our local watershed as shown in Figure 17. The agent in Figure 17 states, "Oatka creek is a part of the Genesee River watershed. This source of water is very important to our local area and includes creeks, rivers and streams that all eventually lead into Lake Ontario. All of the pollutants from the creeks, streams, rivers and runoff from surrounding land will eventually lead into Lake Ontario. It is important that we take care of our local watershed and keep the water healthy, as it can have an effect on plants, animals and even us!" The codes in Figure 17 allow for the agents to be encountered in a specific order.

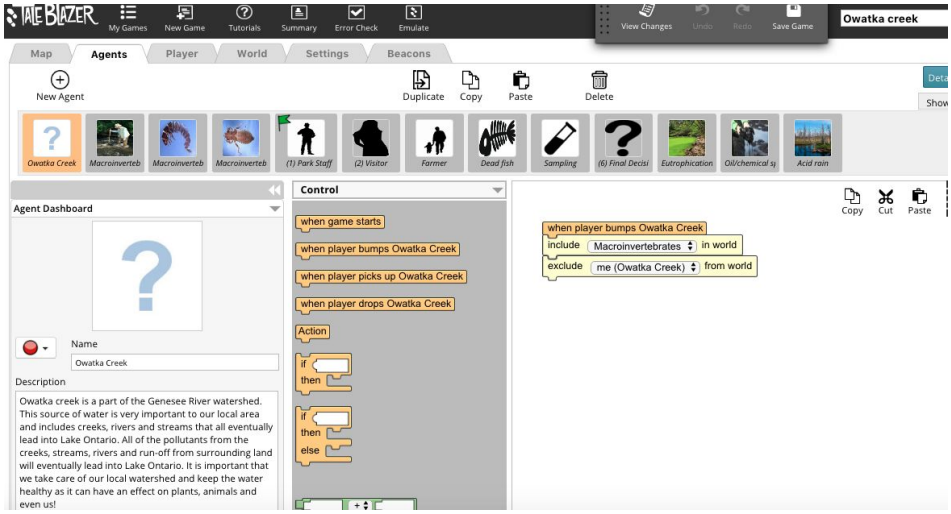

Figure 17. Image shows a screenshot of TaleBlazer editing website and the codes used for the "Oatka Creek" app. This page of the website focuses on Oatka Creek and Watershed importance.

The next agent that the player will encounter discusses the importance of macroinvertebrates that are found in the watershed and states, "Some species that are found in NY freshwater can indicate the health and condition of the water. We can collect samples of different living things in the water for this purpose, this is called Biomonitoring. Macroinvertebrates can be easily collected to monitor the health of the water" (Figure 18).

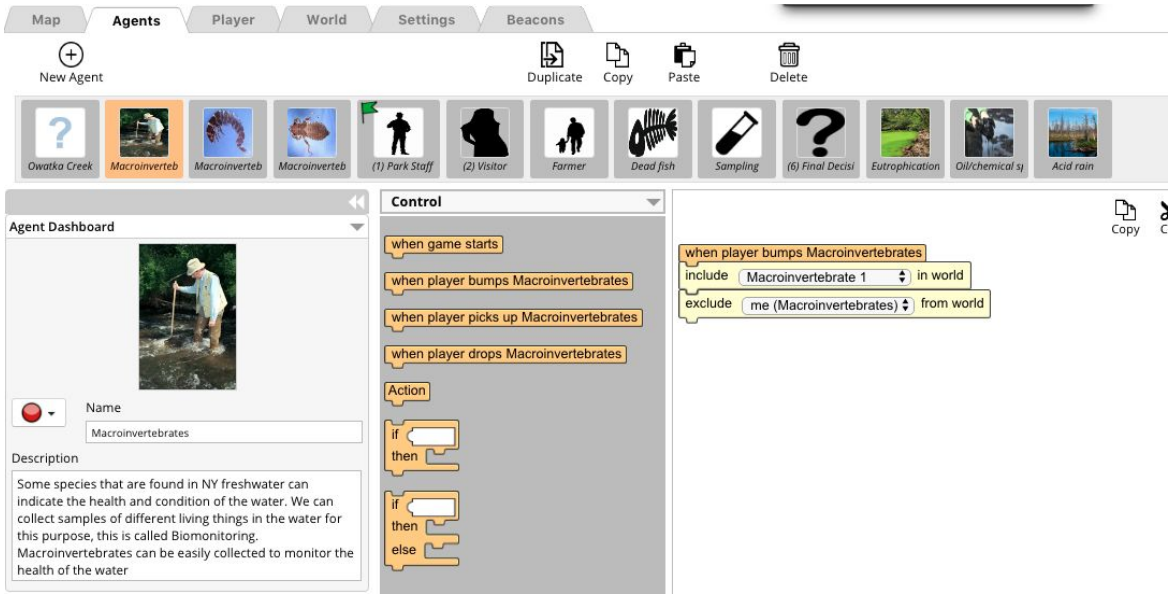

Figure 18. Image shows a screenshot of TaleBlazer editing website for the agent "Macroinvertebrates" and describes the importance of biomonitoring.

After macroinvertebrates are discussed, the player will encounter two specific types of macroinvertebrates that can be found in the creek. The agent in Figure 19 shows a Caddisfly Larvae with a description stating, "This macroinvertebrate spends part of its life cycle in the water. It build cases out of a variety of materials in the water such as stones or organic material for their pupa stage. This organism is an important indicator for healthy water. Identify the larvae shown:". The player must then choose one of the answers shown in the coding section of Figure 19.

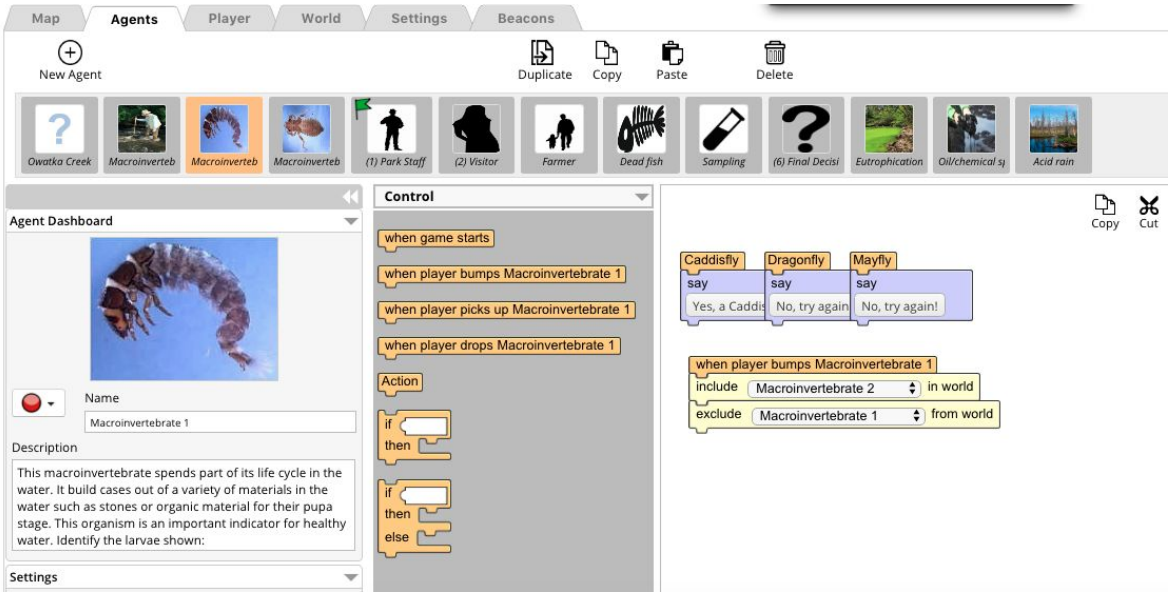

Figure 19. Image shows a screenshot of TaleBlazer editing website for the description of the Caddisfly agent and the codes used for the assessment questions.

The student will receive feedback on their response. If the student answers the question correctly they will be provided with the link to a video to get a better idea of the unique life cycle of the macroinvertebrate as shown in Figure 20. The student will then encounter an agent showing and describing a Dragonfly larvae stating “This macroinvertebrate can be found in healthy local freshwater sources and spends a part of its life cycle in the water. The image shows the larvae stage of this macroinvertebrate organism”. The student will answer the question and will be provided with feedback to their answer and an additional video of the life cycle.

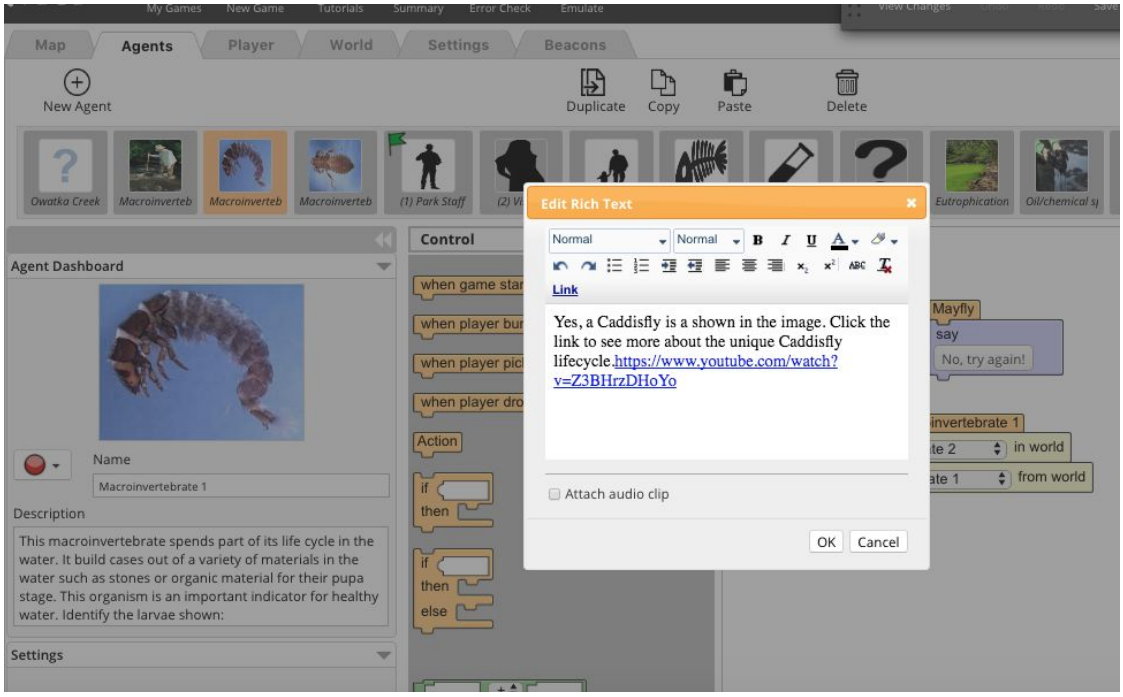

Figure 20. Image shows a screenshot of TaleBlazer editing website for the Caddisfly agent and the information provided in the feedback. A video with detailed information on Caddisfly development is provided in the feedback.

The player is then prompted to complete the role playing activity and act as a Park Staff of Oatka Creek Park and help find out what is wrong with the water (Figure 21). The player encounters a visitor of the park who states "GROSS! There is way too much algae and green goo floating to swim in that Creek!". The player then interviews a farmer who states, “You ask locals nearby if they have been doing anything out of the ordinary that may affect the water ecosystem: "I live up the hill and I have recently started using more fertilizer on my crops." The player then observes an agent that states “You walk over to the pond to take a look for yourself and notice that there are dead fish floating in the water.” Finally, the player takes samples and finds the following, “You decide to take some samples of the water and find: pH: 8; Dissolved oxygen: Lower than average; Nitrogen: Higher than average”

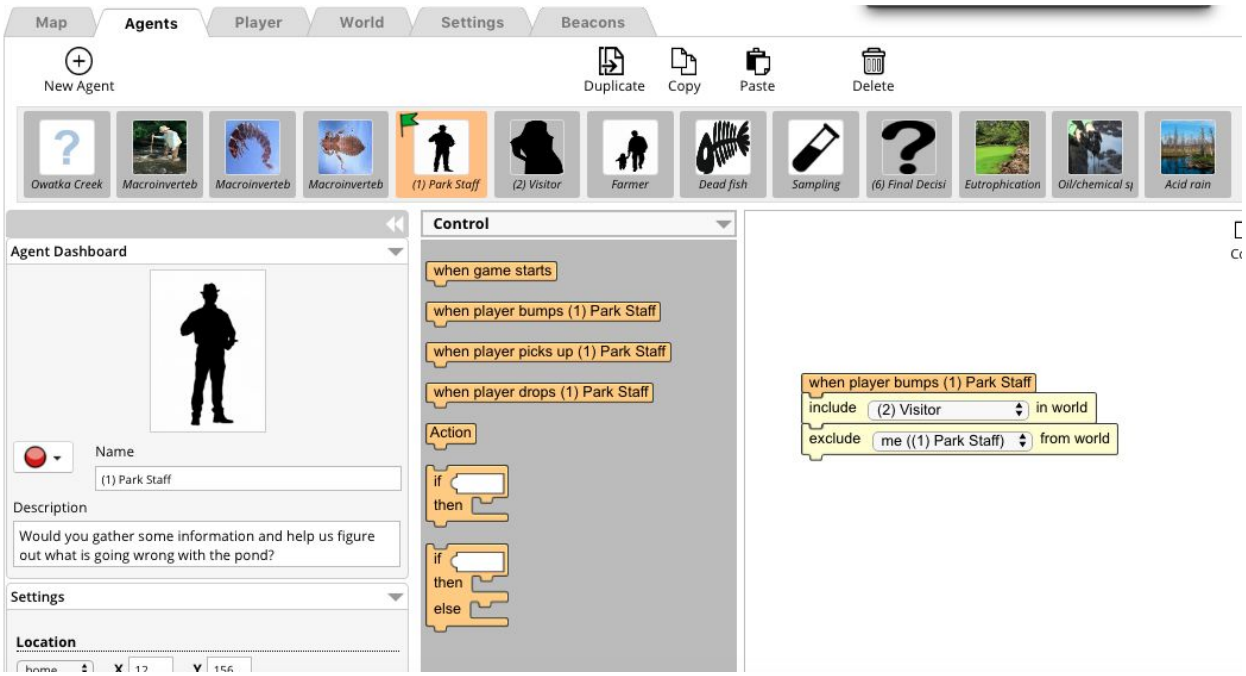

Figure 21. Image shows a screenshot of TaleBlazer editing website for the Oatka Creek Park Staff agent and the codes used for this agent.

The player will then use all of the information that they have collected to make a final decision and answer the question “What do you think? What is happening in the pond and why are organisms dying?” The image in Figure 22 shows the codes that were used to create the final question. The images in Figure 23 show the screen the player would see during game play and the different feedback responses.

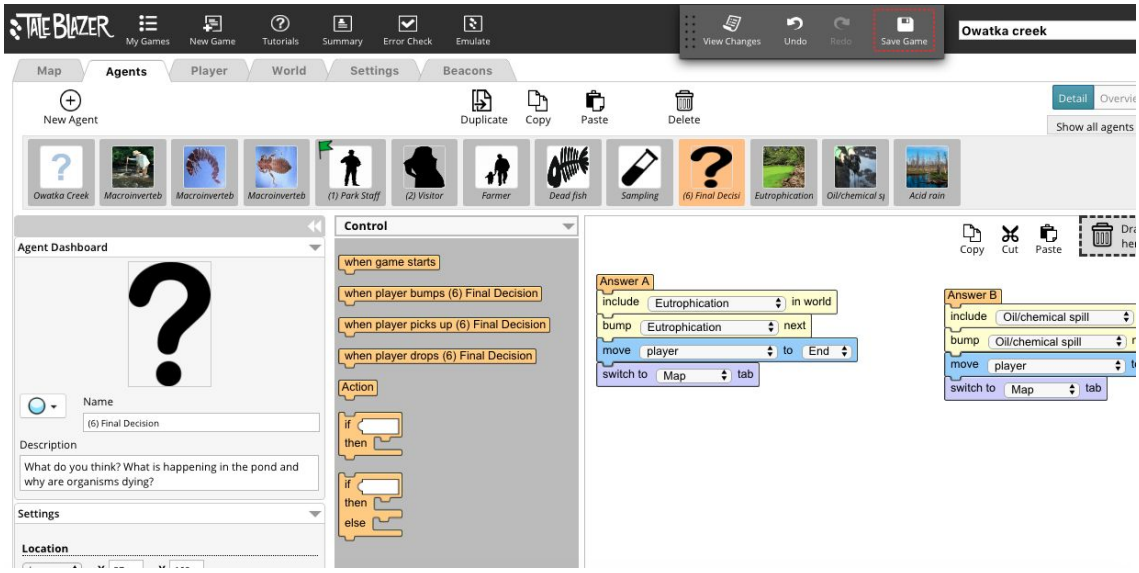

Figure 22. Image shows a screenshot of TaleBlazer editing website for the Oatka Creek Park app and the codes used for the final question.

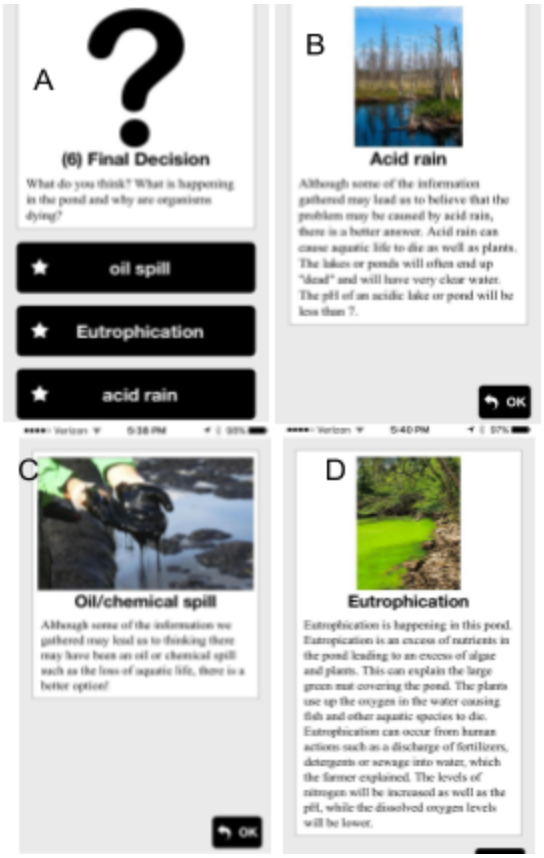

Figure 23. The images in the figure show screenshots of the screen found in the mobile app. The Final Question is provided with three options. When the player responds to the question, the feedback screens will be provided depending on the player's response. A) Screenshot of the mobile app "Final Decision" question. B) Screenshot of mobile app feedback screen for the answer "Acid Rain". C) Screenshot of mobile app feedback screen for the answer "Oil/Chemical Spill". D) Screenshot of mobile app feedback screen for the answer "Eutrophication".

After the completion of this activity the student should gain a sense of stewardship for their community and understand the importance of a healthy watershed ecosystem. Students should also understand different ways to identify healthy water ecosystems and also observe problems with the ecosystem, gather information and synthesize a logical response to the scenario.

Reflection: Learning to use TaleBlazer to create mobile app games

There were four main portions to completing this project. The first part which occupied a great amount of time and energy was exploring different parks, nature books from the library and other online resources to come up with ideas for interactive games that could allow students to learn at the park using a mobile app. The second part included learning how to use the app making platform, TaleBlazer and learning to understand a new language of codes that are used to create different functions in the apps. The third part of the project was taking my original ideas that I had brainstormed and augmented, thrown out and brainstormed new ideas for games that could fit the functions of the game platform. The final part was going back to the parks to test the apps I had created and fixing the parts that did not work. I tested the games on playability to work out errors or glitches with the audio, images and text. I also tested the logistics of using the

app in the real world to make sure the GPS locations were feasible and safe to access. I also assessed the engagement of the games and found that it was difficult to find a balance of the narrative and content to make sure the activity was age appropriate and not too easy or challenging, but somewhere in between. This was difficult to do at first and the first few games that were created were not used since the narrative did not match the complexity of the activity.

For the project, I had to come up with apps and activities that were appropriate with content and that followed the features of the platform. The platform allows for guided tours, role playing, collecting evidence to find a solution and identification of species. The platform allows for the creator to provide an assessment to check for understanding of the activity. The questions and information can be arranged in a way that provides scaffolds for the learner and can be edited as needed. Scaffolding of the activities can be accomplished by making the game sequential to allow for more control of the narrative and the order that information is being released to the player. Another way to scaffold learning this new tool is to provide students with a simple tutorial. A tutorial can be made brief, using simple content to help learn the game mechanics prior to completing activities that contain science content.

I started with designing simple guided tour apps and then eventually learned more codes and began to develop more interactive games with questions, feedback, sound and video. After learning how to use this app platform, it has led my project to think about future uses for mobile apps in science learning. Not only can teachers create these apps for use with lessons outside of the classroom, but teachers can also use this platform to teach students how to create apps of their own using simple codes and functions to take learning to a higher level. The TaleBlazer platform has many different complex functions that can be learned to add to these science

activities. The platform has the capability to make interactive multiplayer games and score keeping. These are functions that I hope to learn in the future to continue to add to my activities and create new activities. Outside of assigning this task for science education, these activities can be used in informal education to help increase awareness of a topic or an issue at a particular location. The students can create their own games to educate the public on science issues like invasive species.

The apps made can be used in the science classroom to introduce material and allow the students to individually explore with the support of the information and images in the game. The apps are considered augmented reality games as they provide additional information that is overlaid in the natural environment and provides information and visuals that can not be seen, or explains what is occurring in nature. The games and guided park activities can be used to provide students with an authentic learning experience. The activities from the apps provide authentic learning experiences using participatory roles that allow students to understand the job of a scientist as well as promoting self-efficacy. The activities take place in local parks that give meaning to the learning experience as the students are familiar with these local places and it can also help to promote civic duty to help their local community by learning about the importance of these places. The games also helps to provide an authentic learning experience by providing students the opportunity to use problem solving skills, role playing and work toward meeting a goal.

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