AR Adventure: Combining Interactivity with Tangibility for Education

Michele Ritter
University of Central Florida
12777 Gemini Blvd N,
Orlando, Florida 32826 USA
ritterm@knights.ucf.edu

Cameron Tolentino
University of Central Florida
12777 Gemini Blvd N,
Orlando, Florida 32826 USA
cameront4504@gmail.com

Matthew Mosher
University of Central Florida
12777 Gemini Blvd N,
Orlando, Florida 32826 USA
Matthew.Mosher@ucf.edu

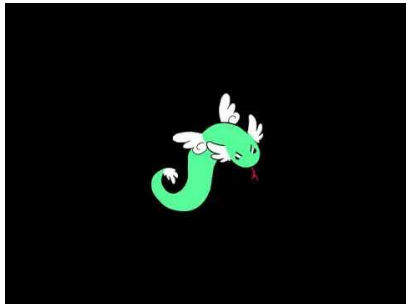
Abstract
AR Adventure is an interactive educational experience that relies on tangibility and physicality to aid teachers in creating a memorable learning experience. It draws on Augmented Reality (AR) by means of Max8 to add "monsters" to a real-time video of the participant. The goal was to create something accessible for teachers that can be implemented in the classroom while relying on embodiment to keep students engaged in learning.

Author Keywords
Embodiment; HCI; tangibility; education; Max8; Reactivision; fiducals; AR.

ACM Classification Keywords
•Computer systems organization~Real-time systems• •Human-centered computing~Human computer interaction (HCI)•Applied computing~Education

Introduction
Using technology as a means of engagement is a proven method to maintain focus and avoid frustrating repetition in the classroom. AR Adventure serves to use that engagement and combine it with the benefits that tangibility and embodiment bring to learning.

Oftentimes, projects focused on interactivity strive to create a fulfilling experience wherein the user interacts



Video 1: Link to project presentation video.
https://www.youtube.com/watch?v=OvMiTzgIckY

with a project and the results of these interactions are reflected in feedback not necessarily directly understandable or visible to the user. In the case of children, instant feedback where students are able to see the immediate results of their actions serves to more fully immerse them in the experience. Using AR to provoke embodiment with interaction serves to ensure that students clearly understand the purpose of the work. The physical and tangible aspects of the project means that students are able to have a more meaningful experience with the work leading to a more memorable interaction. Ideally, this embodiment and tangibility leads to greater retention of knowledge[1].

While embodiment is nothing new to interactive Computer User Interfaces (CUI), very rarely is a project designed with education and accessibility as its driving force. AR Adventure combines embodiment and interaction to guide students through vocabulary terms thus serving to fully immerse them in an experience and provide physicality to learning [2].

User Experience

This project is ultimately aimed at being used in a classroom setting. As such, it is meant to be accessible with what teachers are generally provided in the classroom.

Required hardware consists simply of a computer with a webcam, a smartphone (if the webcam cannot be streamed to two programs at once), and a projector of some kind. Most classrooms are equipped with a Smartboard, however, it is possible to set up the experience using a television with an HDMI cable connected to the teacher laptop. The teacher's computer is placed between the student and projection so that it can record them and students can see themselves interacting with the "monsters" in real time. External speakers would enrich the experience to ensure that the user can hear any background music or audial cues.

There are a few features that need to be adjusted in Max8 before beginning. The camera must be selected and opened. Reactivision, master render, and any chosen background music and sound effects must be turned on.

Once the teacher has set up their choice of vocabulary terms, they select the start "bang" in Max. From there, one image and a word will be randomly pulled from either the Egyptian or Greek banks. The player must determine if the term is Egyptian or Greek and then hit the "monster" with the appropriate sword containing the linked fiducal. One sword will have fiducal 0 and the other fiducal 1. If it hits with the correct fiducal, the interaction restarts.

Image 1: Sample "monster".

Image 2: The "monsters" are meant to be engaging for a wide age range.

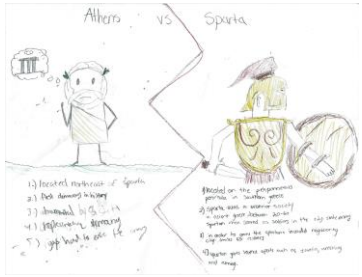


Image 3: A "one-pager" that could be translated into students' personal controllers.

Figure 1:3D rendering of the play set up. It is meant to be easily reproducible. The set up includes a projection, computer, projector, and optional speaker.

The game can be played with one or two students using the controllers to correctly match the term with the correct controller. If one player is interacting with the game, they hold both controllers, if two, they collaborate with one device each to determine the correct answer.

Design Choices

The project is designed to be immersive and engaging while remaining school appropriate. As such, character design is set in the realm of fantasy and cartoon. The "monsters" are not particularly frightening, so young children can enjoy the experience, but they are not overly simplified to the point that older teens cannot find the work stimulating.

While ideally this project can be used in any subject to compare and contrast terms, for the purposes of introduction to the experience, the creators decided to make the experience as intuitive as possible. Thus, the sample project draws from an ancient history lesson asking the user to determine whether a term comes from Ancient Egypt or Ancient Greece. The tangible controllers reflect this choice as they are foam replicas of the weapons from those civilizations. This was done so that the user does not necessarily need any written or verbal instruction to conclude how to interact with the work. The controllers feature removeable fiducal images for ease of changeability.

This also allows for students and teachers to potentially make their own controllers for future lessons. Since the only necessary feature of the controllers are that they include the correct fiducals, inexpensive controllers can be made from any available materials (though cardboard is likely the most available and inexpensive option in a classroom setting).

Additionally, if they so desire, teachers can create a lesson or assignment where students make their own controllers based on the curriculum. For example, a research assignment where students turn the concept of a "one pager" into their own personal controllers to further reinforce the students' involvement with the experience.

As an AR experience, immersion comes from the computer projecting images over a real-world video feed. As such, the creators chose not to create a background or remove the image of the user from the game. Instead, the "Monsters" are projected over the

video of the user in the real world so that they can see themselves in real time and interact with game.

Technical Interface

AR Adventure works by combining Max8 video and audio interactivity with Reactivision's fiducal tracking software combined with Max8's ability to read JavaScript.

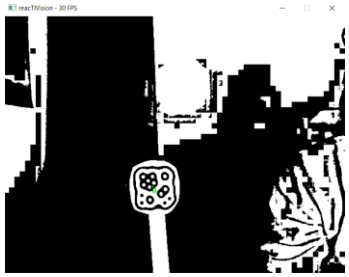


Image 4: Reactivision's Fiducal tracking program. Shown is the ease in which the program picks up and reads the fiducal images.

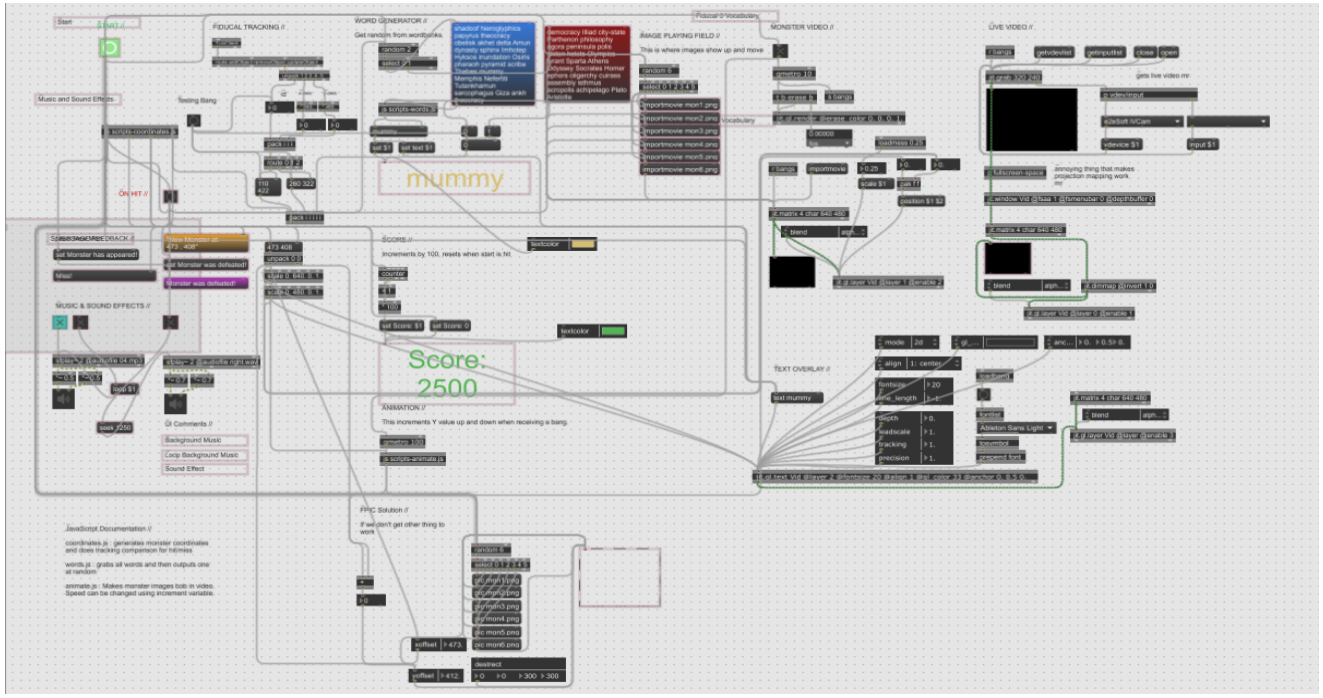


Figure 2: Outline of the Max8 Patch.

Inside the Max Patch, there are two blocks linking external JavaScript: scripts-coordinates.js and scripts-words.js. When the application is started by sending the initial bang (clicking the starter button) the first of these JS files collects this bang and uses it in order to generate an 'instance' of a monster. To clarify, it generates a set of coordinates that are then used by the video/imaging projection in order to plot the instance at those dimensions. After doing so, this same JavaScript also collects data from the fiducial tracking and the word banks in order to determine where the position of the swords the user wields in addition to determining the word's connotation. The program combines this information with the prior instance to

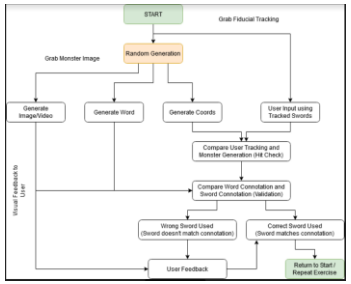


Image 5: Flow chart of the project input and output.

Image 6: Sample weapon controllers with showing detachable fiducals.

perform a series of hit checks: 1) if the player swings at the instance with either sword, 2) if the sword used matches the connotation of the word, and 3) if sword used matches connotation, defeat instance and create a new one. By doing so, the developing team desires to create instantaneous feedback to both teachers and students using the application.

The second script file is much lighter; though, it has similar functions to the previous block. It relies both on Max8's ability to generate random numbers and a select block to switch between these outputs. The file receives words from either bank depending on the select signal and then uses some simple math expressions in order to single out a one, random word. This word is fired out through a bang alongside the word's connotation (determined by which bank it was housed by). As mentioned previously, this information is used by the interface to display the word to the user and check its connotation against the system's data.

These interactions are shown to the user via Max8's videoplane feature which layers the live camera with the "monster" images onto a new window. The image files are projected over the live camera feed so that the user can see their interaction in real time. Players use tangible controllers with appropriately attached fiducal images to connect with the "monster" When they successfully connect the fiducal with correct pixel array, the program will start over while simultaneously playing an optional audio cue to let the player know they were successful.

Reactivision's fiducal tracking creates a more robust interaction as the fiducals are more easily tracked by the computer's webcam than Max8's motion or color tracking features.

Related Works

Academic Projects

There is no shortage of works that combine interactivity with education. For example, Allison and Hodges' 2000 project created a virtual experience for students where they created an immersive environment at a zoo's gorilla exhibit using virtual reality. Their work noted that the novelty of the experience kept the students engaged throughout less interesting lesson features[3]. Unfortunately, the experience was restricted to that specific exhibit.

In 2003, Jenkins, Klopfer, Squire, and Tan described three protype educational games that could be used for engagement in a variety of subjects. Their games were engaging, cheap, and subject specific. The technology based teaching tools that these four created is meant to aid students come to a more nuanced understanding of the subject matter, often by basing the games in real-life situations. However, their work focused on a much broader depth of knowledge using specifity to create an enriching experience[4].

AR Adventure builds upon some concepts used in these projects to create a unique experience. It relies upon the novelty outlined in Allison and Hodges' work and the portability and affordability in Jenkins, Klopfer, Squire, and Tan's projects but relies on a more open-ended concept that teachers can build upon and use in a variety of subjects. This does mean that it sacrifices some of the depth showcased in these works for a greater scope and openness for creativity, but it deliberately includes tangibility and embodiment as a teaching tool. This means that the program does not need to depend on novelty to remain engaging and instead finds engagement through physicality.

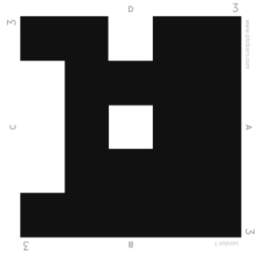


Image 7:A Plicker card.

Similar Educational Tools

While a number interactive games exist that are widely used in a classroom setting, this project differs as it focuses on creating an fully embodied experience. Two widely known tools are Kahoot and Plickers. These allow teachers to create a series of questions that students can be quizzed on in real time and given immediate feedback.

Kahoot projects a question with a timer with multiple choice answers from the teacher's computer. Students log in via a pin number to access the game and answer the question over their phone, tablet, or student computer[5].

Plickers has a similar concept, however, it does not rely on students having access to their own technology (a useful feature as most low-income schools cannot provide technology to all of its students and many of their students do not own or have access to their own devices). Instead, each student is given a piece of paper with a unique code. After viewing the projected question from the teacher's laptop, the students lift their answer so that the teacher can scan the room with their phone. The papers can be positioned with any of the sides positioned on top to determine whether the student chose A, B, C, or D[6].

However, these lack an AR experience where students can *see* themselves interacting with the question. They often questioned whether the program registered their answers correctly and remained in their seat throughout the experience. AR Adventure allows for a physically embodied experience where students move and see themselves interacting in real-time with the work to create a more meaningful experience[2].

Evaluations

The project is first and foremost engaging in its physicality. Users truly become immersed in their task and focus on their goals and movement within the space while simultaneously seeing themselves interact with the "monsters" in real time.

The general consensus of the design processes is that the controllers clearly indicate which weapon is supposed to be used to vanquish which monster related to the given vocabulary term. The "monsters" were met with approval in design and generally considered "very cute" or "vivid". There were some issues with the width of the controllers as the fiducals needed to be scaled up to ensure that the player was fully visible on the while the camera was able to continue to capture the fiducal image. Fortunately, this suited the cartoonish design of the "monsters" and contributed to the overall game aesthetic.

Future Work

Moving forward, this project will be tested in the classroom. The researchers have several middle school teachers who are interested in trying the experience with their students to test it in a classroom setting. These live trials will make known any features that need to be adjusted for the future.

It is important that the work remain accessible and affordable for classroom teachers. As such, there are a number of networks available to teachers such as teacherspayteachers [7] (where work can be shared free of charge, despite the website's name) or github[8] for more technically inclined individuals. Networking is vitally important to proliferating knowledge about projects (especially opensource

projects) as any issues can be addressed by users and the creators can improve the work [9].

Sample lesson plans and controller patterns will be created and hosted with the project with ideas for classroom implementation to assist teachers while not adding on to an already heavy workload. Ideally, the work can be hosted to a website via the MiraWeb package in Max in the future so that those who would like to use the work, but lack the technical knowledge of Max8 can access it and use it in the classroom.

Conclusion

AR Adventure strives to combine tangibility and embodiment with an interactive interface to create an enriching educational experience. It draws on the knowledge of earlier work as a guide for creating a more meaningful experience by relying on AR and physicality. While the format of the game may not be able to be used for rigorous lessons, its purpose is to introduce students to embodied education while supplemented by the content they are learning. The project should be accessible in classrooms as a tool to help teachers create a meaningful, and memorable, educational experience.

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