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The Oceans Above Us: An Augmented Reality Experience

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THE OCEANS ABOVE US:
AN AUGMENTED REALITY EXPERIENCE

A Capstone Project Presented in Partial Fulfillment
of the Requirements for the Degree Bachelor of Arts
with Mahurin Honors College Graduate Distinction at
Western Kentucky University

By

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May 2020

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ABSTRACT

Augmented reality holds the potential to be the new fabric of our everyday lives.

Also known as AR, augmented reality is any technology that superimposes graphical information over a real-world environment, whether it be through a smartphone screen or visually projected onto the environment. Though it has existed in various forms for decades, augmented reality development is still widely considered the work of experts in technology-related fields.

In November 2019, however, Adobe unveiled a new augmented reality development platform, Project Aero, along with boasts that the app's intuitive design and integration with other Adobe programs would place AR creation into the hands of casual users with no background in augmented reality or 3D design. Almost simultaneously, the rapid spread of the COVID-19 pandemic virus resulted in travel restrictions, school and business closings, event cancellations, social distancing policies, and even mass quarantining by spring of 2020. Amidst the transition to working, studying, and socializing in physical isolation, augmented reality technology became a valuable platform for museum tours, art projects, product showcases, and much more.

In *The Oceans Above Us*, I examine the potential of Project Aero to empower casual users to create dynamic, custom augmented reality scenes from scratch, as well as the obstacles that are currently limiting it from fully doing so. I take on the perspective of a teacher, business owner, medical professional, etc. with no augmented reality experience and attempt to create my own "virtual aquarium" animated AR experience from vision to

final product, in order to test whether Project Aero is ready to become ubiquitous in the hands of professionals from across every industry.

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I am eternally grateful to everyone who pushed me to never stop innovating, never stop learning, and never stop thinking during my time at WKU.

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SECTION ONE: BACKGROUND AND RATIONALE

Augmented reality holds the potential to be the new fabric of our everyday lives.

Also known as AR, augmented reality is any technology that superimposes graphical information over a real-world environment, whether it be through a smartphone screen or visually projected onto the environment. Though it has been around in various forms for decades, augmented reality is rapidly becoming commonplace as smartphone apps are integrated more and more into daily life and as the technology improves and innovates by leaps and bounds.

Current examples of augmented reality in daily life include IKEA's Place app, the Pokémon Go app, and Accuvein devices. These represent some of the diversity of applications for augmented reality, touching on the fields of advertising, entertainment, and healthcare, respectively.



Figure 1. The IKEA Place app (left), a battle in *Pokémon Go* (center), and an AccuVein device projecting on a patient's skin (right).

IKEA Place is a smartphone app that allows users to virtually “test out” furniture in their homes before they buy it. Users scan the room they’d like the furniture in, then access a collection of 3D assets representing IKEA furniture that can be overlaid on the space around them.

Pokémon Go is a popular mobile game where players capture and battle lovable monsters. Some versions of the game enable augmented reality battles, where players can see the Pokémon they are trying to catch overlaid on the ground.

Accuvein devices stand out in the world of augmented reality because they do not involve an app or a phone screen. Instead, they use infrared rays to locate veins under the skin, then project a light map of the veins’ location on the skin’s surface. This provides medical professionals a visual guide while inserting needles for greater speed and minimal patient discomfort.

In late 2019, augmented reality technology took on a new value, with the pandemic outbreak of COVID-19, a highly infectious virus that resulted in enforced social distancing, school closings, and the prohibition of events and large gatherings. In this period of change and upheaval, educators, creators, and businesses alike had to rethink their operations within a digital space. Platforms like Zoom—a rising-star teleconferencing app—and Minecraft—a multi-player, open-world game—could replace meetings and social gatherings, but what about museum tours and planetarium shows, dissection classes and art projects? Here, augmented reality presented a meaningful, virtual alternative.

With augmented reality in the hands of everyday people, a teacher could walk students through a battlefield diorama, a business could continue to showcase appliances within customers’ homes, an individual could send their spouse a vibrant bouquet of

flowers on their anniversary, a designer could pitch a packaging design mockup to a client, and classes could walk alongside dolphins or stand face-to-face with a shark on a virtual aquarium trip—all from miles, national borders, and quarantine restrictions away.

However, at the time of the outbreak, these opportunities were not being widely taken advantage of because augmented reality development was considered by many the exclusive work of experts, too advanced for anyone but video game creators, computer programmers, and user experience designers. Though still mainly limited to use within technological industries, a number of development platforms existed, intended for use by those without prior augmented reality experience as well as experts:

Apple's Reality Composer and ARKit are apps that allow users to build augmented reality scenes, including moving, scaling, and animating the assets, and is generally considered the most popular option for creating AR applications. The one great weakness of these apps, though, is that they exclusively create experiences for Apple iOS, meaning that only users of iPhones, iPads, and so forth can enjoy these experiences.

In response to this limitation, Google created ARCore, which closely mirrors ARKit's capabilities, but with a focus on Android devices. It is a popular option, additionally, because Google offers support and documentation on how to use the software, making it accessible to beginners.

Vuforia, another development platform, is popular in particular with video game creators because it is integrated with Unity, the leading engine for game development. While Vuforia is powerful, adaptable, and built to be modifiable for advanced functions, it has little relevance for beginners because it comes with a greater learning curve than ARKit, Reality Composer, and ARCore.

However, November 2019 marked the arrival of another option.

In a coincidentally well-timed release, Adobe unveiled a new development platform boasting an intuitive design with “no complex coding required.” Project Aero, built for smooth integration into a streamlined Adobe workflow, exists as a plugin in Adobe Dimension, Photoshop, Illustrator, and more, as well as a mobile app for assembling, editing, and sharing polished augmented reality scenes. Within the app, users can import their own custom 3D models and images, then arrange and animate the scene with a few clicks of a button or simple, intuitive gestures.

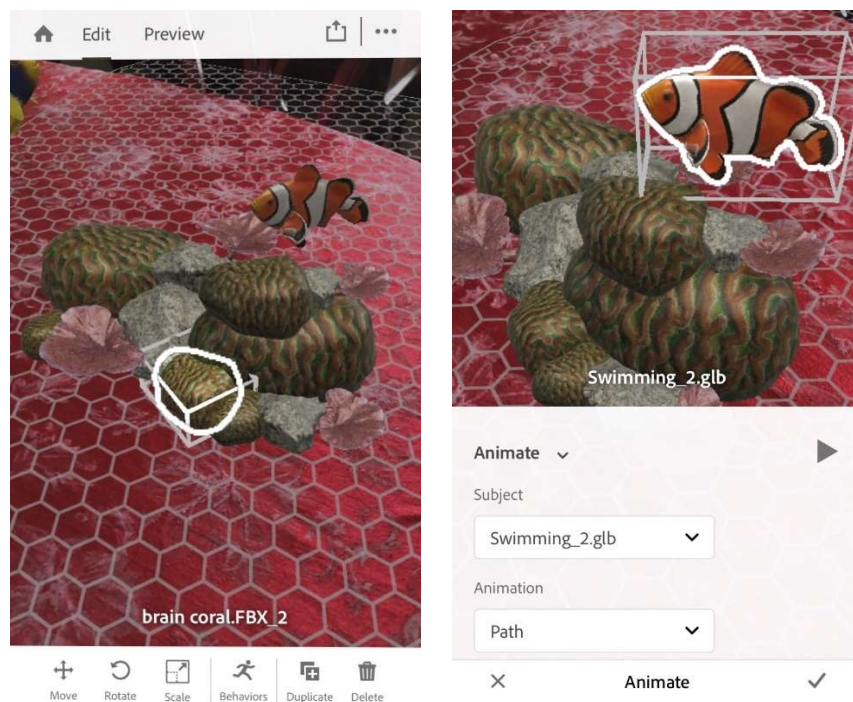


Figure 2. Screenshots of the Project Aero app on a smartphone.

Adobe claims Aero's features allow for easy yet powerful customization "so the experience flows just the way you envision it," while remaining simple enough for inexperienced users to "craft engaging AR experiences quickly and easily."

This Honors CE/T project sought to test those claims. Approaching the process as a beginner, I aimed to create a complex, moving AR experience in Project Aero, a "virtual aquarium" scene populated with coral structures and swimming fish. If I, having no previous experience in augmented reality, 3D design, or animation, equipped with only the resources available to the average consumer—other than the generous financial support of the Mahurin Honors College through an Honors Development Grant—could take a unique vision from concept to a shareable reality, so could a teacher quarantined away from their students, a small business required to shut its doors, a design team scattered across the world, or even a soldier stationed away from their children on Christmas Eve.

The Oceans Above Us is a project focused on potential, as I explored not only Project Aero's capacity to put powerful augmented reality development into the hands of everyday people, but also the bugs and obstacles keeping it from doing so, as of April 2020. It is my hope that once these limitations are addressed, Aero will have the potential to revolutionize life as we know it and empower the visionary in all of us.

SECTION TWO: INTENDED PROCESS

The Oceans Above Us began with a vision. Before discovering any technical bugs or restrictions due to the pandemic, I wanted to create a walk-in exhibit space on Western Kentucky University's campus, featuring traditional craft elements—such as crocheted seaweed hanging from the ceiling and papier-mâché coral structures—as well as posted QR codes that users could scan with their mobile devices to access an augmented reality scene. The scene, which would be geographically anchored to the exhibit space and integrated with the craft components, would depict an upside-down tropical reef scene, with rocks and coral appearing to grow from the ceiling and fish, turtles, rays, and more swimming around the environment and the user.

Following preliminary research of Adobe's official support resources¹ and a variety of online Project Aero tutorials, I developed a four-step workflow I felt could be followed by any inexperienced user to create a strong augmented reality scene with Project Aero, which I then intended to use as a guide for my own process in creating *The Oceans Above Us*. However, due to bugs and limitations in the current release of Project Aero, as well as the sudden changes imposed by the spread of COVID-19 partway through the project, I had to rethink parts of this process.

My initial intended process consisted of four phases:

1. PLANNING—this phase consisted of researching and mapping out the exhibit. To create a realistic ocean scene, I consulted with Cydne Kitchens, a December 2019 graduate of WKU's Ogden College of Science and

Engineering with a focus on marine biology, who assisted in creating a list of fish, corals, and other creatures that would realistically be found in a tropical reef environment. With this list in mind, we researched and purchased 3D models of these creatures on turbosquid.com, an ecommerce website for 3D assets. During this phase, I also sketched out the layout for the augmented reality scene, though these sketches had to be revised when the project was reimagined as a portable AR-only experience.

Because it did not require use of Project Aero itself, I was able to carry out the entirety of this phase as intended.

2. ANIMATION—now in possession of static 3D models, I intended to animate the fish models to swim in place and then export them to Project Aero. After learning the basics of 3D animation and watching a number of tutorials, I loaded my models into the animation program Cinema 4D and tested out two different animation styles:
 - a. A simple bend deformer: an invisible cube placed around the fish's tail that, when bent back and forth, causes its contents to bend as well, lending the tail a side-to-side swishing motion. While very simple, this animation isn't as believable because the tail is the only part of the fish that moves.

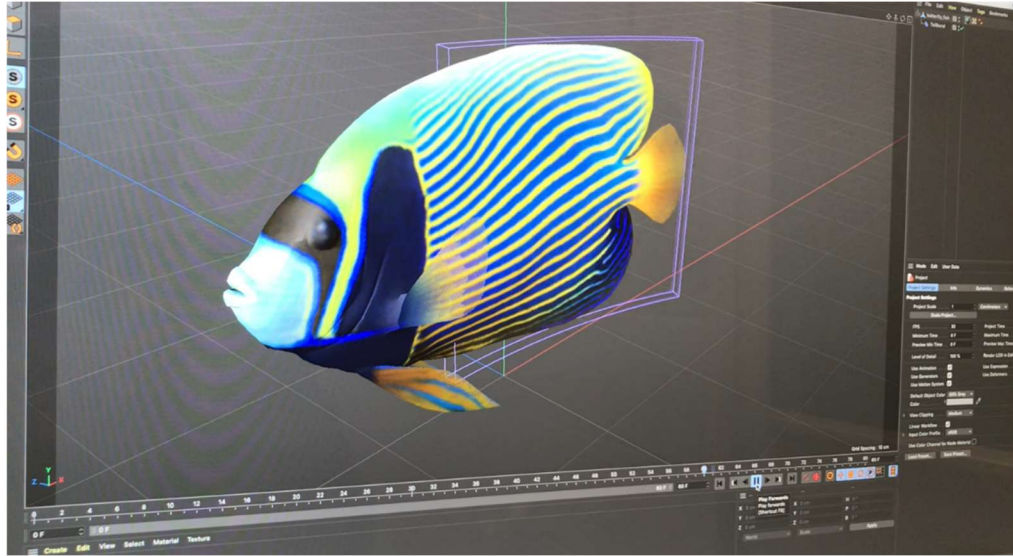


Figure 3. Screenshot of simple bend deformer animation in Cinema 4D.

- b. Joints with a vibration tag: as seen in Figure 5, I created a spine out of joints that ran the length of the fish's body. I again created an invisible cube, but this time expanded it to engulf the entire body, and used a "Bind" command to link the motion of the cube and the fish's spine. I created the back-and-forth motion of swimming by applying a "vibration" motion tag to the spine, which allowed me to adjust its settings and send a wave-like motion down the joints on an infinite loop. Though this approach is much more complex than the simple bend deformer, it creates a much more realistic and dynamic animation.

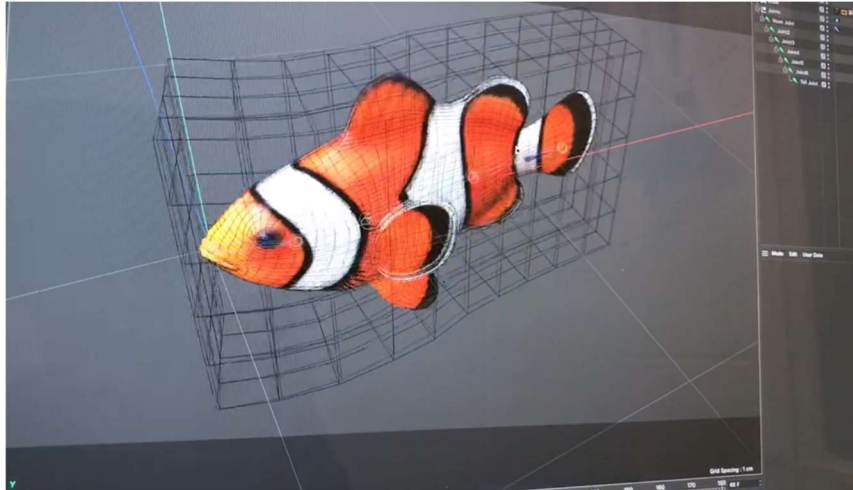


Figure 4. Screenshot of a clown fish animated in Cinema 4D using a cube, joints, and a vibration motion tag.

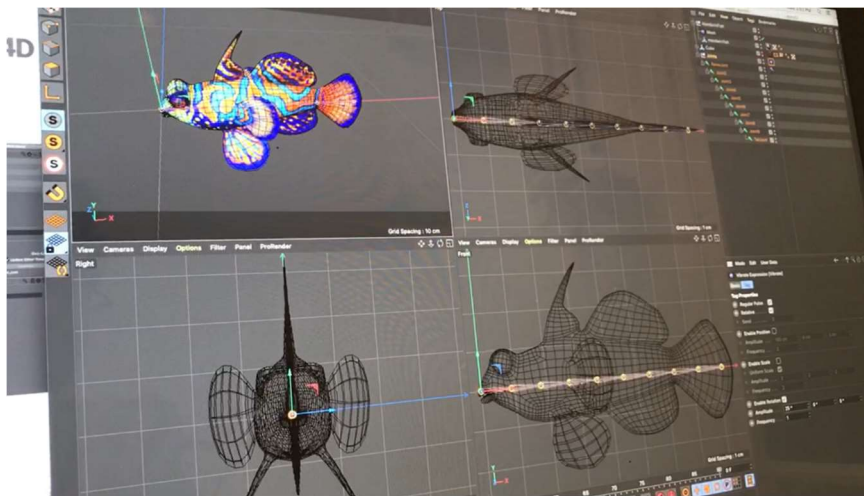


Figure 5. Screenshot of a mandarin fish animated in Cinema 4D using a cube, joints, and a vibration motion tag.

While I was successful in animating the models, due to limitations of Project Aero that I will discuss in Section Three, this was the last phase I was able to complete according to the intended process.

3. PROJECT AERO—once the models were animated and exported for augmented reality use under the .fbx file format, I intended to begin creating

the virtual scene in the Project Aero mobile app by importing the animated models. This could be done by uploading the models to my Creative Cloud documents, to which there is direct and easy access within the app. Then, I planned to use the tools within Aero to arrange the fish, as well as static models of coral, into a full scene, complete with schools of fish, some larger creatures, such as turtles or rays, and environmental effects like bubbles. I would also use the app's "animate along a path" tool to make the fish move around the scene, which, combined with their swimming animations from my work in Cinema 4D, would make it appear as though they were propelling themselves through the environment like living fish.

With the scene complete and fully animated, I intended to export it as a shareable augmented reality file, accessible by scanning a QR code with a mobile device.

4. THE EXHIBIT—before the rapid escalation of the COVID-19 pandemic resulted in events and gatherings, such as public exhibits, being prohibited, I had aimed to share *The Oceans Above Us* as a walk-in exhibit. I planned to reserve a physical space, arrange the craft components of the experience in this space, and place QR codes along the walls that were linked to the scene, so that, when scanned, they would open up the scene within the space, allowing users to walk around and interact with both the physical and virtual components of the exhibit, as well as with each other. The goal was to recreate the feeling of going to an aquarium, without the glass walls.

SECTION THREE: OBSTACLES

From bugs and limitations within the Project Aero app to a viral outbreak, a number of factors prevented me from completing this project according to the intended process detailed in Section Two. Due to these factors, I rethought the process according to the actual execution outlined in Section Three.

Because I framed this project around what would be reasonably achievable for a high school teacher, small business owner, political campaign manager, etc. with no previous experience in augmented reality, I considered an obstacle to be any malfunction, hardware/software requirement, or overly complex set of steps that would make the average casual user abandon the process in frustration.

Therefore, even if it was technically possible to realize my initial vision by studying advanced concepts for long enough or acquiring more substantial resources or equipment (such as an iMac Pro or access to a private beta release of software), I evaluated the process as prohibitively difficult and re-evaluated my process.

I determined the most noteworthy obstacles to be:

1. Importing .fbx files into Project Aero—The first major obstacle to following my intended process was a limitation of the Project Aero mobile app as of April 2020. The .fbx file format is very popular for exporting animated 3D models, and it was the format I initially exported my animated fish models under. Unfortunately, while Aero supports importing .fbx files, as of this project it does not support animation attached to those files beyond

position-size-rotation animations, meaning that my complex swimming animation—or even the simple bend deformer I experimented with in Section Two—would not load. Instead, the fish models would simply appear as static objects.

Additionally, Project Aero does not consistently load the materials associated with models in .fbx files. Materials are what lend models their color and quality (such as reflection or metallic sheen), and without them, 3D models will appear like homogenous, off-white clay figures. When importing with the .fbx file format, as well as the .obj format, several users on the Project Aero forum² have stated that the materials on their models will not load in Project Aero.

2. Exporting as .gltf/.glb—While Project Aero does not support complex animations (“complex animations” in the context of this paper simply referring animations other than position-scale-rotation animations, not necessarily those of a degree of difficulty beyond what is achievable for a user with limited experience in animating models) associated with .fbx files, it does support the same for files of the .glb format. Fortunately, Cinema 4D is compatible with a plugin that allows it to export animated models in .gltf and .glb format. However, the exportation process for these formats consumes more memory than for .fbx files, and so both of the computers I had access to following the imposition of school and business closures in reaction to the COVID-19 pandemic were unable to successfully export any models as .glb files. Because both of these computers, one a Windows

device and the other an Apple MacBook, were equipped with a fairly standard 8GB RAM, I considered this to be a prohibitive limitation. I reasoned that the average casual user would likely not be using a device with significantly more computer memory than this, particularly those working from home in isolation.

3. Mixamo animations—Unable to import my animated models using the .fbx or . glb file formats, I attempted a very unorthodox workaround to animate the fish. Mixamo is a rigging and animation service acquired by Adobe that allows the user to define certain points on their model (such as knees, elbows, and chin) and then analyzes the model in order to automatically rig it. The user can then select one of the many preset animations available in the Mixamo collection and the program will apply the animation to the model. Due to Mixamo belonging to Adobe, Project Aero is optimized for importing even complex animations from Mixamo.

This was an unusual approach for this project because Mixamo is intended for humanoid models with clear arms, legs, heads, and torsos. However, as I will detail in Section Four, I adapted my models for use with Mixamo, and was able to apply the service’s animations to my models. Unfortunately, even when I could successfully apply these animations, the results were not always favorable. When I applied the animation “Swimming” to a clown fish, mandarin fish, or any other vertically short fish, it looked quite clean and realistic. In contrast, models that were tall along the y-axis would appear crumpled, like an inflatable fish with air let out at the top, when the

same animation was applied. For this reason, I attempted to apply the animation “Bellydancing,” which actually more accurately reflected the swimming motion of a fish, except with the fish’s body rotated 90 degrees upwards, so it was standing on its tail. Though the animation appeared realistic within Mixamo, it was problematic when imported into the Project Aero app. By adjusting the rotation settings of the model, I could set the fish to be properly oriented, with its stomach facing downwards, but as soon as a path animation was applied to make it move around the environment, it would revert to a humanoid orientation, standing on its tail with its stomach facing forward.



Figure 6. Screenshot of a clown fish in Mixamo, oriented so it is standing on its tail, which is, of course, very strange for a clown fish.

Additionally, though Mixamo claims it accepts .fbx files and .obj files, as well as .zip folders containing a combination of .obj files and their accompanying material and texture files, it can only process older versions of .fbx files (typically from 2013 or earlier) and many .obj files will be processed without their materials and textures, even if they were uploaded as a .zip containing these files. The latter error results in fully colored and textured models appearing and later importing into Aero as smooth, off-white figures.

Despite being able to successfully animate and import multiple models using Mixamo, I consider this part of the process an obstacle because Mixamo can only serve a limited functionality, reflecting an overall limitation of Project Aero as of April 2020. Because only certain models are compatible with Mixamo, it cannot be seen as an all-encompassing solution to animating assets for every project or as an adequate replacement for the ability to import custom animations from Cinema 4D, Maya, or other programs.

4. Sharing the experience—As of April 2020, options to share completed scenes are limited for inexperienced users. Project Aero has one-click buttons for exporting scenes as .usdz, .reality, and .real files, although until March 2020, selecting the buttons consistently yielded errors for many users. Additionally, the process to convert these files into usable apps or embedded into existing websites is prohibitively advanced for the kind of beginners Aero is marketed towards, requiring extensive knowledge of

Xcode and/or use with Reality Composer. This leaves beginners with the option of sharing their experiences within the Aero app, meaning others can only view the experience if they also have the app, which is free, but also only available for iOS devices with a very large amount of storage available. Thus, at least by users without extensive experience with Xcode, experiences made in Project Aero can't claim to be truly for everyone, limiting Aero's ability to become commonplace.

5. COVID-19—As mentioned in Section One, the rapid spread of the COVID-19 virus in late 2019 and 2020 resulted in the closure of the University and other businesses, as well as the cancellation of events and prohibition of large gatherings. This was a clear obstacle to the completion of the last phase of my intended process, as creating a walk-in exhibition would violate these closures and be poorly received because most of the public was engaging in self-isolation. However, I was able to revise the final goal of the project to create a more portable experience users could enjoy, and potentially recreate, from within isolation.

The effects of the virus also forced me to rethink my process because it meant I no longer had access to resources at the University, such the powerful iMacs in certain computer labs. Similarly, the casual users whose perspective I focused this project on would also not have access to similar resources, whether they be work computers or educational licenses to software purchased by their school, which prompted me to rethink my

process in accordance with what resources would be reasonably available to an average individual.

SECTION FOUR: ACTUAL EXECUTION

Finally, keeping in mind the challenges explored in Section Three, I reworked my intended process from Section Two into a realistic approach that I followed in order to create the final product of *The Oceans Above Us*:

1. PLANNING—As described in Section Two, I consulted with WKU marine biology student Cydne Kitchens to create a list of marine creatures, including coral, that would belong in a tropical reef environment, and then purchased models of these creatures online through turbosquid.com, using funds from an Honors Development Grant provided by the Mahurin Honors College.
2. ANIMATING THE MODELS—After discovering that the files I animated and exported as .fbx files would not successfully import into Project Aero, I adopted a more unorthodox approach to animating my fish models, uploading them to the rigging and animating service Mixamo. Though Mixamo is intended to process humanoid figures, I was still able to process some of my fish models depending on their body shape. In the service's auto-rigging menu, I set my fish models to appear standing on their tails with their fins out to each side like arms, and then labeled parts of their body according to their approximate human equivalent, as seen in Figure 6.

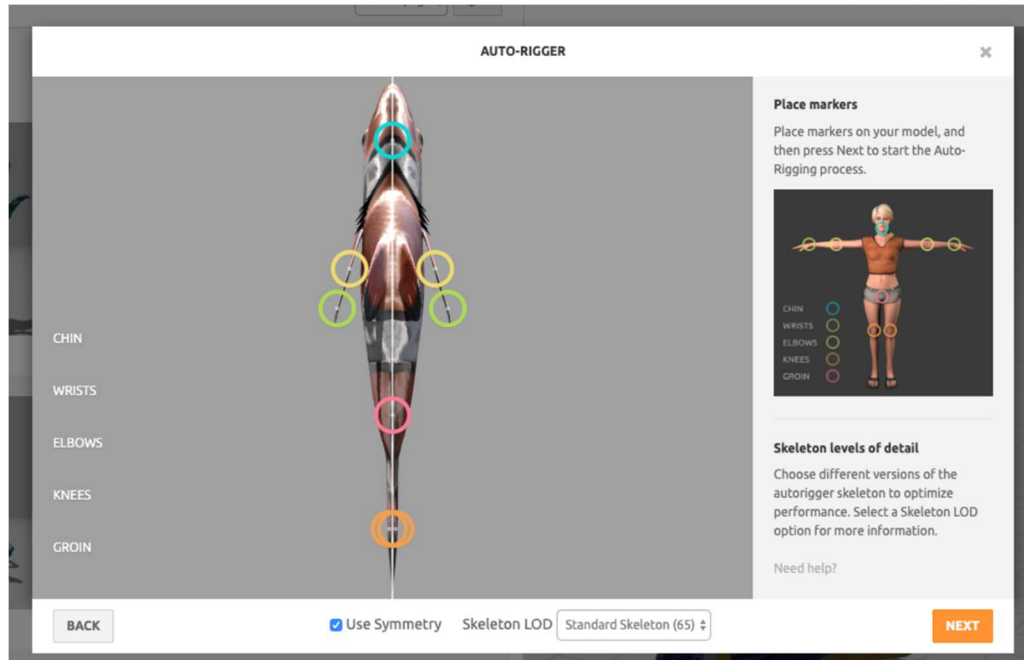


Figure 7. Screenshot of a clown fish in the auto-rigging menu of Mixamo.

After Mixamo rigged each model, I could browse its library of animations to apply to my models. I chose the animation “Swimming” because it placed the model horizontal and most closely resembled the custom swimming animation I had initially created in Cinema 4D. However, not all of my models were compatible with this animation, so I populated the exhibit with the few models that were.

After rigging and animating each model, I selected “send to Aero” within Mixamo, uploading them into my Creative Cloud documents for easy access within the Project Aero app.

3. CREATING THE SCENE IN AERO—Within the Project Aero app, I created a new, blank scene, scanning the ceiling of the room to anchor all objects to it as a foundation. I then began building coral structures by importing my static coral models and stacking them in groups, applying

small, subtle animations, such as a slight back-and-forth rotation, to create the effect of the coral waving in the current. Once I felt I had created a dynamic base for the fish to swim around in, I began importing my fish models. For each model, I applied an “Animate” behavior under the behaviors menu, then set each to display its swimming animation, as well as to move along a path I drew by tracing my finger along the screen. I created schools of fish by duplicating an animated fish several times, then modulating the size and speed of each duplicate to add variation. Additionally, I took advantage of the range of interactivity options by setting some animations to trigger only when an object was touched or when the user entered a certain proximity of the object, such as a shy fish that would swim away when approached.



Figure 8. Still frame from video of a small-scale test of the augmented reality scene.

As I arranged the scene, I walked around and examined the experience from different angles to make sure it would flow smoothly for users whether they were sitting in a chair at a desk, laying in bed, or strolling around a room. Using the “Preview” feature in the Project Aero app allowed me to experience the scene exactly as an end user would experience it, even while I was constructing it as a work-in-progress.

4. SHARING THE EXPERIENCE—After constructing and testing a beautiful final product, I made *The Oceans Above Us* available for other users to experience by sharing a link and exporting it as a .real file. Anyone who had access to the link could open the experience in the free Project Aero app on their own mobile device to view and interact with it. Users who accessed the .real file, the format for saving working Aero documents, could import the file into their app and edit it themselves, in addition to simply viewing it. This opened up the possibility of customization, allowing users to make unique versions of the experience by adding in their own models or rearranging the scene.

In addition, this form of sharing offers a potential avenue for making augmented reality development more readily available to beginners. A developer with AR or 3D modeling experience could set up a basic scene in Aero and share it as a .real file with beginners, who could then customize it for their purposes using Aero’s intuitive tools. For example, in a classroom setting, an anatomy instructor could create a scene containing a human model and a number of labels of body parts, then task students with opening

the scene as a .real file, arranging the labels to match up with each body part, and then returning the file to the instructor for grading.

By following this process, an inexperienced, casual user would be fully capable of creating a similar experience, demonstrating that Project Aero is usable for creating polished, shareable scenes. However, creating The Oceans Above Us required an almost complete overhaul of my intended process, as well as significant time and experimentation in order to make the experience unique according my vision. So is Project Aero ready for wide use by beginners? Or is it limited by bugs and complicated fixes?

SECTION FIVE: CONCLUSION

This Honors CE/T project aimed to showcase the power of Adobe's fledgling Project Aero to put augmented reality development in the hands of casual users, as well as to investigate what bugs and limitations prevented it from doing so as of this project's defense in April 2020.

In summary, while it was, in fact, possible to make a somewhat limited experience with reasonable resources and no prior augmented reality experience, the abundance of technical limitations and advanced knowledge required to address them make the development of custom experiences from scratch in Project Aero prohibitively difficult for the inexperienced users it claims to market itself towards. Reproducing a scene based on an official Adobe tutorial and using the same models, apps, and animations may be intuitive and free of a learning-curve, but attempting to use custom models or animations, or to create an original scene from vision to reality, requires extensive technical knowledge and/or programs and computing power that a public school student, small business owner, or family practitioner may not have.

To realize Project Aero's full potential, I have concluded that Adobe must address these major issues:

- Support for .fbx files: Animating models in Cinema 4D, Maya, Blender, or a similar software, and then exporting these models as .fbx files is the simplest way to create custom animations that can't be produced in Mixamo or Project Aero's built-in interactivity tools. Though many beginners will

not want to bother with learning how to create custom animations, those looking to make a specific vision come to life may feel this is necessary, but finding a way to incorporate them without support for .fbx file animations (beyond basic position-scale-rotation animations) would likely be too advanced for the majority of these users.

- Mixamo animations for non-humanoids: As an alternative to providing support for .fbx file animations, Adobe could expand the purview of Mixamo to include a basic selection of animations for non-humanoid models. This could be as simple as a walk cycle for four-legged animals, a slithering animation for snakes and fish, and a wing-fluttering motion for butterflies, birds, and other airborne creatures. Because Mixamo is quick and beginner-friendly, providing more options for users to integrate it into a greater variety of augmented reality scenes would actually be an ideal solution for casual users with no animation experience.
- Easy sharing outside of Aero: Learning to create custom apps in Xcode is far beyond the commitment a casual user is likely to invest in developing augmented reality scenes, so sharing Project Aero experiences within the app is the most logical option to these users. However, as Adobe has made the Aero app available only on iOS, it is automatically inaccessible to Android users, who Forbes magazine³ says make up a greater percentage of active smartphone users than those of Apple devices. Additionally, as the Project Aero app is large and requires a great amount of device storage and memory, not every iOS device will be able to support it, alienating some

iPhone users as well. If Adobe wants Aero to become commonplace technology, it must design it to integrate with commonplace technology.

If Adobe were to address these issues, I believe Project Aero would be become everything it boasts itself to be: an easy-to-use, intuitive platform for creating powerful, highly customizable augmented reality experiences without any prior expertise in the industry. With the ability to bring any vision to life in the hands of families, educators, businesspeople, medical professionals, analysts, public figures, and more, any individual could in any industry could create experiences specific to their field, revolutionizing the world from the ground up.

NOTES

1. Support resources available on the Project Aero page on Adobe's website:
helpx.adobe.com/aero/get-started.html

2. Users who have reported this issue include eros_vfx in the thread "Import assets in Aero:" community.adobe.com/t5/aero/import-assets-in-aero/m-p/10726961?page=1 and drewmacmalon in the thread "Import from C4D into Aero:" community.adobe.com/t5/aero/import-from-c4d-into-aero/m-p/10989972?page=1

3. As of this 2017 Forbes article, Google's Android held more than half the smartphone market share: www.forbes.com/sites/johnkoetsier/2017/05/18/surprise-google-reveals-apples-ios-market-share-is-65-to-230-bigger-than-we-thought/#1bec244f5890

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