TURNING STORIES: A MYTHOTROPE AS AN AUGMENTED REALITY EDUCATION PLATFORM

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Abstract

It is a challenge to introduce and practice computational modes of visual narrative in art and design and computer science classroom environments. Students need to learn, practice and synthesize a collection of multidisciplinary skills when they develop projects (software development, art production, animation, interactivity, game design, electronics, among others), and such efforts often require collaborative work in team-based environments. These challenges are especially acute in domains such as augmented, mixed and virtual reality, where teams are also tasked to innovate in emerging platforms, as standards, affordances and potentials are open-ended and changing rapidly. As students address such design problems with creativity, they practice divergent thinking, and ingenuity, solving problems in inventive ways– such skills are difficult to teach.

Emerging curricular strategies sometimes focus on fostering collaborative spaces and challenges that require multidisciplinary problem solving for unorthodox scenarios and the interplay of technology, arts, and design thinking. That is the focus of this paper. We present a project and technology platform called Story-Go-Round. The particulars of the platform are evolving-- it was developed over the course of an academic semester, as a studio assignment for art and design students. The project involves a collection of technologies and a flexible, open-source design-- a depth camera, actuated physical stage, basic electronics, digitally fabricated cabinet, computer and game controller controls, and a series of software templates and development environments. The students are asked to consider the affordances of the system and consider its potential to be modified, hacked and hybridized, towards the goal of creating a novel, cyclical storytelling experience.

Story-Go-Round is a *mythotrope*, meaning “story turning”, a term coined by the authors as a reference to a zoetrope, a historically significant cylindrical pre-film animation device developed in the 19th century. It is an experimental physical development platform for producing augmented digital experiences. Students physically construct dioramas in an actuated carousel, modify the hardware platform, and then integrate the hand-crafted sets and engineered technical system with digital content, animation, interactivity, gameplay and effects.

The platform has a low barrier to entry, it first involves crafting using methods familiar from childhood. It then introduces foundational skills, allowing the students to show off expert skills while at the same time crossing discipline domains into new areas. Along the way students consider the history of animation, video game consoles and digital media.

As educators in this highly virtualized era, we are tempted to shift the focus exclusively to digital tools; however, this limits the design that students produce to choices and levels of complexity offered by software, and the results become alike and repetitive. We wanted to create an assignment that functions by combining two made-up worlds: one that is physically produced and another that is digitally animated and controlled.

When students try to develop a multi-faceted project like this, which crosses multiple technical and artistic domains, and try to quickly learn the skills they need to implement their vision, they get to experience the remixing, mashup, open-source making culture, which is so prominent in the way we work today. How else can young designers best learn the duct-tape and jerry-rigging skills which will allow them to see potential opportunities in disparate things, and find new ways of hacking them together to create something new, playful and whimsical, even if what they create is also “absurd”, and often not practical?

Keywords: augmented reality, computational media, creativity, animation history, visual narrative, game design, interdisciplinary education, circularity.

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1 INTRODUCTION

It is common practice for computational media instructors to reference precedents, prior art, and the history of media, when teaching visual narrative, animation and game design in art and design and computer science classroom environments. Our students can explore the lineage of artifacts and modalities which emerged due to the adaptive changes of the past, where generations of makers and storytellers bent, recombined and invented technologies to tell new types of narratives. These resulting stories uniquely expressed their cultural moment and its dynamics, and motivated further advancement of these technologies and modes of expression. The relationship between the development of tools and story artifacts is profoundly cyclical, as is the core process of innovation in these realms.

The day-to-day design practice of storytellers and engineers generally conforms to a cycling process too, which is evident as we imagine the typical *design thinking* iterative loop-- the process of research and ideation, seeing if existing solutions will “solve the problem” or if innovation is required, and then developing a schema, prototyping and testing the artifact, to eventually restart the process again. This echoes the more mythic cycle of Joseph Campbell’s *Hero's Journey*, the repeated motif of a protagonist's call to action, who then leaves home, confronts and overcomes profound obstacles, is tested and returns a transformed hero, who might venture forth another day [Fig. 1].

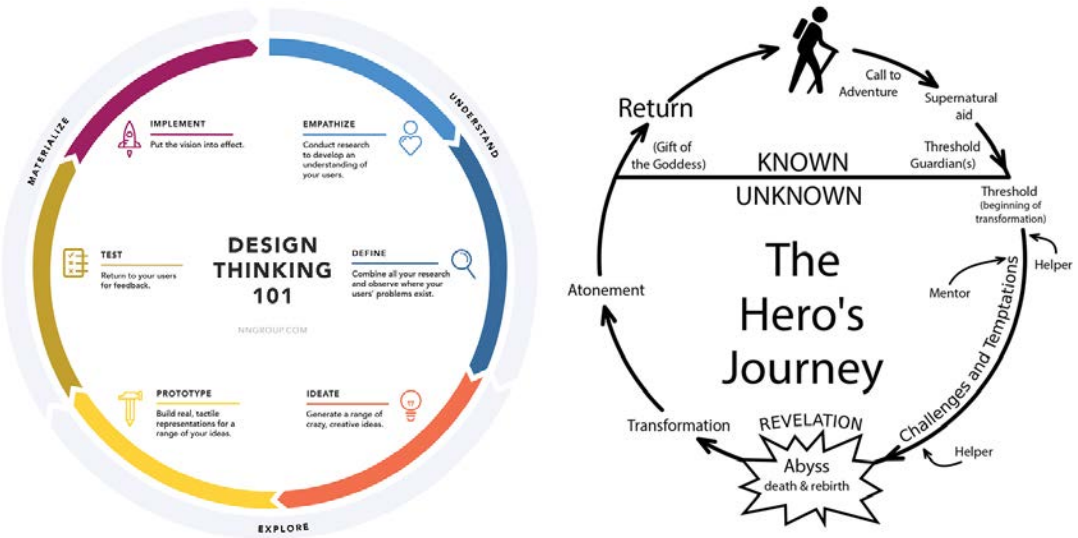

Figure 1. Design thinking cycle (left), Campbell’s storytelling monomyth (right)

As instructors, we hopefully try and encourage our students to practice creativity, which is more than exhibiting a set of rote skills and mimicking the work of others. Creativity requires our students to set off into the unknown, prepared with a toolkit of pre-existing knowledge and skills, excited to tackle an adventure that matters to them (in the constructionist model of Seymour Papert [1]), confident that they will be able to improvise and learn as they go, equipped with the fortitude to persevere and eventually produce something that is truly new-- to invent. This journey involves risk, the potential of failure, and the likelihood that a student’s initial experiments won’t work out. Through time and effort, students might build confidence that they can overcome obstacles, and look for opportunities and potential in their failures.

When teaching creativity in computational media realms, we often propose design and project prototyping exclusively in established digital development platforms, say a computer game engine or virtual reality authoring environment. Then students frequently create artifacts in established commercial genres, perhaps a 2-D platformer game, interactive graphic novel, or location-based GPS game, to randomly pick a few. This immediately encourages them to produce facsimiles, repetitive variations on genre conventions and tropes using their known affordances, or only use the interfaces and capabilities that the authoring environments give them. This works fine to teach and reinforce certain skill sets, demystify the technical artifact, build excitement and confidence, hone the craft of a particular genre, or accomplish a prescribed goal.

Students are not often asked to invent the tools and platforms to do their work or push media, its technology and conventions, into new territories. This becomes a hindrance when confronting novel problem spaces, where innovation in technology has opened vast unexplored territory. Such is the case with domains such as augmented and mixed reality, where the simultaneous introduction of mobile computing power, wireless networks, inexpensive head-mounted visual displays, computer vision and machine learning, have allowed us to dream of a synthesis between our analog and digital worlds.

Mixed reality is an emerging genre, and its affordances and expressions are open-ended and changing rapidly. What are the opportunities of the existing physical space, an individual or community's needs and desires, fluidly mixed with the digital domain, procedural experiences, display technologies and networked ecosystems to build new storyworlds? Such design tasks often require thinking outside the box, and by nature often necessitates a cross-disciplinary approach to research and project development, a breadth of required skill-sets, and also entails team-based collaboration, which is not always a comfortable mode for students.

This paper introduces an education platform focused on building mixed and augmented reality experiences, while also encouraging physical and digital hacking, crafting and low-stakes play. It poses a novel and flexible design prompt, encouraging creativity, interdisciplinary teamwork, and learning a range of technical and making skills.

The platform is called Story-Go-Round. The particulars of this project are evolving-- it was developed over the course of an academic semester, as a studio assignment for undergraduate and graduate art and design students. It involves a collection of technologies and a flexible, open-source design-- a depth camera, actuated physical stage, basic electronics, digitally fabricated cabinet, computer and game controller controls, and a series of software templates and development environments. The students are asked to consider the affordances of the system and also consider its potential to be modified, hacked and hybridized, towards the goal of creating a novel, cyclical storytelling experience.

Story-Go-Round is a *mythotrope*, meaning "story turning", a term coined by the authors as a reference to a *zoetrope,* meaning "life turning", a historically significant cylindrical pre-film animation device developed in the 19th century. It is an experimental physical development platform for producing augmented digital experiences. Students physically construct dioramas in an actuated carousel or rotating stage, modify the hardware platform, and then integrate the hand-crafted sets and engineered technical system with digital content, animation, interactivity, gameplay and effects [Fig. 2].

Figure 2. Story-Go-Round mythotrope (left), Student augmented reality game (right)

The platform has a low barrier to entry, it first involves crafting using methods familiar from childhood. It then introduces foundational skills, allowing the students to show off expert skills while at the same time crossing discipline domains into new areas. Along the way students consider the history of animation, digital media and video game consoles.

When considering questions of teaching creativity in the emerging domains of augmented and mixed reality, it's interesting to look at the history of animation, the development of the zoetrope and similar actuated contraptions, and study how they evolved toward the invention of motion picture film technology. It hints at the potential of devices like a mythotrope to encourage student innovation when they approach augmented reality storytelling.

2 A SELECTIVE HISTORY OF ANIMATION AND TURNING STORIES

The first efforts to visually depict life's motion are ancient, preserved on the walls of Palaeolithic cave paintings. They evolved through millennia to incorporate real-time representations in the back projection of puppetry through *shadow play* more than 2000 years ago, to the use of *magic lanterns* with moving imagery in the 17th century.

The early development of mechanically actuated animation and cinematography began in the early 1800's, with Joseph Plateau's invention of the *phenakistiscope* in 1833 [Fig. 3], a spinning disk device which showed a revolving sequence of still images through a thin slit, relying on the "persistence of vision" phenomenon to create the illusion of motion. This device was reimaged that same year by Simon Stampfer, and concurrently by William Horner, in cylindrical form, which was eventually improved three decades later by William Ensign Lincoln, as the prototypical *zoetrope*, a spinning drum with replaceable strips of images– an early form of a removable media device [2].

In both cases the motion depicted was limited, as the devices could only accommodate a small number of still frames. Considering this limitation, the animations captured a cyclical depiction of life, focusing on the magic of animation, simple looping vignettes, and the continuous mechanics of physical motion. Lincoln sold this invention to Milton Bradley and Company in 1866, who mass produced and sold it as a popular toy and entertainment.

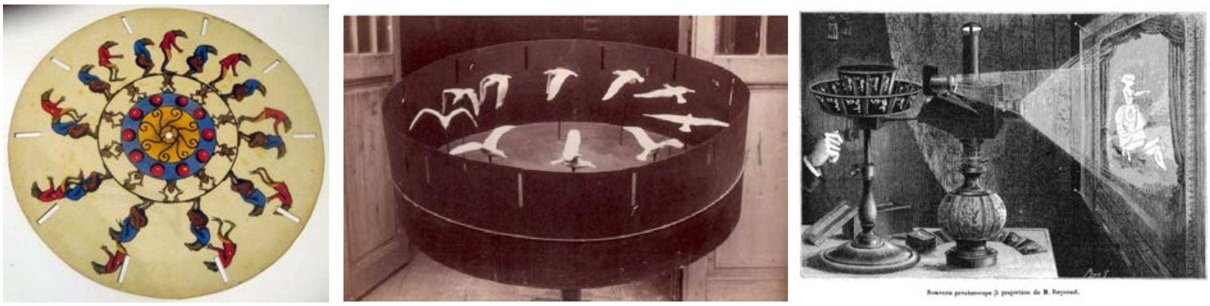

Figure 3. Phenakistiscope disk (left), Zoetrope - Marey's Gull (center), Praxinoscope (right)

Throughout the latter half of the 19th century, people extended the zoetrope, some animating 3-D elements, which was used by Étienne-Jules Marey in his studies of the mechanics of flight [Fig. 3]. In 1877, Charles-Émile Reynaud hybridized the device, incorporating optical elements, lens and mirrors, and oil lamps, to allow the projection of animation onto walls or theatrical scrims, resulting in the praxinoscope [Fig. 3]. He and others improved its function through the addition of a steam engine and gearing, providing for an autonomous actuation of the drum.

Concurrent with the progression of such small-scale animation devices, 19th-century inventors and storytellers developed other techniques to visually depict motion and narrative, often at larger scales, to produce entertaining experiences for the public. The phenomenon of the *moving panorama* emerged, most notably developed by John Banvard in 1848, perhaps the first "moving picture", which conceived of grand moving panoramic paintings, mechanically actuated, rotating on scrolls or perpetually cycling on an endless loop [Fig. 4][3]. People packed into theaters to witness the spectacle of a moving story, for example, a steamboat journey up the Mississippi, or a "Whaling Voyage 'Round the World'"[4]. This experience virtually transported the viewer to exotic, often foreign locations, and offered the illusion of traveling through space– an immersive visual journey.

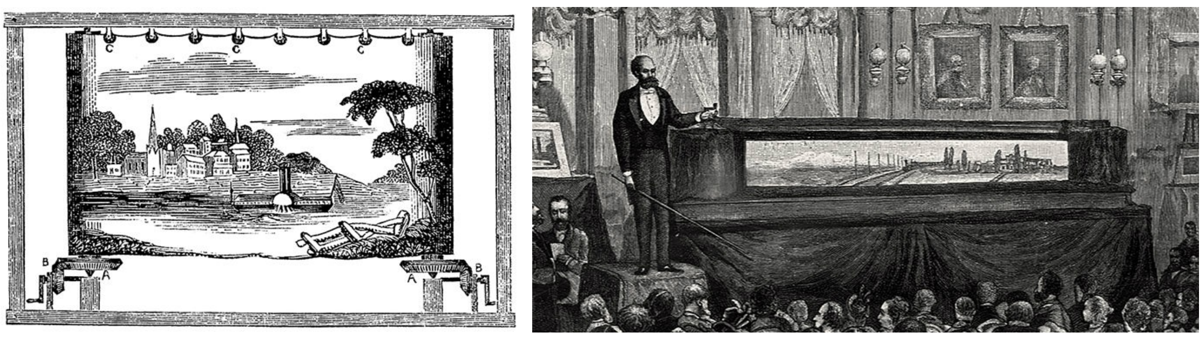

Figure 4. Moving Panorama (left) / Crankie (right)

Such technology was also developed in smaller-scale devices such as the *crankie*, often accompanied by a narrator and other performers, to create an often-charming theatrical, scrolling pictographic experience [Fig. 4]. The apogee of moving panorama technology came perhaps with the development of the *mareorama,* an attraction built for the 1900 Paris Exposition by Hugo d'Alesi and a team of engineers [Fig. 5]. They built a massive actuated moving platform with a replica of a ship's deck, and pair of moving panorama paintings, to allow the spectator to take a simulated ocean journey, visiting ports of call and circumnavigating the world. To add to the illusory effects, large fans produced an ocean breeze, the sensory experience further augmented with ship sounds and the smell of seaweed and tar [5]. Such an invention towards large-scale narrative co-existed with the early spectacle of motion pictures in theaters and anticipated the promise and sensory immersion of virtual and mixed reality more than a half a century later.

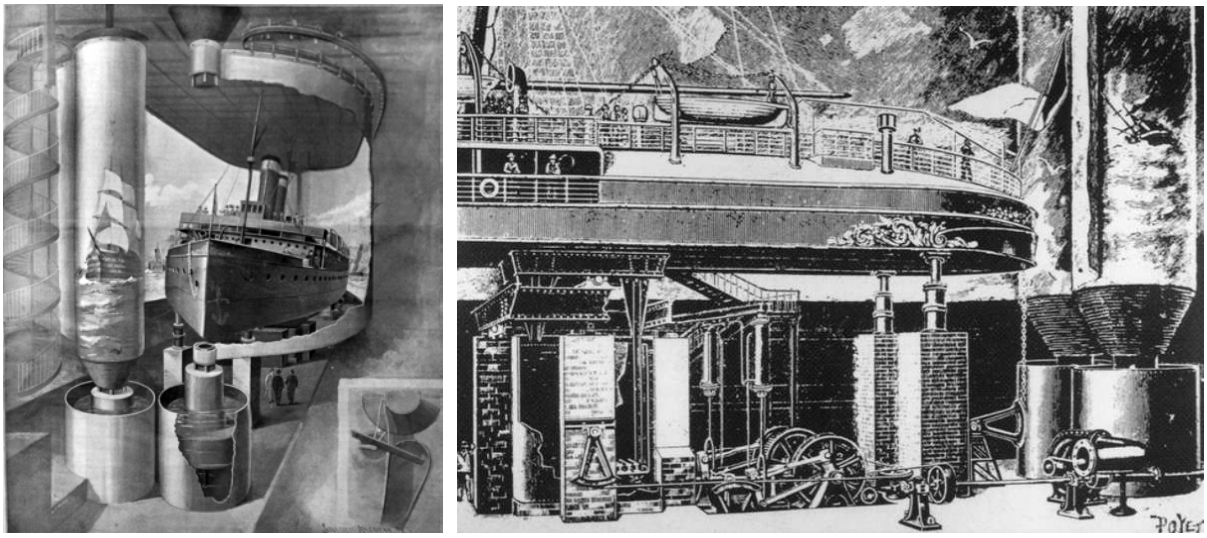

Figure 5. Mareorama

Successive engineering innovations on multiple fronts, and a range of creative applications and experiments with zoetropes and moving panoramas (among other devices), provided the foundation for the emergence of motion pictures. George Eastman invented flexible transparent celluloid roll-based film in 1889, which allowed the affordances of previous animation modalities to be synthesized in the motion picture camera and projector. These mechanically actuated devices captured the analog world and hand-drawn animation, and then allowed the lamp-based projection of film-based animated imagery at various scales, critically storing the time-based sequences on removable film reels. This allowed longer duration moving stories to be presented, copied, and easily distributed. The capabilities of this device were significant enough for it to become the most successful and sustained platform for animation and motion representation for the majority of the 20th century, gradually being supplanted by the advent of analog video, computer graphics/animation and digital video.

There have been countless innovations in the discussed realms, which have enabled media to more closely capture animated motion, the phenomena of life and our narrative experience. The focus of this paper isn't a comprehensive survey. Instead we'll note that each generation of these technologies has generally increased in technical complexity, as they have hybridized and integrated multiple layers of innovation. Animation storytelling platforms (from early filmic devices to modern computer games engines) have increasingly obscured the elemental mechanics of animation, the illusion and magic of motion through the display of a sequence of still images, and the "persistence of vision" phenomena, something a devices the zoetrope so perfectly captures.

Relevant to this paper, though somewhat an aside, in the early 1930's animators and engineers in the Disney animation studio developed an elaborate mechanical mechanism to enable them to more easily produce *motion paralla*x effects (the perception of depth through differences in movement between foreground and background elements) in a monocular filmic image. They invented a unique tool, the *multiplane camera*, to heighten the illusion of three-dimensionality in hand-drawn animation. While such devices produced effects which were natural to the film spectator's eye, the techniques to allow this effect exist as a strata of technical complexity implicit in the produced artifact, but hidden. If we were to teach and illustrate the fundamental concept of motion parallax, we would likely not have students start playing with Disney's camera [Fig. 6], as fun as that might be, we would instead look for more basic platforms, or ask the students to find their own creative ways for producing the same effects.

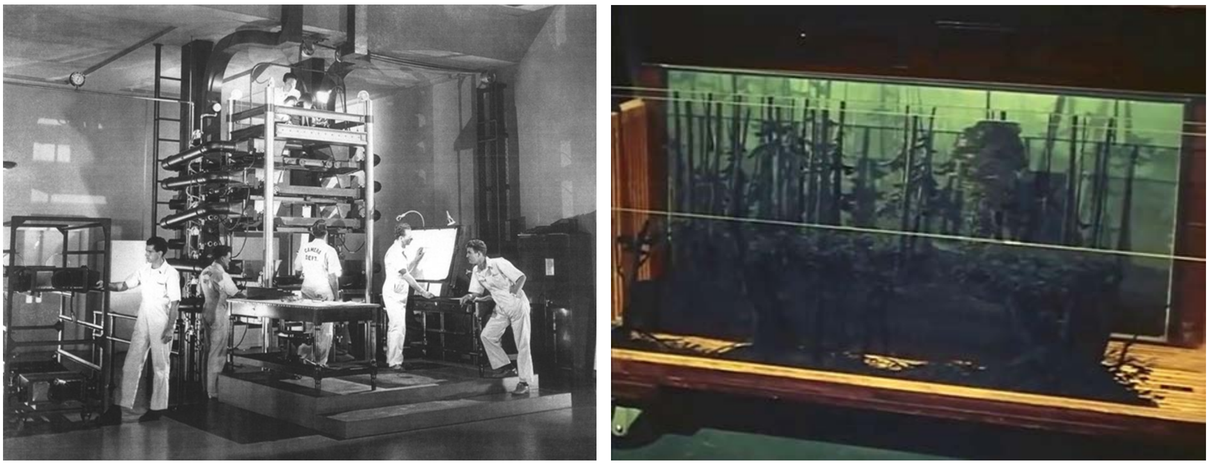

Figure 6. Disney Multiplane Camera

When teaching the basics of animation and computational media and approaching emerging genres such as augmented and mixed reality, we might do what Robby Gilbert advocates in his journal article "The Concrete Zoetrope"–

"By excavating early animation and cinematic devices such as the zoetrope and praxinoscope and examining their roots in physiology, medicine and mathematics as well as entertainment, students can develop a broader understanding of the current states of existing and emerging technologies, envision new applications for the movement-illusion, and re-establish an understanding of animation and the moving image as a fundamentally interdisciplinary endeavour."[2]

It's an endeavour that requires its practitioners to be comfortable within such interdisciplinary environments, to be able to understand the fundamental concepts of the medium and its lineage of innovation, and sometimes deconstruct and hack their tools of production, like their predecessors, whether they are storytellers, designers or engineers, and work together to extend the "state of the art" through cooperation and creativity.

3 AFFORDANCES FOR TEACHING USING ZOETROPE-LIKE DEVICES

There are a number of reasons that zoetropes and other such early devices are good teaching tools for animation, and these hint at strategies that would be transferable as we develop introductory teaching platforms for augmented and mixed reality, especially to encourage creativity and innovation.

A few potential strengths–

- <u>Simplicity</u> - the basic function of the device and its affordances are apparent, and it exposes the phenomenon of motion animation, through sequential imaging and persistence of vision. This simplicity emphasizes the core "magical" phenomena and makes it more approachable and understandable.
- <u>A small, confined storytelling world</u> - the cyclical, rotating motion of the device forces repeating/looping narratives with a limited number of frames. This encourages the student animator to focus on succinct/efficient storytelling (even the "storytelling" within a single animated motion) and is the perfect device to introduce basic topics like character walk cycles. It is often valuable for students to work within constraints; it frees them to concentrate on the core learning objectives, and then innovate within those restrictions.
- <u>Interacting with the history of media</u> - by actively playing with an animation device developed early in the evolution of media, it asks the student to consider the lineage of innovation connecting past technology to present technology (how novel inventions have addressed previous limitations, and suggested new avenues for narrative expression).
- <u>Exposing and aestheticizing the core technologies and innovations</u> - most early animation devices were developed in the Victorian era. It's no wonder that many of them highlight and emphasize

the “elaborate contraption” aspects of the device (whether deliberately or not), and the promise of engineering generally. Such an emphasis suggests that the mechanisms of technology, and invention itself, are an interesting and aesthetic phenomenon, worthy of exploration.

- Make it hackable and open to modification - the simplicity of the devices makes them quickly understandable, and also approachable as we extend their capabilities to accommodate our narrative imagination. The zoetrope’s history illustrates how often it was “hacked”. The core limitations of the system make students want to push its constraints and re-define the device.

4 MYTHOTROPE

In the spirit of the above discussion, the *mythotrope* is a teaching platform that introduces students to augmented reality storytelling by connecting them to media’s early history (in devices like zoetropes, and cartridge-based video game consoles), the elemental skills and modalities of digital and analog making, and the necessary need to develop technical systems to bridge analog/digital worlds to pursue unique narrative visions. It is by nature a ridiculous device, a contraption, and perhaps the least commercial device imaginable. That’s a strength, as the students cannot approach it with any obvious precedent that has been commercially viable.

The platform was initially developed as a design project for an art + design studio, where many students were approaching interactive media design, augmented reality, game development, coding, electronics, and other technical domains for the first time. Almost all of our students are excellent visual artists, illustrators, motion graphics/animators and crafters, so we wanted to leverage those comforts and skill sets, and many of their analog skills, as they began to experiment with digital making, coding and production in an environment such as a game engine like Unity or Unreal [7].

We looked for hybrid analog and digital spaces that added richness to the interplay between traditional craft and emerging technical affordances, and found inspiration within the game industry, including State of Play’s “Lumino City“[8], and animation projects like Wes Anderson’s “Isle of Dogs” [9] and “Fantastic Mr. Fox“, all of which combined a precious, handcrafted aesthetic with technical innovation. Beginning with similar set design via dioramas, the students were asked to imagine, design and engineer an interactive, augmented reality experience, it could be a game and/or narrative, with animation and interactivity.

Circularity was a theme of the project. As mentioned before, the idea of cycles inhabit much of the work we all do as designers, storytellers and engineers– from the circularity of narrative in the patterns of myth and fiction in human culture, to design itself, in the looping structures of a design thinking process, to the life cycles of the products we build, an ever more pressing concern as we face the limits of nature and sustainability. This was a text and subtext for the assignment and its artifacts.

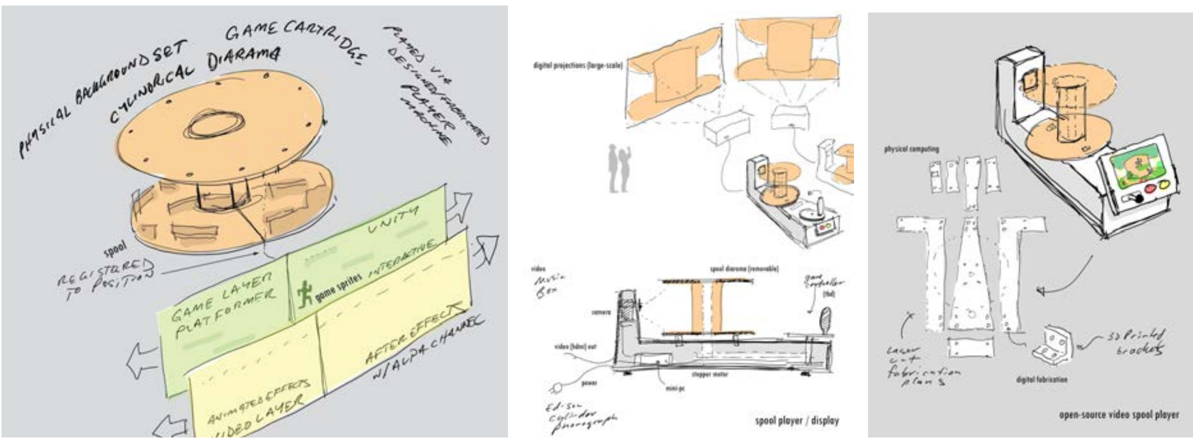

Figure 7. Early Concept Sketches Shared with Students

The assignment began with a rough description of a technical system, and with a recycled artifact, a wooden spool or reel– recovered from a networking cable installation [Fig. 7]. This was the initial world they built in, a blank theatrical stage, that could be mechanically actuated and rotated along its axis. The students could imagine the spools as game cartridges placed onto a video game console we were inventing together, people eventually playing augmented reality games, which could be displayed on screens or projected up on the walls. The students asked themselves, “What are the poetic potentials therein, and how can we invent and develop a technical system to express this potential?”

The students first focused on diorama making and storytelling. The diorama was a small physical world, a laboratory, where the merging of analog and digital worlds would occur. The instructors in the studio focused on developing the general technical system, and helped the students solve their technical challenges and develop strong narratives and gameplay.

As a class, we started to build and modify the components of the mythotrope, using digital fabrication tools like laser cutters and 3d printers. The students printed out core pieces that allowed the spools to be mounted and initially scanned. Students were asked to initially consider coordinate spaces and the concept of affordances. The spool is both a hybrid 2d and 3d space, its environment repeats as it is spun, and it can be spun indefinitely. As the spool rotates, physical objects on the platform exhibit motion parallax, reinforcing the perception of depth. They imagined the scene through the eye of a camera and completed some initial video scans of the emerging dioramas and experimented with lighting to create mood and enhance the narrative.

This work was combined with learning a bit about electronics and working with Arduino microcontrollers. Students practiced assembling and controlling simple circuits and discovered the basics of how stepper motors and gearboxes allowed smooth and precise movement of the spool, and perhaps took the first tentative steps into programming. More advanced students could integrate both visual and depth information, and learn the basics of computer vision techniques, and integrate that information into their applications.

To support the platform, the faculty developed a number of pieces of software which run on the mythotrope computer– a spool controller/scanner application (SCSA), a Unity-based “game” application, and also a small control program running on an Arduino in the cabinet. The SCSA is an intermediary in the system, it relays game controller information from the Unity app (via OSC) to the Arduino board (via serial connection), which is controlling the precise rotation via stepper motor/gearbox. The SCSA relays positional information from the Arduino (also via OSC), as well as capturing a live video feed via 4k video or depth camera (or playing a recorded spool video), and shares this with the Unity app (via shared GPU textures (Spout)).

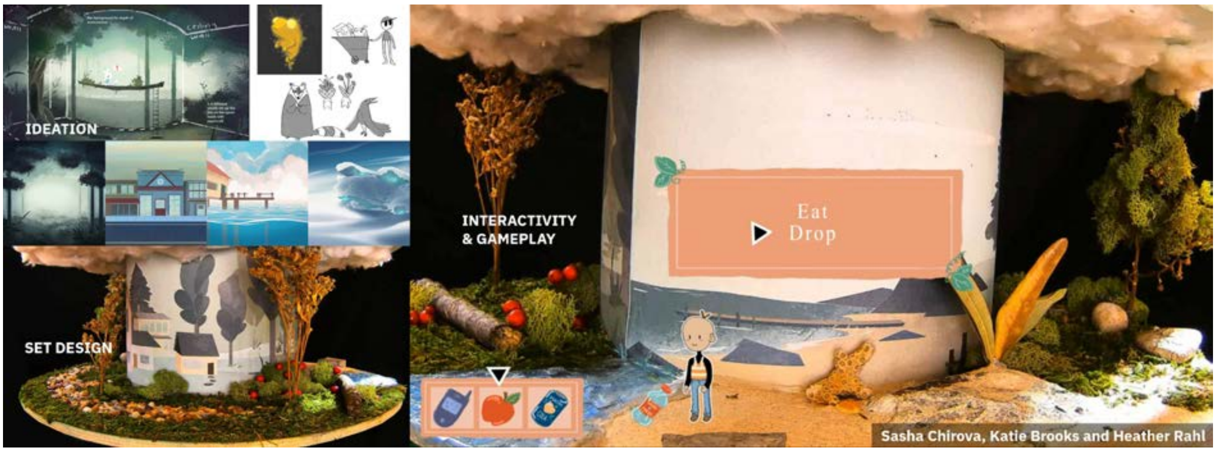

Figure 8. Student project, design and development cycle

The Unity application was provided as a template project for the students to use in developing their projects. We wanted these templates to be relatively lightweight and simple, and not try to incorporate all of the spool control code, or need to directly interface with the camera.

Through the project, students completed a design ideation/prototyping cycle, researched and developed their concepts, and crafted their dioramas [Fig. 8]. Then they engineered their augmented reality games, working with the mythotrope’s affordances, adding custom electronics in the spools (like embedded lighting), and programming in Unity. They honed their interactive prototypes, tested and improved them, before publicly showing the work at a large gala exhibition [Fig. 2]. In the process they were introduced to the basics of digital fabrication, electronics, programming, character walk-cycles, working with computer games engines, and developing basic gameplay and interactive control systems.

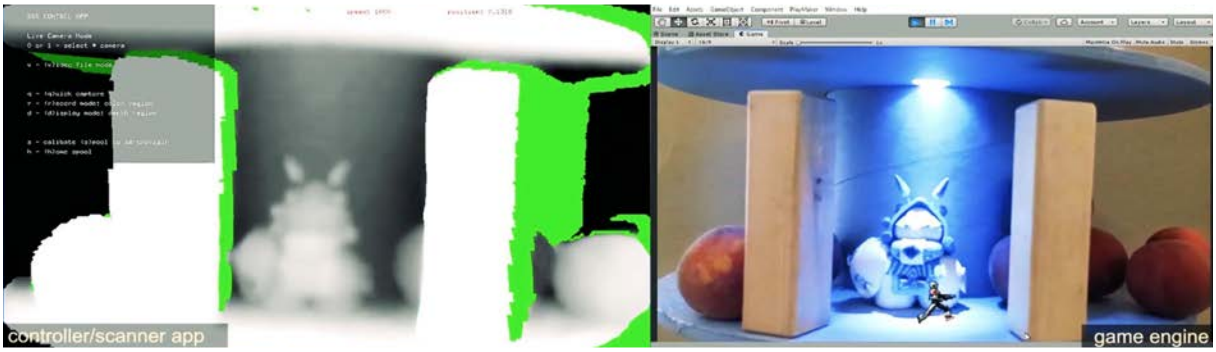

Figure 9. Depth image for masking and colliders (left), Real-time experimentation and play (right)

In our experience this project was a success as a teaching exercise; it warrants further development as a robust open-source project to be shared with the community. In the future, we plan to more fully integrate an Azure Kinect depth camera (the same camera used in the Microsoft Hololens 2 headset) to generate real-time colliders for game-based interaction [Fig. 9]. We also would like to include further control and actuation within the spools, i.e. so that game-based digital elements can affect physical elements in the spool environment and trigger localized lighting and sound effects.

5 CONCLUSIONS

In this highly virtualized era, it is tempting for educators to shift the focus exclusively to digital tools; however, this limits the designs that students produce to choices offered by software, and the results become alike and repetitive, and are often not truly creative or inventive. This is especially problematic in areas of emerging technology, like augmented and mixed reality. We wanted to create an assignment that functions by combining two made-up worlds: one that is physically produced and another that is digitally animated and controlled and asking the students to freely invent technical systems to bridge them.

This project is an inspiration for further exploration of physical, mechanical, electronic, and virtual coexistence in storytelling and play. The opportunities in the future are exciting, as AR glasses make a breakthrough and depth cameras become more mainstream. The “magic” that will allow a meaningful interaction between the two worlds, bi-directionally, is also an extremely exciting design challenge.

As an educator, it is sometimes useful to look at the history of media, and devices like the zoetrope, to suggest ways for our students to approach this challenge.

When students try to develop a multi-faceted project like this, which crosses multiple technical and artistic domains, and try to quickly learn the skills they need to implement their vision, they get to experience the remixing, mashup, open-source making culture, which is so prominent in the way we work today, and invent to learn in the best constructionist sense. How else can young designers best learn the duct-tape and jerry-rigging skills which will allow them to see potential opportunities in disparate things, and find new ways of hacking them together to create something new, playful and whimsical, even if what they create is also absurd, and often not practical?

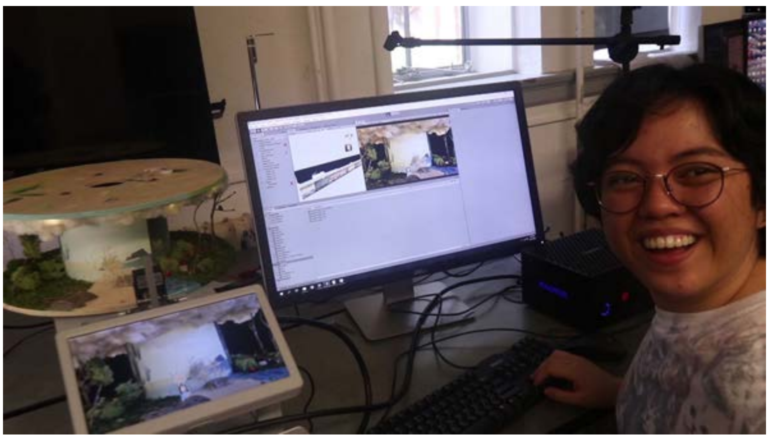

Figure 10. Student developing project on mythotrope

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