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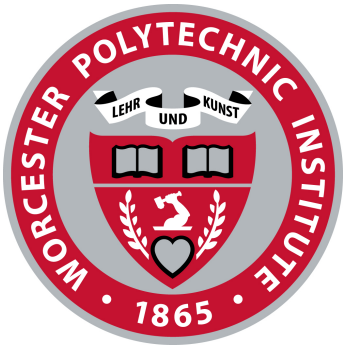


# Exploring the Crossroads:

# Augmented Reality and Tabletop Role-playing Games

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April. 27, 2023

## Abstract

Augmented Reality has significantly declined, with fewer developers designing experiences for either dedicated or compatible devices. Although the market for AR has become more affordable and open to the consumer market, interest in developing products for this market has only decreased. This paper covers our findings regarding whether consumers still found AR engaging and if we could design such an experience. Through research, we determined that a feasible and exciting way to utilize Augmented Reality was to explore the crossroads of AR and tabletop games. We developed a Dungeons and Dragons Fifth Edition game module with integrated Augmented Reality tools. We propose solutions by deciphering the strengths of tabletop gameplay and enriching them via novel applications in AR.

## 1. Introduction

### AR fading into relative obscurity

Following the release of the Oculus Rift and Pokemon GO in 2016, the gaming industry was abuzz with excitement and expectations for new virtual reality (VR) and augmented reality (AR) technologies bridging the boundaries between the real world and games. In the GDC 2016 state of the industry report, roughly 20% of developers said they were already working on a game for an AR/VR platform, while a whopping 75% of developers expressed interest in developing for AR/VR. If you skip forward 4 years to the GDC 2020 report, however, development on these platforms had largely stagnated. 20% of developers were working on VR/AR, of which, only 1/4th were focused on AR. Through the following years, AR's share of that percent only dwindled further, down to an all-time low of 2% of developers developing for

that technology in 2022, a statistic which resulted in GDC lumping all AR hardware platforms together in 2023, a change which only boosted AR's statistics by 2%.

In 2023, it seems evident that developers believe VR to be the superior platform. However, even almost 7 years later, Pokemon GO, an AR game, continues to be played and remains in contention for the slot of the single highest grossing mobile game of all time. This can be attributed to numerous factors, such as the loyalty of the fanbase or a fortunate synergy between AR and the style of game. Nevertheless, we found this to be demonstrative of the potential of the technology and grounds for exploring AR technology further.

## Intention to Explore the Crossroads Between AR and Tabletop Games

As we researched ways AR might find a way back into the mainstream, we began to notice a pattern in which AR games were the most successful. The top mobile AR games, such as Pokemon GO, Harry Potter: Wizards Unite, and Jurassic World Alive, are all established brands which use AR to enhance mechanics which would already be functional in a standalone game. We determined that emulating that pattern as best we could is most conducive to producing a successful product, but realized that doing so would come with two significant hurdles. The first issue was that we needed to find an established brand which would allow free use of their materials without copyright infringement. Then, we'd need to conceive of an interactive experience and game mechanics that could make use of AR without stepping out of the potential scope of our team's abilities and limited time-frame.

We then researched different games' policies on material usage and found that the solution to both of these problems was to develop a playable Dungeons and Dragons (D&D) module with AR elements. Wizards of The Coast, the owner of Dungeons and Dragons brand,

offers an “open gaming license” which allows players to produce materials using their rules and name, so long as certain conditions are not violated. Furthermore, a playable tabletop module would not require too much technical acumen, limiting potential future hurdles and allowing our members to divide their skills evenly between design and technical implementation. The D&D framework was also uniquely well-suited to AR integration, as many campaigns make use of maps and diagrams which could be enhanced, both aesthetically and functionally, by AR.

## 2. Background

### Defining key terms: GM and GM-less Modules

The Game Master (GM) is a position unique to the TTRPG genre. In D&D, the primary role of the GM is determining how the world responds to the actions of the players. If, for example, a player wishes to ask a non-player character for information, the GM is responsible for roleplaying responses from said character. They are also responsible for simulating combat decisions made by enemies, calling for players to roll dice in certain events, and, if the group is following a pre-written module, accounting for any and all actions or events which take place outside the written and accounted for content.

In D&D, players embark on an adventure that is expected to take several sessions of gameplay, which we call a “campaign.” Typically, before a campaign, the GM conceives of an adventure hook, world, and characters, which the players are going to experience themselves. To do this well requires a significant amount of time and planning, on top of the in-game demands such as remembering rules or adjudicating the results of player actions. To aid GMs, writers create “modules” which are pre-written documents that provide a world and adventure for the players to experience. These modules eliminate much of the demand placed on GMs and are a

staple choice for new GMs to get acquainted with the role without taking on all the responsibilities. Typical content found in a module includes a story, pre-written character dialogue and responses to player questions, dice rolls, balanced combat encounters, and visual aids such as maps and tables.

A GMless module is a module designed to be played without a game master. This can be achieved in numerous ways, such as limiting the players to set options or conversely leaving the rules extremely open-ended and allowing each player to fulfill aspects of the role of GM. The defining factor is that these modules implement new mechanics to allow for us to not only ease players into the basics of D&D, but connect the design of the module to the AR app.

## What is Augmented Reality

So what exactly defines Augmented Reality? AR is a technology that overlays digital elements of computers with the natural world while giving some level of interaction with data from the physical world. The history of Augmented Reality branches off to several paths of interactive mediums. Due to the similarities between AR and other technologies, such as Virtual or Mixed Reality, it is necessary for us to understand the differences between these technologies. Virtual Reality and Augmented Reality differ heavily, with VR replacing the user's environment with a digital one while AR adds digital elements to the environment. Many have also noted the similarities between AR and heads-up displays (HUD). HUDs precede AR and involve projecting computer data into the physical world. However, unlike AR, the significant difference between the two is that HUDs do not use data from the real world to interact with digital elements.

The history of AR spans across decades of iterative development. Dr. Ivan Sutherland made the first application defining modern conventions of Augmented Reality at the University of Utah (Sutherland p.757). The project was called The Sword of Damocles, and it used a Head-Mounted-Display (HMD) connected to a computer. The headset was rather primitive, having a bulky design with a large wire coming out of the back. It used small cathode ray tubes (CRT) and mirrors to draw transparent wireframe images on display (p.758). What made Sutherland's device unique was how it used the data of the user's position to draw the images, utilizing accurate data to draw the image from the perspective they would see. This was done originally to substitute a theory of measuring the user's eye rotation, though it is now how most AR devices display the digital objects. Sutherland explains that determining the rotation of an eye is not an easy task, so he was fortunate that the lenses keep the image consistent if the user stops focusing their eyes on said object (p.757). Taking the technology's position and creating the relative angle for the digital object is now a common standard for developing AR applications.

AR HMDs have come a long way, and unlike Sutherlands design, the technology progressively became more comfortable and advanced. HMDs are still used, as they are now available to consumers, though they have yet to become a widely used platform. Standalone headsets like the Hololens 2 or Apple's upcoming AR glasses are significantly more expensive than modern VR devices (REID). These devices are also designed to be more mobile than Sutherlands design, with either the HMDs having few wires coming off of the device itself, or none at all. Some HMDs that are specialized for VR have AR capabilities as well.

AR isn’t restricted to HMD’s, as several platforms for VR have been developed. Modern smartphones use multiple camera lenses to take pictures with wide-angle lenses. The two cameras work in a similar manner to the HMD optics, using the cameras to track specific points

in the physical world. Although the quality of phone AR is not as good as specialized AR hardware, they are the largest platform for AR experiences.

The cameras on consumer smartphones have allowed various apps and games to use AR for a more open and larger audience. The mobile market has various examples of famous use cases for AR. For example, Apple includes an iPhone measurement app that utilizes AR to measure physical space between two points (Apple Inc.). Another App that allows users to experiment with physical space through AR is IKEA Place (AYOUBI). The user looks at an IKEA catalog and chooses the furniture they want. The chosen object is then cast in AR, allowing them to determine if the furniture will fit in the space before they buy it. The most successful mobile AR game recently has been Pokemon GO (Wingfield and Isaac). Pokemon GO allowed users to catch Pokemon through their camera lens, simulating the idea of being a Pokemon Trainer and venturing into the world to catch Pokemon.

AR has strongly impacted interactive mediums, and video games are no exception. One of the most popular forms of AR for home consoles was Microsoft's Kinect. The original Kinect for the Xbox 360 applied AR by pointing the technology at the user (Wang p.21). The user would typically need an open space in their living room, approximately 5ft for one player and 7ft for two players. The device had two cameras and an infrared project to detect the room's depth. The information processed by the cameras allows the software to determine how to draw objects, and it even plays into the interaction of the objects. In addition, the Kinect could track the player's body, and the Xbox One version could even detect the player's fingers. Microsoft wanted to compete with other motion-based devices designed specifically for video games, so they made this the primary way to interact with AR objects.

Being one of Microsoft's biggest competitors in interactive technology, Sony also experimented with AR experiences with the Playstation Camera (Macmanus). Sony wanted to give the PS4 some level of motion-based play. Sony has experimented with AR on their previous consoles, but the PS4 Camera followed in Kinect's footsteps. Although it was less advanced than the Xbox One's Kinect, it could do similar tasks using only two cameras. The PS4 even shipped with an experience known as the Playroom, where players could select from various experiences. Unfortunately, the Camera's development shifted focus during the PS4's shelf life, as it was later used to track the PSVR Headset.

The 3DS is one of the more significant examples of AR being used on a handheld console. The 3DS comes with six plastic "AR Cards" that were used with the console's AR app (Nintendo). These cards each had a unique image, with one displaying a generic icon for AR while the others featured various characters from popular Nintendo IPs. Similar to other mobile devices, the 3DS has two cameras on its exterior so that when the user is playing, they have the two cameras facing away from them. This allows them to point the cameras at the card to use the AR features. The two cameras track the AR cards, and various minigames and tech demos are featured to play. The player can interact by moving the Camera around and a button to act depending on the scene (shooting, fishing, capturing photos, etc.) The AR also transforms a drawn mesh, making it appear as if the plane the card is on is rising or lowering.

## 3D Tabletop

We researched several methods players have tried applying the gameplay of Tabletop Games in a 3D environment. We found a couple of different approaches others have taken towards translating the elements of a 2D Grid to work with 3D objects. A common approach

would be to use modular tiles that fit within the grid and create a better representation of the world. Unfortunately, few of these tiles allow for additional layering of the world, especially on the same grid space. Another format for playing tabletop games outside of a grid is via a sculpted terrain. Terrains are commonly found in classic wargames, tabletop games aimed to offer a simulated version of a battle. Terrains are also designed for D&D as the game itself was based on classic wargames like *Chainmail* (D'Anastasio). Terrains do not follow the traditional grid. Instead, players must measure the distance with a ruler to determine whether they are in range. Although it might sound inconvenient, players who can use terrains are willing to play the game this way for presentation. Terrains look more realistic, not flat surfaces but bumpy hills that make the board look like a grassy plain.

Although these methods are good at representing a map's environment, players also have the option to play 3D tabletop maps digitally. The digital approach comes with many benefits when compared to a physical approach. For one, the digital environment is not limited to finite physical approaches. Players can be as creative as they want, allowing for detailed and dynamic maps that would take more effort if created in real life. Digital approaches also offer a wide set of tools to immerse players. Users can prompt sound effects, music, and particle effects to make the scene more dynamic.

*Tabletop Simulator* is a popular pc application meant to simulate physical tabletop play. It can play a variety of different games, and a majority of people do use it to host RPG sessions in a 3D environment (Berserk Games). Players also have different interface options, using their mouse and keyboard or a VR setup. The software even uses the steam workshop, a repository for specific games for players to download and publish custom files.

Many maps we researched in the Steam Workshop used the 3D capabilities of Tabletop Simulator. We studied the maps from various Tabletop RPGs (D&D, Pathfinder, Star Wars FFG, etc.). We noticed that some maps still used a 2D grid while some strayed further away from the traditional structure. Each map also had prominent objects that stood tall, contrasting the others. Some maps had dynamic capabilities, allowing players to turn on and off select layers to provide a more accessible means to view the map.

However, Tabletop Simulator is not meant for playing a specific module; it provides an environment where players can simulate any tabletop game. It also did not serve the purpose of teaching players how to play the games provided. Since we weren't looking to design an app that served the same modularity as Tabletop Simulator, we opted to look at how others designed environments in the game.

## Experience Goals

The use of AR was meant to engage players more in the settings of the combat encounters. The idea was that players would see the battlemap in great detail, which would get them to think about how to take advantage of the environment. We also wished for players to be able to experience highly detailed maps in three dimensions with their phone or tablet, which takes up less space than a physical 3D map would. Later in the project, we became interested in using Augmented Reality to improve the quality of the experience for players and reduce the need for repetitive or boring calculations.

For our level design, we wanted maps that allowed the AR elements to feel engaging. We felt that this would work towards our goal of creating an memorable AR experience. This would mean emphasizing the capabilities of AR and 3D level design. We wanted to create environments

that not only were optimized for the project we were making, but took principles from other mediums. We wanted to emphasize the principles of both level design and architecture.

In terms of narrative, we envisioned an adventure that would strike a balance between the fantastical and the mundane. It was important that our module, and by extension the narrative, was going to be accessible to players of all experience levels. With consideration for players both familiar and unfamiliar with high fantasy, we elected to ease players into the fantasy elements, gradually introducing more over time. We also wanted it to be entertaining, believable, and adaptable. Believable in the sense that every event had a logical cause and effect, and characters had motivations in line with their personality. And adaptable in that the story was malleable enough to account for players performing actions and/or roleplaying outside the boundaries set by the module.

## 3. Design

### Project Scope

We determined the project's scope by determining the tasks we knew we could complete each term and anticipating the type of work we had to do in the following term. We wanted the project to follow a standard workflow in the AAA industry, so we opted to follow this project in the SCRUM Methodology (SCRUM). SCRUM focuses on the process of incremental work, where each week, a sprint happens. In a sprint, team members are anticipated to finish a goal between that sprint and the next. When the following sprint comes, the work is reviewed, and the team has to plan the following sprint. We did this by comparing our weekly sprint progress to the project's timeline, deciphering how much time we had to finish our upcoming tasks and which features would be included or scrapped.

Because our project was initially a group of 3 with diverse roles, we knew how we wanted to split up the work we needed and when we would need to merge our changes. In addition, each of our disciplines had a different process and methodology for development. However, we each anticipated getting our work made each sprint.

Our mapping process was similar to how AAA handles designing a level for Gameplay and, later, Aesthetic purposes. At first, we began designing these maps for the player experience before we considered making something aesthetically pleasing. Typically, the designer designs a level, and the environment artist reiterates their work. It is common to mistake the roles of a level designer from an environment artist as they are two different practices in the field of game development (Bycer). Level Designers are responsible for the gameplay experience of a level by designing the layout and scripted elements. Environment Artists are heavily focused on providing art for a scene. Their responsibilities are separate from the interactive elements but rather the visual elements of the level. There can be an overlap between these skill sets, but they are separate disciplines in the industry. Our workflow was similar, as after the Rooftop Battlemap had a well-rounded design, we passed it on to our lead Artist, Conor Dolan, who polished a significant amount of the work in the map. This approach did not mean our members did not take on other tasks outside their roles. Due to the size of our team, initially only three people, we had to divide tasks among each other.

In the early stages of the project, the goal from a programming perspective was to produce a minimum viable product. In SCRUM Methodology, a minimum viable product (or MVP) is the smallest product version that can be tested so the creators can receive feedback. For this app, the minimum viable product was viewing a Dungeons and Dragons map in Augmented

Reality. From feedback, we gathered that the AR aspect of the project needed to be more interactive and more integrated with the narrative, which led to expanding the project's scope.

## AR Design

### *Concept Iteration*

The form in which this project would use Augmented Reality technology was iterated on over the course of the project's first term. In the original pitch for this project, the intention was that players would be viewing the maps at life-size, as if they were really there. While it was certainly more immersive, this idea was dropped due to its logistical complexity and its being better suited to VR than AR. The next iteration of AR functionality was for players to place the map on any surface with a touch. We scrapped this idea as well; our project intended to explore the intersection between the physical tabletop and digital AR elements, but that idea leaned far too heavily on the digital realm. The third usage idea, and the one we settled on, was to use image tracking to place the 3D map on a 2D representation of itself, allowing for any players not looking at the app to still engage with the game.

### *Interactive Tools*

In the second term of this project, we decided to implement tools to improve player experience. To determine the most beneficial tools, we looked at the adventure we created. We considered our own experiences with tabletop role-playing games. We realized that we had yet to play with maps that incorporated verticality. Nevertheless, we were creating technology and an adventure that did so.

In our own experiences, we wished to keep track of specific locations on the map. Additionally, we were developing for Dungeons and Dragons, which originated as a tactical wargame and still contained mechanics that reward good positioning. The Beacon Tool assists players with both keeping track of essential locations and communicating strategy to each other. A beacon can be placed on the map that will persist until another one is placed elsewhere. Thus, players can leave a beacon somewhere they intend to visit later and focus on the current point of the narrative.

A narrative that involves battling on rooftops introduces the risk that characters will fall from the rooftops. However, fall damage in D&D is based on the distance a character falls. Therefore, it is only possible to determine how much damage a character will take from falling if expanding the grid vertically or listing the height of each building. The Fall-Distance Tool was created to assist in this. The tool takes in two points on the level that the player touches and determines the vertical distance between the first point and the second. It converts this distance in Unity's units to a number in feet, which is put through D&D's system for determining fall damage. Finally, it displays the amount of dice the player must roll.

D&D is typically balanced for a party of 4-6 players, but our module was designed to be playable as a solo adventure. Destiny Points were introduced to compensate for the game's difficulty, allowing players to escape from difficult situations. This module assigns 5 Destiny Points to the players at the beginning of the adventure. The third interactive tool visually represents how many remain in the form of stars. Players can mark off Destiny Points within the app, resulting in stars disappearing.

The final tool to be developed was an audio player. This tool controls an audio source game object required for Unity to output sound. The idea for this tool came from the team's

programmer, Alex, who had previous experience implementing audio in Unity. The audio tool allows the user to switch between a town track and a battle track and play and pause the current music track.

## Audio Design

The audio had to fit within the context of our module, whether we were talking specifically about the plot or emotional elements. Our initial playtesting would focus on Chapter 1 of the module. This part of the module took place in a section of the Old Town, a filthy slum where a variety of scenes can happen in the module. The mood and theme of Old Town are meant to be run-down, drab, and impoverished. We needed to relay this context through various components of the piece.

For the Muhd Theme, we must emphasize the qualities one would expect from the characters of "The Muhd." The track would be played during roleplay when tensions are not high. We wanted a piece that was enjoyable but also stuck to the misery of Old Town. We also wanted the layering of the track to hint at not just Old Town's history but where it fits into the "Coin." The setting is more than just a slum; it is a large sprawling environment where the lower class is abused. We knew that both of our compositions had to relay this context.

We also wanted the instrumentation to fit the setting of D&D. The game takes place in a fantastical setting that borrows inspiration from the middle ages. However, this context did not necessarily mean that modern instruments, like synthesizers or digital pianos, could not be used as they could offer a fantastical tone to our arrangement. Instead, we had to use them sparingly, emphasizing particular instruments over others. The Muhd uses different instruments to achieve this texture: bassoon, oboe, contrabass, tuba, violin, and a grand piano (two staves).

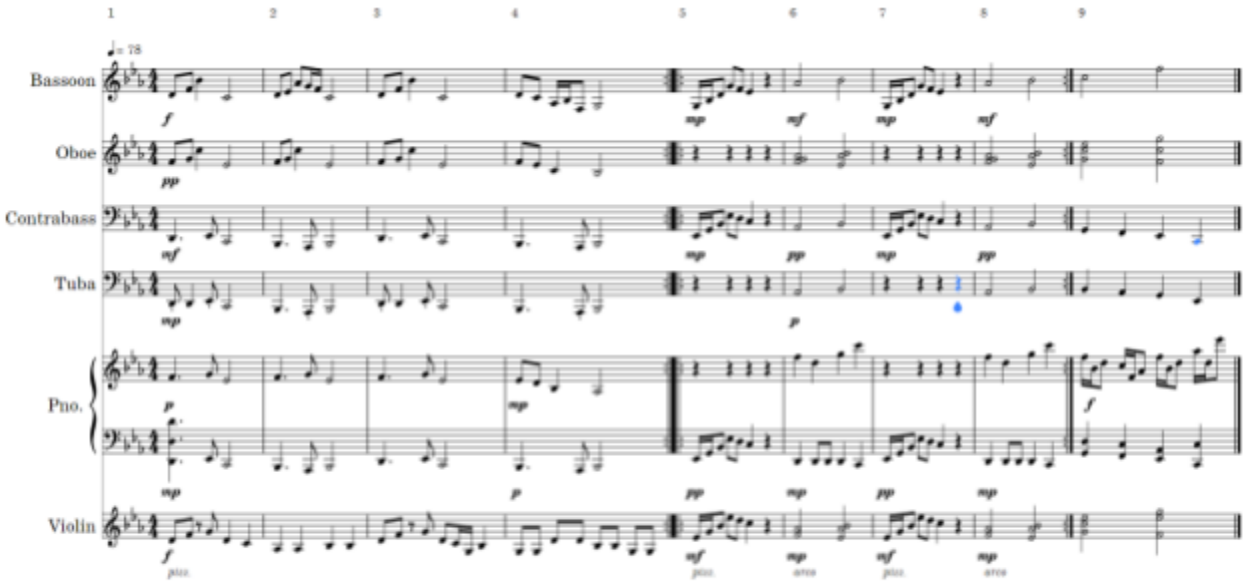



Fig. 1
Midi Composition of The Muhd

Figure 1 displays the final composition of the Muhd Theme. To keep the music fitting the dreary mood of Old Town, we chose a slower tempo. We went with 78 Beats-Per-Minute (BPM) to achieve this. Although only the violin plays on each downbeat, all the instruments have a place in keeping a consistent form to the beat. Each instrument follows a parallel harmony, emphasizing the rhythm that gives the song the necessary mournful flow. The song's key is C Minor, but the song only resolves to the C Chord at the end. Since the key's tonic is a solid note to resolve, we keep the music moving around the supertonic to give it the unease that lingers in Old Town.

We dropped the instruments with a warm timbre during the bridge to create tension. The tension is emphasized with suspense, as we have a moment of rest for measures 5 and 7. The song then uses dissonant chords to further this until the bridge resolves. We then bring all the instruments back during the break to create a significant return to the beginning. The sudden contrast of the large soundscape in a small and desperate piece gives a bittersweet tonality,

making it fit within the context of Old Town. The bold instrument in the piece is the violin. The articulation for the instrument is initially pizzicato, giving the song the plucky element that provides us with a fantastic middle-age feeling. This methodology also provided a percussive layer to the music, as the track lacked that timbre. It then switches to the bow during the large chords of the bridge, helping us emphasize the emotion we wanted out of that section.

The second track we began writing was the Rooftop Scuffle. This composition is meant to be played when Players enter a combat situation. This track needed to emphasize the dread of fighting in Old Town, and we took several measures to match that energy. For one, the track is written in 131 BPM to provide an urgent tempo. The track also uses some of the Muhd's prior instruments, including the Violin, Contrabass, and Piano. We omitted the Oboe and Tuba for Marching Bass Drums and a String Ensemble in this track.

One thing that makes the Rooftop Scuffle stand out from the Muhd Theme is the percussion. For this texture, we used bass drums to make it fit the battle theme as if the player's heart began beating more frequently. The bass drums are Marching Bass Drums, and drumline performances inspired the rhythms. However, some elements of typical bass drum cadences had to be excluded, like the clicking of the rims, as it gave the composition a brighter and more optimistic texture. However, the rims did not fit our mood and theme, so we scrapped these elements. In light of this, we brought back the pizzicato violin as the pitch and tone of the instrument were more manageable for us to manipulate.

## Level Design

### *Conceptual Work*

For our design research, we looked at various sources of diverse media. We knew the project would strongly emphasize level design, and we aimed to design a believable setting and playspace for our game. Therefore, we chose to research some principles of architecture that would help us create more engaging maps for the user. Our level design took inspiration from two books focused on architecture: The Image of the City and 101 Things I Learned in Architecture School.

The Image of the City is a book that discusses how individuals navigate and create mental maps of their city. Lynch was displeased with how American Cities were designed, discovering a lack of thoughtful planning regarding the city's design. He coins the word Imageability, "that quality in a physical object which gives it a high probability of evoking a strong image in any given observer" (Lynch 9). Although we are not designing an actual city, this

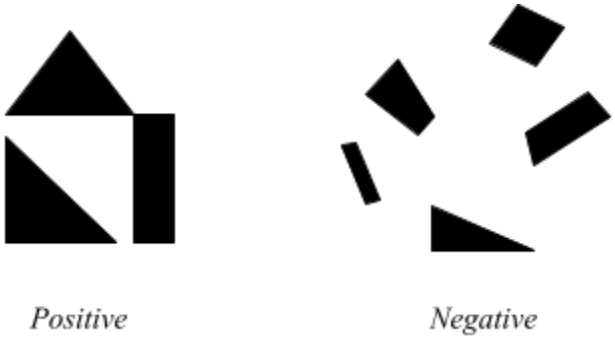



Fig. 2
Positive vs. Negative Spaces

idea of Imageability was significant to our conceptual designs. We wanted to experiment with the principles Lynch establishes through our maps. We wanted the maps we designed for the app to emphasize Imageability heavily. It would leave a stronger impression on players and ensure a

higher probability of the player remembering the layout. He breaks down and categorizes different city elements (Paths, Edges, Nodes, Landmarks, and Districts) to assert the importance of how one visualizes a city in their mind. We brought these elements in our final designs, excluding districts, as they did not apply to the size of our maps.

We also wanted to use Positive vs. Negative Spaces (Frederick 14-15). In a positive space, figures are arranged to have the ground create a defined shape to navigate through. A negative space contrasts this by being a navigable space with no definition, meaning the ground does not have a shape defined by the placement of the buildings. These two spaces are distinguished by how we experience them. Positive spaces are environments where figures shape the explorable space. "People almost always prefer positive spaces for lingering and social interaction. Negative spaces promote movement rather than dwelling in place" (Frederick 22). We applied the positive vs. negative space theory in our conceptual and final designs, depending on our design environment. Cities had a heavier emphasis on positive spaces. In contrast, negative spaces were mainly utilized for areas we wanted players to have a complete view.

In all games requiring digital or physical levels, the design elements should be parallel to the gameplay experience. We knew how vital our approach would be, so we had to establish what elements would be integral to our level design, specifically what makes a strong 3D Tabletop Map. We determined our design by approaching the problem to not just its artistic principles but the player experience.

2D Tabletop Maps are typically designed with an overhead view. This perspective provides a comprehensive view of the setting while allowing players to understand what options are available to them. This is because most objects are contrasted and isolated via a 2D grid layout. The layout emphasizes essential areas to the player and what structures would typically

hold higher significance in the gameplay. However, our app would be in AR, which would be the primary way players interacted with the world. We needed to determine which aspects of our 3D design would be important and be applicable to the standard rules of D&D. Ultimately, we decided that the process of designing these maps needed to emphasize the following qualities: 3D Visual Representation, Exploration, and Grid-based Battles.

In the AR app, the map is visually presented as a projected object by tracking an image or a point seen via two cameras. Not only could players hold their phones above the map, they could be provided a more comprehensive set of perspectives to view the map. For example, instead of looking above a dungeon corridor or a tight alley in a city, players can study various aspects of that area by positioning their phones. We also wanted an aesthetic that fits the theme and mood of our story and worked within the limitations of what phones could draw.

Exploration is an element of tabletop gameplay that is more conceptual and elusive to players. GMs choose how much of the world is open to the players, but it is ultimately up to players to decipher what is visually interesting to explore in the game space. Exploration in Tabletop games is only sometimes about providing a clear path; players are often encouraged to make creative decisions to solve a problem in games hosted by a GM. However, our module would be a single-player experience, meaning our maps had to be provided with clear and more concrete options to play the game.

The 3D representation provided in AR could be used as an interactive aspect of said exploration. We hypothesized interactive elements of the game world that could play into exploration by designing nontraditional methods of gameplay. What if players needed to find hidden objects or orient their phones in a specific perspective to solve puzzles on the map? We

originally opted not to include these elements as our App was initially a module that a GM would use, but our design later focused on GMless content.

We also wanted the maps to serve the purposes of battle. In most Tabletop Games, the elements of the environment can be huge factors when simulating a battle scene. In D&D, some spells and abilities for classes rely on what is around the player, meaning some can only be cast if the environment allows it. We provided a variety of different elements in each of our maps to accommodate for this. We also need players to measure the distance to see if an ability is viable. Some attacks also have a limited range, making it necessary for players to be able to decipher how far their target is from themselves. In D&D, 2D Grids are standard for representing the space a player can move. The rules state that a tile represents 5 feet in the game's world, so we also decided to have the map follow a grid. We opted to do this instead of making players measure the distance via a ruler to make the gameplay more accessible and parallel to the rules. The layout also allowed us to keep the maps optimized and determine how much space we needed for each scenario.

All three of these elements (visual representation, exploration, and battle layout) are impacted by the structure of the level. We wanted to experiment with layouts outside traditional conventions in Tabletop Gameplay. We separated what makes the 3D stand out from 2D design in regards to our experience goals and we related our goals to the structural design of our maps. Based on our research, we wanted an emphasis on verticality, layering, and depth that would provide Players with a novel experience in playing D&D. Not only would we be using the visual benefits of 3D design, but these elements would also impact the players' exploration and creative decisions.

At the beginning of A Term, we were concerned with how levels would be used in AR. Although we had researched and developed a philosophy of approaching the maps, we needed to experiment with what we had learned. AR isn't a conventional means of playing tabletop games, so we began working with concepts that fit the themes and ideas we wanted to emphasize for our project. Doing this allowed us to determine what aspects would benefit us when translating the elements of 3D Tabletop to AR. The work we started was built on emphasizing as much of the information we could gauge from our research. Although some of the work was not brought into our interactive app, these concepts guided the rest of our design and gave us a better understanding of our project's aim.


Fig. 3
Conceptual Layout for Town Design

One of our original approaches was breaking down standard designs in Tabletop Maps. Instead, we opted to conceptualize town settings emphasizing dense positive space, outdoor environments emphasizing negative open spaces, and an interior for a building that would again emphasize positive spaces. We chose these three examples for how common they were and how their structures depended on the functionality of the in-game setting. In addition, each environment comes with different expectations. For example, an indoor environment has a different context, emphasizing intentional design more than the outdoor one.

The first conceptual level, the town, had the most considerable emphasis on functional design. A town is typically anticipated to fit conditions suited for the needs of a closed

community, so this led us to our first design question: "What should be expected in this town, and how do we determine the placement of said objects?" To solve this, we compiled the typical qualities of each researched town map into a list. We then separated these assets into their categories and began determining what we wanted to accomplish for the town.

We then began designing the map layout based on the 3D elements. First, we aimed for a condensed environment based on one positive space. Then we determined how to build the verticality, starting from said positive space to the town's boundaries. This method was also how we determined the depth, from the ground level of each space to the positive space. Finally, we established which spaces would use the aspects listed for the town. We went through a similar process for both the Outdoor and Interior designs, except our approach was adjusted to fit the functions of those environments.

The final design of the Town Map, shown in Figure 3, had a unique and tight layout for a community. We start with the Main Square Centerpiece, where the main positive space is drawn at the lowest depth. This area is where the entrance of the town is also located, so most of the buildings are there to function for travelers making quick stops in town. The town is also surrounded by a brick wall for security. The path then splits into two, leading to a market that provides services. The other path leads to where most of the houses are situated, and both this area and the main square have only two entrances to the town. Finally, the market has a path up to a higher elevated section of the town with a Temple, Graveyard, and School to isolate and contrast their significance from the rest of the map.

We were ultimately pleased with the concept, though, looking back, there are a couple of changes we would redesign. First, swapping the NPC houses with the market would make more sense and keep the town's residents more protected. Also, lowering the height of the Temple's

location would give the map a more natural and less artificial look. Finally, altering the depth of the platform the Temple is sitting on to a more gradual climb would make the design seem less juxtaposed with the rest of the town. These iterations would benefit our design to fit the functionality of its setting. However, we would also have to consider the technical implementations for these maps.

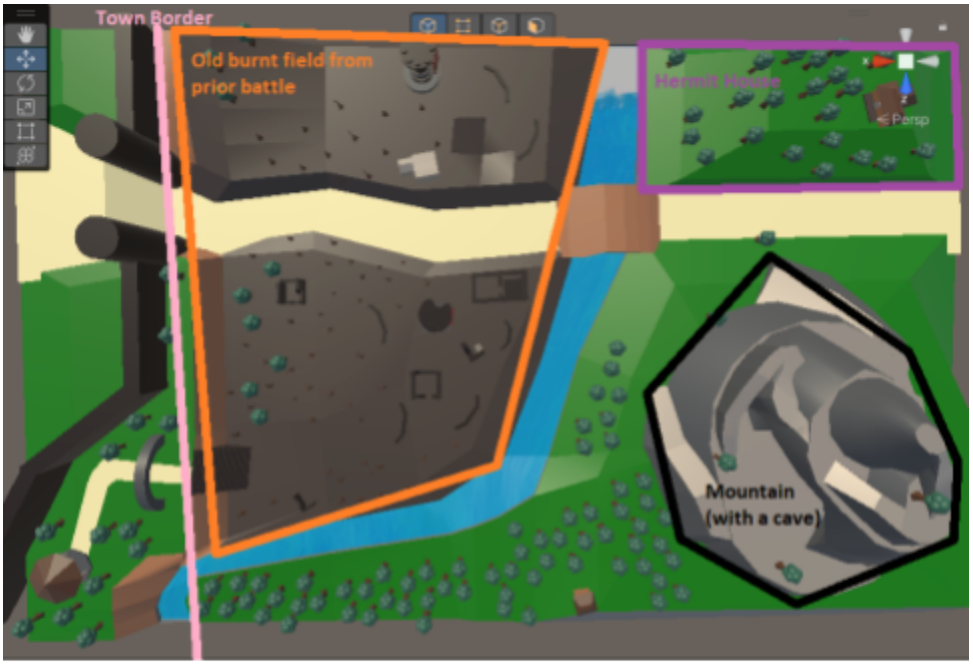



Fig. 4
Conceptual Layout for Outdoor Design

Our approach to the Outdoor map was similar. We were able to assess that this kind of map would need to offer opportunities through negative space. We also wanted the map's elements to determine not only the space players could inhabit but what was contrasted from the negative space. Most of our isolated objects would have to be manufactured structures that would imply a history to the setting or natural objects that do not have an intentional design. We decided to set this area to be the outskirts of the town, as the actual module is only set in that environment and it would allow more liberty for our design.

The Outdoor Concepts final design led to a more open yet articulate means to approach the layout. Figure 4 shows that the map is divided into two halves, with a minor area representing where the town's border resides. Near this border is a lone gazebo raised at the height of the town's ground. Below this is one of the significant halves of the map, an old battlefield where the grass no longer remains. A few trees reside here to represent how nature is starting to take back what was once taken. In addition, a few artificial structures reside in this field, displaying a decline in stability and neglected maintenance one would expect. The map is then split by a river, where the other half of the map remains. The most prominent and isolated feature seen is a mountain on the far end of the map. This mountain offers a variety of layers, and the top of it is the highest point on the map. The mountain also features a cave with a campsite hidden within. On the other side of the cave is a small building called the "Hermit House." This house is also one of the few objects to be isolated from the rest of the map, though it remains shrouded and hidden by the forest.

Overall, this map was a significant step above our work on the town map though we still have to consider what we would reiterate. We learned how providing more detail, like nature growing into the battlefield, would benefit the map's silent narrative. Reiterating that concept would make the silent narrative more significant than initially designed. We would also like to adjust various elements of the terrain to make everything blend in with each other. However, that would mean our topology should also be adjusted, as some of the faces on the mesh would benefit from an extra edge to minimize any distortion.

The final conceptual map was the Interior layout, and this design was primarily based on the function of the space. We wanted our design to display the features and traits of an interior for one of the many buildings in the first town concept. These map elements are meant to

characterize the world and everything needed for that building. We chose the political building as the design could be one of the more involved interiors to capture the aspects of our experience goals.

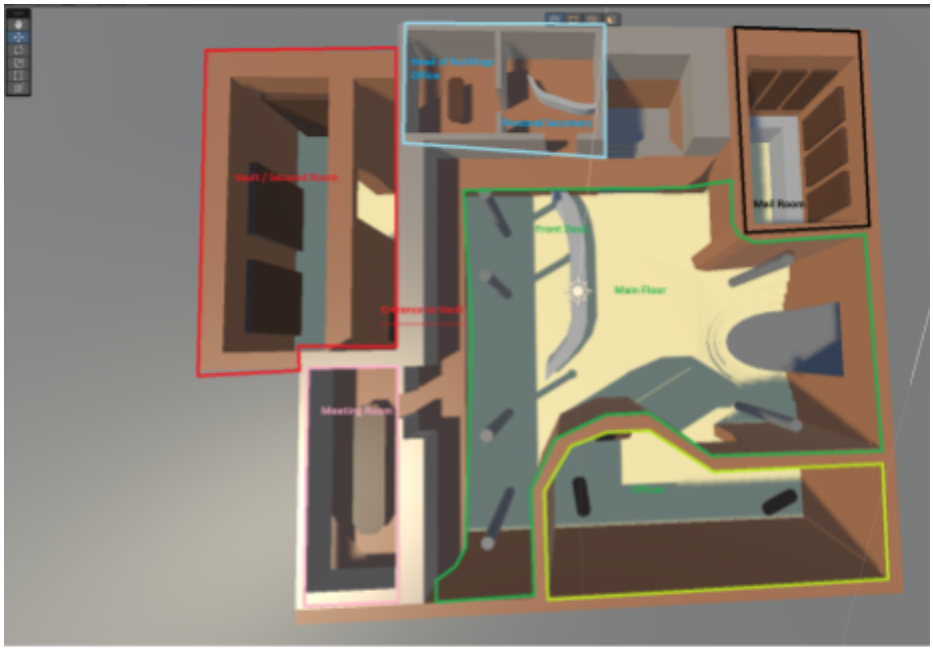



Fig. 5
Conceptual Layout for Interior Design

The final design focuses again on the most positive space being shaped via the entrance. Both sides have a room, one for mail and the other for simple offices. In Figure 5, the main floor has a front desk that obfuscates a hidden room that contains several vaults. The second floor holds a meeting room and the highest political figures' office. This room is technically split into two, putting a personal secretary between the office and entrance as a filter.

Although the design has qualities we were aiming to achieve for the concept, there are several things we would do differently in retrospect. The positive space could be better defined as the layout does not seem to be a practical means for its functionality, especially when accounting for the office space on the left side of the entrance. The placement of the head office

could also be adjusted on the second level to make it appear as if the head of the building would have a better view of the premises. However, these observations are insightful, reminding us what elements work towards our experience goals.

### *Rooftop Battle Map*

The Rooftop Battle Map was the first map designed for our minimum viable product. Before we focused on the map's structure, Warren practiced drawing out the shapes of the rooftops by taking inspiration from both layouts found in D&D maps and architecture in the Worcester Area. As seen in Figure 6, Drawing these shapes out allowed us to determine the types of positive spaces we could build and how we could fit these shapes within a condensed area. After practicing, we put these shapes into a layout, arranging them to fit our scene's flow. The map layout was designed first in a 2D Grid and took many of the values we needed from the concept stage.

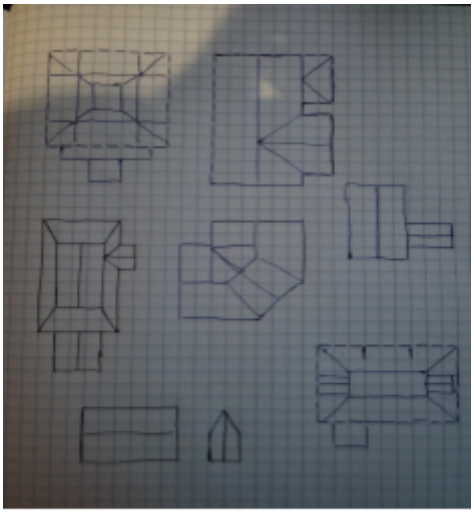


Fig. 6
Rooftop Shapes and Geometry

The Rooftop Battlemap took much from our Conceptual Town map by emphasizing positive spaces. The main positive space resides in the center of the town, where a fountain is isolated from anchoring the player's perspective but the tracking of the AR object. We also determined how alleyways could draw their own positive spaces and how they created unique opportunities for different layering.

The layering of our map was determined before we translated the 2D Layout to 3D. The central aspect of the map that would offer different layers was our rooftops. We adjusted the

shapes of the roofs to fit the needed gameplay, making it easier for players to traverse the roofs. Although it was difficult to determine the verticality at this stage of development, we designed the Layout with intention, considering how we would translate the 2D shapes into 3D geometry. For example, we wanted to make some of the more significant buildings have high roofs and make the smaller buildings ramp up to their roofs.

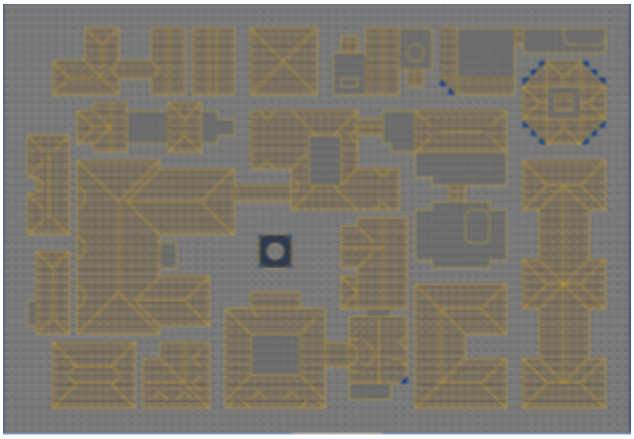


Fig. 7
Original Rooftop Battlemap Layout

Although the layout looked promising, we soon realized that the original layout needed to make a significant change when we determined how big the layouts should have been. The bounds of the building went outside the constraint size we were trying to fit our maps in. One option was to shrink the map to fit within the size of the paper, but then our physical grid would not be viable. Instead, we decided to crop the layout to the aspect ratio of the map, which allowed us to keep several elements of the layout while fitting within our limitations.

We were ready to start working on the map in the engine at this stage. We imported the image into the Engine and turned it into a material to draw the 3D layout on top of it. That material was then placed on a 2D Mesh with a transformation of the size of the aspect ratio (disregarding the Y Value in Vector3). Before blocking out, we put this mesh under a parent object titled RoofTop Battle Map, which essentially held everything in the levels prefab. Outside of allowing us to keep our hierarchy organized, it kept the transforms of the child object consistent, as Unity can only transform its Child objects correctly when its parent object is

uniform. Otherwise, the child objects on the map can distort when rotated, making it appear that they are stretching.

On top of the 2D Plane, we began drawing out Probuilder meshes to fit the layout. We started developing roofs first, as they were the primary objects that followed the grid. Then we raised the roofs and began developing the rest of the building's body. The buildings were built with primitive objects; most were cubes with resized faces. This stage was where we began determining the height of each building, making adjacent buildings have a gradual climb or descent.

Around this time, we did some minor detailing with unique props around the map. The detailing at this stage was done for something other than aesthetic purposes, as they were mainly placed for gameplay. These objects provided players with a means to climb onto the roofs from different map points. For example, we have more straightforward routes, like ladders used for construction on top of the roofs. We also had objects that did not purposefully serve the function in the game set. However, we offered that opportunity in the context of gameplay. An example would be the boxes and crates one could climb to access a roof. These props followed our design of displaying options allowing creative decisions in our single-player module.

Our original white box was reiterated several times with many adjustments and additions, making the map the best possible version of itself (within our scope). One of our early iterations was changing the color of each mesh. The decision to change the default materials to vibrantly colored materials was meant to contrast the more prominent buildings from each other. However, the vibrant colors did not match the mood our module was aiming to convey. So we decided to adjust our color scheme to fit the gritter tone and theming of the setting. The difficulty in this

came from retaining the contrast between each of the buildings' primary colors. However, we could still emphasize vast differences between the buildings while keeping the mood.

Our next step in reiterating the map was continuing the detailing of each building. Most buildings were given objects to represent the base of the building. We then added pillars, beams, and borders on various buildings to further emphasize their structural integrity. Finally, some additional geometry was added to select roofs to provide an abstraction of shingles. Our design for the Rooftop Map was nearing completion, but we still had a few iterations to make.

We then began altering the props placed around the map, shifting our focus from gameplay to aesthetic design. The props meant to give access to the rooftop level now have materials that allow them to stand out from the toned-down palette of the map. These props were also detailed to fit better into the theming of the scene. We also varied the placement of these objects. While they still offered the same opportunities in gameplay, we made sure to make their placement feel more natural to the setting.

We also polished the objects that drew out our layout. Our buildings had extra detailing, with beams and cobble bases added. We also placed doors and windows on the building's walls and chimneys for the roof. We also added patterns to our designs, giving the roof layers that followed a step pattern and the walls varied materials in the middle. In addition, objects that emphasized our positive space were further reiterated. For example, the fountain was adjusted to make it appear chipped and dirty, giving further character to the scene.

The final detail for our level design was the lighting. A majority of the lighting in the map is meant to simulate how the light sources would glow within the scene. Most of these sources were from lantern props placed around the scene. These lights gave off a soft glow with a light yellow hue, further cementing the mood of the map. This map also contained a directional

light that had a very low intensity. This lighting suggests that the scene might be at sunset, as the town is lit but not overly exposed. Both forms of lighting helped us achieve the dreary look of the town.

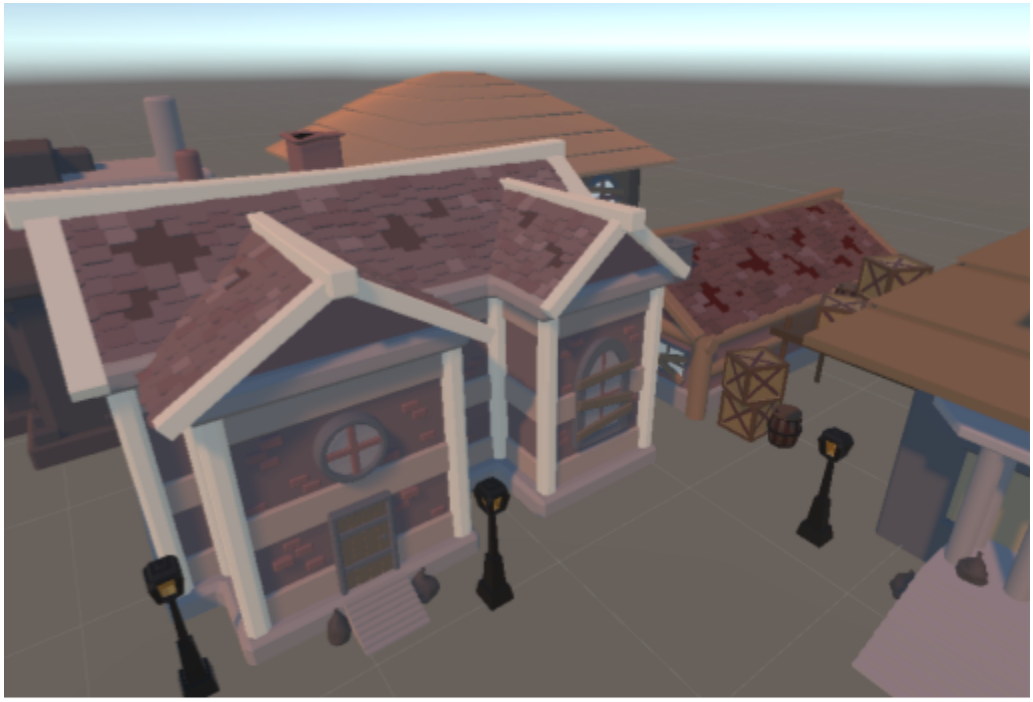


Fig. 8
Environment Art for Rooftop Battlemap

Conor reiterated the Rooftop Battlemaps Buildings by providing several details that pushed the mood and aesthetic we wanted. The final iteration is seen in Figure 8, with the final detailing added to the buildings. For instance, most roofs were layered to emphasize the object's shape. Some roofs were also given proper shingles, and the buildings' bodies were also given patterns of bricks. We further adjusted the town's palette, making colors less saturated and bleak.

*Sewer Battlemap*

While developing the Rooftop Battlemap, we began our work on the following map by considering the elements needed for that section. The setting would take place under the town in the sewers, meaning we were dealing with interior designs with a significant emphasis on functionality. In addition, Shawn had aspects important to the narrative that needed to be included in the layout. For example, one of the maintenance rooms served as a hideout, containing some simple furniture and a small room attached. When designing the Sewer map, we considered these concepts to feel parallel to what the narrative required.

We referred back to 101 Things I Learned in Architecture School to determine the placement of several map elements. Our space planning needed to focus on the function of the interior, being that the environment should feel like a system of its own (Frederick p.36). We also needed to design sections that complimented the players' experience. Since the map would be a sewer, each section was designed to be a positive space.

We also used lessons in the book to determine how pillars should be used in the layout. The book describes the different spatial effects that Pillars have on the environment (p.141). Pillars are not just for structural integrity but also serve as a rhythm to the space to create a more navigable environment. We applied this principle to our player's perspective instead of the character's POV to make the scene more legible. We considered each of these aspects before conceptualizing the layout of the map.

The layout has several branching paths, making the setting seem like an endless system of tunnels. These aspects of the map also made the maintenance rooms contrast heavily from the rest, queuing players in to explore them. We also placed wooden boards across the pathways to bridge players across select areas. This layout was ultimately more straightforward than our

previous map's layout, as we wanted to focus on the strengths of the interior design after our previous interior map.

The white boxing occurred when the Rooftop Battle Map was ready to be moved onto the Polish stage. The white box for the Sewer had a couple of interesting design choices. First, each tunnel had a good display of layering and depth. We further emphasized the depth of specific segments by raising half of the map higher than the rest. This decision also made it seem as if the water flowed down to the other side of the map, making it serve a function in the scene. We also added a large stairwell in the middle of the raised segment to add a layer to the bridging arc. Another example of our emphasis on depth and layering is the isolated maintenance rooms. Each of these rooms is at a different depth, which makes them contrast more with the closed tunnels of the Sewer.

After doing a simple white box of the layout, this map went through various iterations. This time we first added the materials to the meshes, which benefited workflow as the faces of different objects were more likely to contrast than blend in. Our color palette could have been more vibrant. We wanted the Sewer to come across as a gross and mostly uninhabited environment. Instead, we used various grays and deep green, blue, brown, and purple tones in various meshes. The colors gave the Sewers the mood we aimed for, and we felt confident moving past the palette.

We then started to detail our white box, focusing on the edges of the walls and placing props around the map. The tunnels are packed with various pipes that work as both a form of detailing and obstacles to be traversed. Different tunnels have larger drains in the water, and many pillars are placed along the pathways. The maintenance rooms were also given a variety of

props to suggest not only the function they serve in the sewers but how one of them serves as a hideout. Two ladders also reside on the map, suggesting two ways for the player to exit the map.

We then began adding light components to our scene. Our original light sources were floating point lights without a source object from which the light would come. The light source was a vibrant blue, glowing intensely in each tunnel. These were toned down to make their emission point more subtle and make the sewers seem less vibrant. The color of the lights was also toned to deep green, giving the scene a sickly aesthetic.

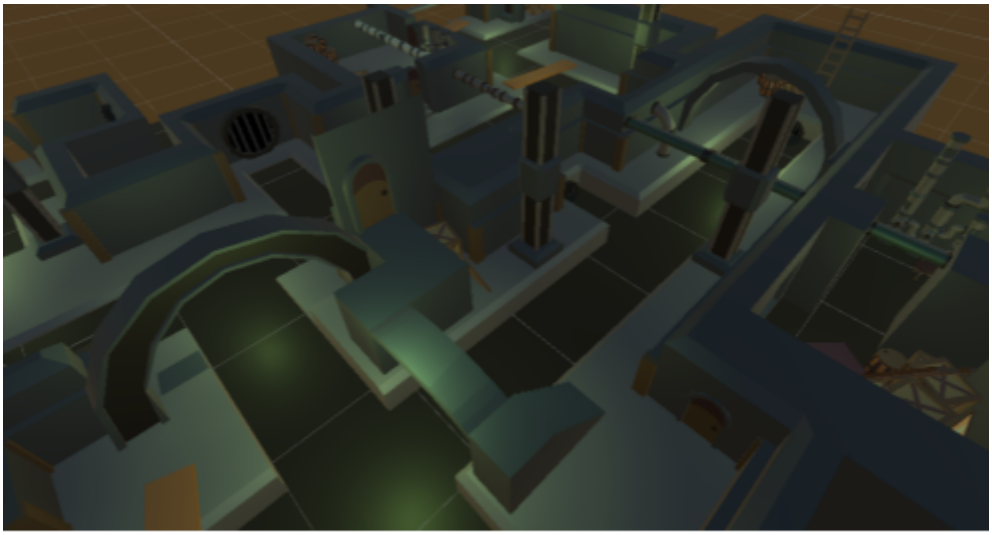


Fig. 9
Final Iteration of Sewer Battle Map

## Writing

### *Narrative Design*

D&D modules provide stories and worlds which the players choose to integrate themselves into. The selection process for which module a group chooses to play is usually as simple as a given module carrying the kind of story/environment a group of players wants to

experience. Thus, I considered first and foremost the promise of the premise. In screenwriting, this is what the trailers most try to encapsulate; what makes this specific piece of media worth watching? (Snyder).

To conceive of my premise, I needed to consider not only what players want to play, but what kind of experience I want to deliver. We wanted this module to be beginner oriented, so I immediately narrowed my options down to scenarios that are digestible and perhaps not too far removed from reality. A healthy dose of the mundane would allow players to ease into the world and prevent close-minded players and/or those inexperienced with high fantasy, from being deterred by the immediate introduction of wildly fantastical creatures. I brainstormed some ideas, and eventually created some high-concept pitches which I offered to my teammates. We settled on a city where a longtime class struggle has led to unrest between the poor and the rich. A series of recent social elite murders seems like it might be the last spark needed to set off the proverbial powder keg and throw the city into civil war. We felt that this idea was digestible even to those with little high fantasy experience, but left plenty of room for fantasy elements to be incorporated.

The official Dungeon Master's guide for D&D 5e was an invaluable resource for determining where to start implementing game elements once the major beats were figured out. The guide states that the start of an adventure should grab their attention right away, jump quickly into the action, and demonstrate that further adventure awaits (WoTC). This definition initially concerned me, as immediate action doesn't seem conducive to easing new players into the complex mechanics of D&D. Eventually, after looking at other published modules such as "Curse of Strahd" and "Death House." I came to realize that action is not strictly defined as combat, but also opportunities for the players to roleplay and make meaningful decisions.

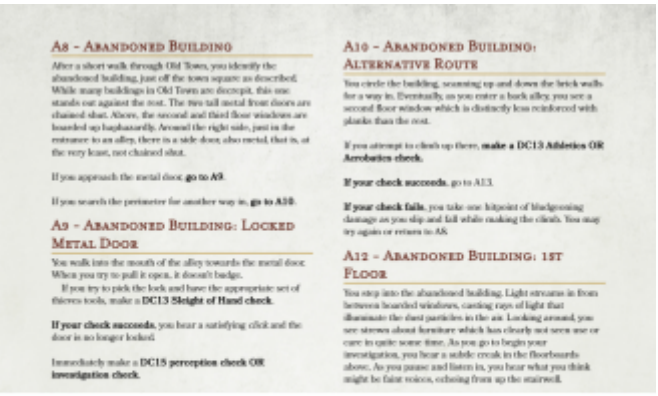
Another issue is that Dungeons and Dragons modules aren't made linear. Typically, module writers are able to focus solely on providing a compelling narrative because D&D skills, spells, and traits are intended to have broad applications which are applicable to any conceivable scenario. However, this module was designed to be GMless and geared towards beginners. Without an experienced GM to suggest times to use spells or even explain that using spells was an option at all, I needed to provide opportunities to organically introduce players to them.

I first inserted a section in the introduction explaining how a player might perform actions or spells not prescribed in the module, as it'd be too time-consuming, even for a team twice our size, to handwrite branches and routes for every spell. Then, I inserted suggestion boxes at the bottom of different scenarios, prompting the players to consider some specific spells and skills as solutions to the problems. One such example from Chapter 1 is when the players are trying to find their way into an abandoned building. The suggestion box prompts them to consider options like the "jump" spell or "guidance" cantrip, which have applicable uses.

Another focus of the narrative design was ensuring that there was cohesion between the written and AR elements. D&D is historically heavy on exposition because of how much it relies on theater of the mind. However, with there being 3D representations of the setting described, I had to be careful, as with every new adjective I was creating more work for the 3D modelers. Another concern was locations. As it was an urban environment, there needed to be a number of buildings modeled, however only a small number of buildings were actually used as locations in the module. Thus, I worked with the 3D modelers to ensure that the significant locations, such as the sticky nickel tavern, were more detailed and distinguishable from other buildings.

*Structure*

As this module is GMless, the structure is unique amongst D&D modules.There is no precedent, at least in officially published modules, when it comes to creating a D&D module that functions as a GMless adventure. The structure of this GMless module was instead inspired by homebrewed (created by players and not Wizards of The Coast) adventures, such as "To Hell and Back Again," which use an almost choose your own adventure style format. This format, which involves the player moving from heading to heading, making decisions, skill checks, etc., constrains the player to a narrower scope of the story, but has the benefit of ensuring that players don't lose immersion trying to figure out how to make something happen, or if they even can at all.



A8 - Abandoned Building

After a short walk through Old Town, you identify the abandoned building, just off the town square as described. While many buildings in Old Town are decrepit, this one stands out against the rest. The two tall metal front doors are chained shut. Above, the second and third floor windows are boarded up haphazardly. Around the right side, just in the entrance to an alley, there is a side door, also metal, that is, at the very least, not chained shut.

If you approach the metal door, **go to A9**.

If you search the perimeter for another way in, **go to A10**.

A9 - Abandoned Building: Locked Metal Door

You walk into the mouth of the alley towards the metal door. When you try to pull it open, it doesn't budge.

If you try to pick the lock and have the appropriate set of thieves tools, make a **DC13 Sleight of Hand check**.

**If your check succeeds**, you hear a satisfying click and the door is no longer locked.

Immediately make a **DC15 perception check OR investigation check**.

A10 - Abandoned Building: Alternative Route

You circle the building, scanning up and down the brick walls for a way in. Eventually, as you enter a back alley, you see a second floor window which is distinctly less reinforced with planks than the rest.

If you attempt to climb up there, **make a DC13 Athletics OR Acrobatics check**.

**If your check succeeds**, go to A13.

**If your check fails**, you take one hitpoint of bludgeoning damage as you slip and fall while making the climb. You may try again or return to A8.

A12 - Abandoned Building: 1st Floor

You step into the abandoned building. Light streams in from between boarded windows, casting rays of light that illuminate the dust particles in the air. Looking around, you see strewn about furniture which has clearly not seen use or care in quite some time. As you go to begin your investigation, you hear a subtle creak in the floorboards above. As you pause and listen in, you hear what you think might be faint voices, echoing from up the stairwell.

Figure 10:

A screenshot of the structure of the module

While there are no official GMless D&D modules, there are, however, numerous other GMless games. Two of the games I looked most closely at were "Fiasco!" and "Ironsworn." Both games hinge on group storytelling mechanics and limited prescribed rules, which lends to player-driven narrative and vast roleplaying opportunities. This sounded feasible initially, but I quickly realized that there were a few reasons this system wasn't compatible with our project. The primary reason was just that D&D is a heavily rule-bound game. This module would fail at giving players an idea of what the

unabridged game is like, and at teaching them the mechanics, if we were to liberate them from too many rules. For that reason, I decided to go the choose your own adventure route.

## 4. Implementation

### Technical Tools

A significant factor in our project was what Game Engine we would work with to create the app. The Game Engine we chose would need efficient performance and a flexible workspace for our development cycle. A few options seemed preferable for our design, and we had to decide which one would help us with the path forward. We ultimately slimmed our list down to 2 viable options: Unreal Engine and Unity.

Whether AAA or Indie, Unreal Engine has been gaining more traction in recent years when compared to Unity. Various software, including Maya, has integrated support for Unreal Engine (Epic Games Inc). Unreal Engine also has its level editor, using BSP files to draw the geometry of a level. The Engine is also considered beginner-friendly in terms of programming, as it has a drag-and-drop form. Users place nodes to program mechanics within the Engine, and the nodes can be easily converted to C++.

Unreal Engine did have its shortcomings when it came to our project's scope. Although Unreal Engine offered many options and fancy features that would be interesting to use, our core concept could have been better. We also found the Engine to be taxing on the hardware we were both developing. So even though Unreal can make an AR App, its features did not suit what we wanted from our project.

Our other option was also a reasonably popular game engine, Unity. Our group members have worked in Unity before and found it more flexible than Unreal. For one, the Engine was

more lightweight in terms of performance as it split its features across the Engine's Package Manager (Unity Technologies). In addition, this repository would allow us to determine which tools were necessary for our project while accommodating optimization. Unity has also had more extended support for the mobile market than Unreal, making it a perfect fit for our platform.

These factors ultimately led us to choose Unity as it fitted our project's necessities better than Unreal. In addition, it suited our platform better, and the package manager had several features that benefited our project overall. The choice was obvious, so we began setting up our project. We chose the working version 2021.3.16f1 of Unity because it was one of many recent updates to the Engine that we found stable.

### *AR Tracking*

The AR functionality was initially based on simple elements in the Unity AR Foundation package. Creating an instance of a virtual object when the camera detects an image is handled by a tracked image manager. This manager takes in a reference library of images and a prefab, and it instantiates that prefab whenever any image in the library is detected.

It is possible to expand the functionality to unique objects for each reference image; indeed, this code exists in our project in preparation for the sewer map. In the code that we used, the reference images and corresponding level prefabs needed to have identical names. When an image is detected, the code looks at the name of the image, looks at a list of prefabs stored in its script, and instantiates the prefab with the same name.

### *Player Input*

Our App has many ways for Players to interact with the AR and UI Elements. Since our App focuses on providing a learning experience through AR, we wanted to bridge the augmented aspects of the App with the level of interaction the player has. The interaction both had to serve as a means to teach the player the mechanics of D&D and benefit the gameplay through an AR interface.

One of our approaches was to have players interact with the abstract objects projected in the scene. Our technical design to achieve this interaction goes as follows: when the player taps on the screen, the App draws a raycast from that position on the camera to the map. These raycasts allow us to determine the point (a stored Vector3 variable) at the player intended to interact with the 3D objects. We can also store multiple points in our script, similar to how our Fall-Distance Tool can take two points and calculate the fall damage between the two points.

Our Beacons utilize the same input by placing the Beacon on a precise point and disappearing when the Beacon is the tapped object. In addition, the Beacon allowed players to keep specific points on the map within context, as we did not have physical objects to interact with the map during its development. When we added these tools, our Player Experience seemed more involved or invested with the AR Object.

### *Whiteboxing*

We needed 3D modeling software for this project to white-box the levels. Determining which tool we wanted was tricky, as there are a large number of options to go about 3D Modeling, or more specifically, designing a level. Regardless, the software we chose aws based on different factors that would help us develop the levels on time. We knew the software we

needed had to provide features that encouraged our design to be reiterated, optimized in an immediate context, exported its files in a standard format for most 3D software, and offered support for our Game Engine.

Maya was the first 3D modeling software we considered for the level design. It is one of the most widely used tools for professional 3D modeling. It has support for engines like Unreal while also having support for Autodesk's other tools. Many artists at WPI are taught 3D modeling with Maya, so it would also be beneficial if we wanted to focus on art later. Its verbosity has made Maya a very valuable tool in game development, making it one of the more widely used options in AAA.

Although the 3D software is used for professional work, it did not suit what our development desired. For one, Maya is a very involved tool used for art assets. Although this could be desirable for the end of our scope, it did not fit the stage of development in which we use it. We ultimately decided to leave it on the back burner, and if we could use Maya for 3D modeling in the future, we would reconsider.

Blender is another standard software used for Modeling. Blender has a couple of advantages over Maya. One aspect that makes Blender widely used is that it is a free, open-source 3D Modeler. This approach to Blender helps developers in various ways, like disregarding bloat that would typically come with DRM Based software like Maya. We also found Blender's interface more approachable and not as dated. However, there were better options than Blender too.

Blender still needed features that were important to our project. However, just like Maya, we found most of the features Blender provided negligible when trying to develop within our scope. We also found it inconvenient when it came to reiterating our previous work. Iteration

would not necessarily be complicated with Blender, but we wanted the work to be seamless and quick to test within Unity. Swapping between two types of 3D software and then pushing it to Git would take too much time when trying to bug fix or adjust our design.

Luckily, Unity's Package Manager provides us with a library of tools of varying purposes. One of these packages is Probuilder, a 3D modeling tool integrated into Unity. It is optimized for iterative prototyping of Level Design, making it a prime candidate for our project. We also found it more practical than swapping between Unity and another third-party software. Ultimately, this was our level editor.

Outside of deciding which software we needed to use, we had to consider some limitations for our maps. This would allow us to optimize the maps for both the player experience and efficiency. Due to the App being run on a phone, meshes were designed methodically by limiting particular faces and how maps would be drawn at a time. Outside of optimization, the white boxes served the purpose of gameplay which also guided their design. Since most of our maps were designed to be battle maps, their structure followed a grid. In D&D 5e, one grid space equals 5ft. Abiding by this rule helped us decipher the maps' abstract scale and make a believable space for gameplay.

Another one of the technical constraints we had to abide by in our maps was the aspect ratio and size of a Standard Sheet of Letter Paper. In our early app prototypes, we were looking to bridge the App and physical aspects of the game to create a more cohesive player experience. Our decision ultimately led to a design where the levels tracked images on paper to keep the 3D Level on a specific physical space and provide a typical 2D battle map. This decision affected our approach toward the map design as it had to be adjusted to fit within the constraints of a piece of paper. Standard Letter Paper is 8.5 by 11 inches, but we found that the in-app model

scales had to be adjusted by a scale modifier of 0.02 Unity units to fit the physical size of the paper.

To keep our designs aligned with the grid, we designed the layouts of the levels in Grid Cartographer. This software allows users to design 2D layouts and draw them in 3D for quick prototyping. The software is even advertised as a tabletop map creator, focusing on creating maps that fit in a grid with simple textures. The tools of Grid Cartographer are how we ensure that our objects would fit within a grid, making our 3D versions of the maps look great on the physical paper.

Another interesting constraint of the white boxes was how we drew light onto them. Two Unity's Light Components types were used: Point lights and one directional light. Point Lights draw light in a sphere around certain parts of the map to give off the emissive effects of lanterns or make the map easier to view. Some of our levels also had a single directional light that would shine above the map like the sun or a glowing moon. These were initially drawn in real time but were later baked onto the textures for optimization.

Before we jumped into the aesthetic and artistic aspects of the project, we still wanted to consider the mood and theming of our design. Although it could be lighter in its artistic approach or complex in technicality, we wanted to provide players with the proper setting to play the game. We did this by making several materials in Unity that were only flat colors. Although they did not have Albedo Images, we made some materials that have properties that fit the objects we placed them on. Reflection and metallic tones allowed us to convey our desired idea for our player experience.

## Artistic

### *Module Assembly*

Our module had to match the established structure and aesthetics of published D&D 5e modules. Most published D&D modules used *Adobe InDesign* to layout the visuals and text on each page. This wasn't feasible for us as a tool because our budget was limited, we had no experience with the software, and InDesign would require that we create or source many visual assets on our own. As we sought out more accessible software, we discovered two websites frequently used by D&D creators: *Homebrewery* and *GMBinder*. Unlike InDesign, these websites were designed for the explicit purpose of creating D&D modules, and thus their free assets and templates were specially curated for use in them. The tools on these sites are also split into two windows, which would allow us to write and code, then see our implementation in real-time. After experimenting with both, we began implementation in Homebrewery, but quickly switched to GMBinder, as we found that it was more user friendly and less strict with coding grammar.

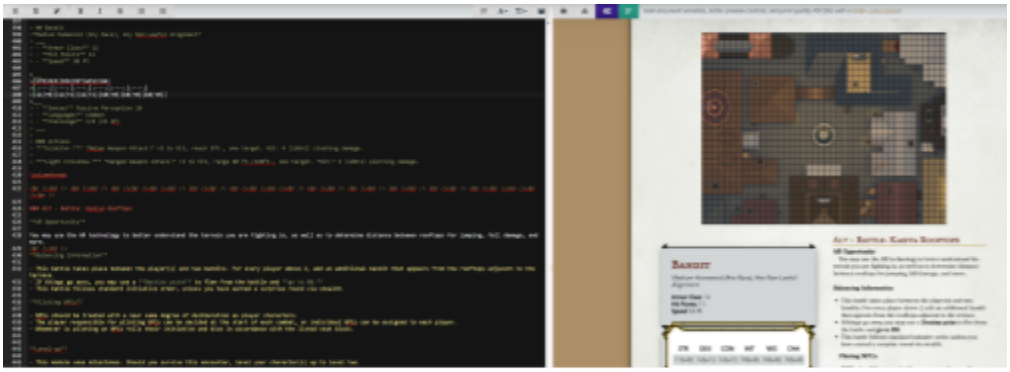


Fig. 11
GMBinder Interface

GMBinder works by converting HTML5 code into a visual model. Much of the code, however, is handled intuitively on the back end, allowing the user to focus on the content of the module while the software handles semantics and makes it more difficult to halt your progress with coding grammar mistakes. This software's specialization in making D&D modules specifically was highlighted at numerous times during implementation. Each inserted table, heading, stat sheet, etc.. was automatically made visually consistent with D&D aesthetics and the text was altered in accordance with our style template.

### *Audio Tools Used*

Since we wanted music that sounded like it was played by an orchestra, our easiest means of designing the tracks was through midi. Midi files are essentially digital forms of sheet music, and they allow for various arrangements by assigning instruments to a line of measures. The software we chose to write the music had to include instruments that sounded good enough for what we wanted to accomplish and able to be exported as their own audio files. Our compositions were written in the program *Flat.io*. This browser-based software allowed us to write midi compositions anywhere we went, allowing one to open a cloud-based library of compositions on any device. It also offered a wide selection of instruments, making writing music that fit the app's context easy. However, we needed help making the track loop after finishing a piece. Flat.io is not designed to make perfect looped songs, so that we would export the track as an MP3. We would then process the MP3 in Ableton to make it loop properly, then finally adding them to the app.

The Audio files were played in Unity via an Audio Source Component. This allowed us to give control to the user, as we designed a tool to control the playback. Players were able to

choose, pause/unpause, and restart tracks. The audio source was placed on the camera object, allowing the music to be heard wherever the player's position was. Overall, we were satisfied with how we implemented this feature.

## 5. Playtesting and Results

### Playtesting

During the late stages of the project, we began playtesting the module to see if our intended player experience was working and finding ways to further iterate on the project. Before this, our team was the only one to experience the project, so we began searching for ways to playtest it to a different audience. Our process to get IRB approval from WPI took longer than expected, and we needed the approval to share the results in this paper. After we were able to get IRB, we were able to start receiving data that would be shared in our report.

Two playtesting sessions were held by the Interactive Media and Game Development department. In addition, other playtesting sessions were held individually by our team members. Playtesters were provided with an IRB Informed Consent Form, a copy of the module, a D20, the tracking map image, and an Android tablet with the latest build of our app. These sessions were conducted for up to an hour, with 50 minutes dedicated to the gameplay. The remaining time was allocated to a survey.

Our survey focused on different elements of both the module and the AR app. We were interested in seeing how familiar players were with a GMLess module and whether they could easily navigate our module. We also included questions we felt were relevant to the app. The survey also contained open-ended questions regarding general feedback. We wanted to know what players liked and did not like and any suggestions they wanted us to consider.

## Results

Our results from playtesting were informative, allowing us to see if players were getting the intended experience. Our feedback was positive and constructive, as players gave feedback that we wanted to be utilized in the next iteration. Shown in Figure 12, a majority of our Players

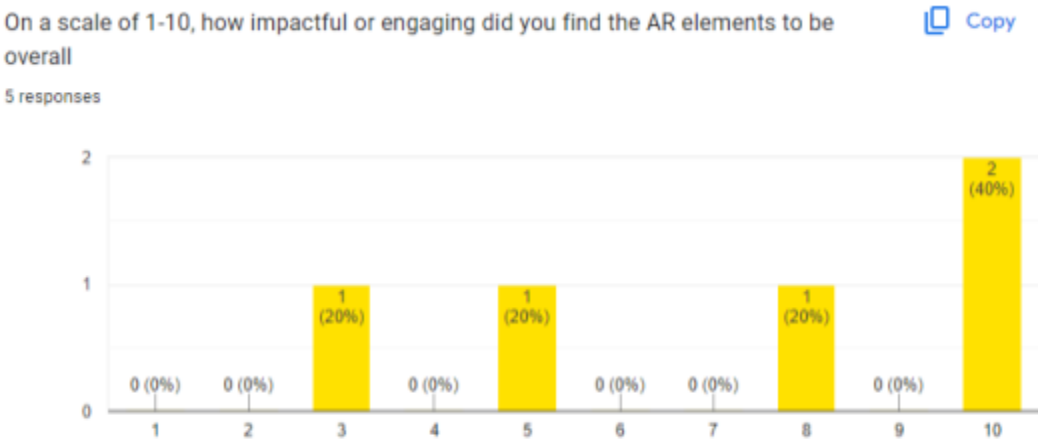



Fig. 12
Feedback from the Playtesting Survey, regarding the engagement of AR elements

did find the AR aspects engaging, as most reacted positively during the playtesting session and in the survey. They enjoyed that it was a custom module with its environment. They also enjoyed seeing the world of the module come to life, citing the terrain as one of the aspects they liked about their experience. They also found the dialogue and characters interesting. Players reported wanting to learn more about the game's world after hearing characters like the children speak about "the monster."

Something common amongst most of our playtesters was that most of them were unfamiliar with GMLess games, and both their experience and feedback demonstrated this. A couple of our playtesters admitted to struggling with our module, as they were not fond of the

linear nature. Players felt restricted within the confines of the paths, claiming that the module didn't offer them opportunities for creative decision making. A common reason they provided was the agency, as they felt they could only take specific actions or paths already defined within the module. Some of our playtesters suggested adding more options to the module. They believed that including more paths would sell the illusion of agency. However, players also

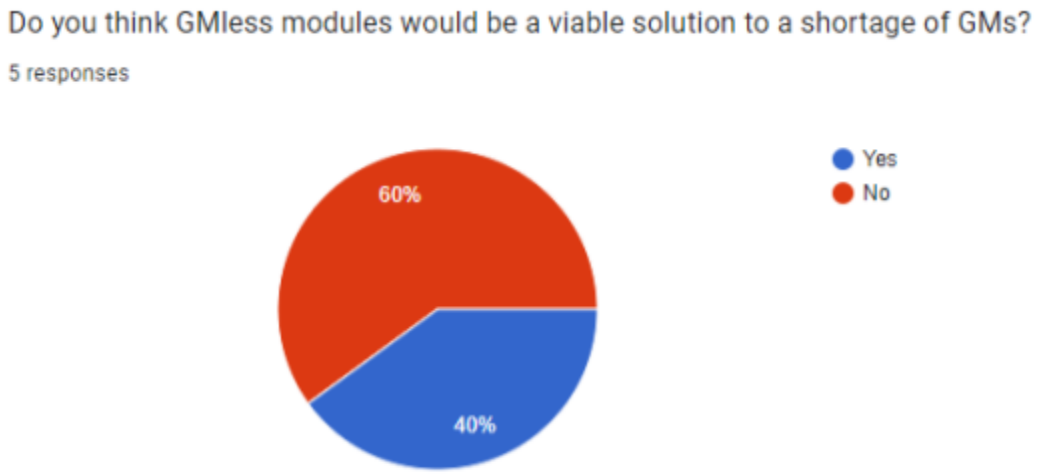



Fig. 13
Survey results regarding how players felt about GMLess modules filling the roles of a GM

needed help understanding their options. They would often get stuck as they felt the paths provided needed to be clarified and applied to how they ended up at that point.

## 6. Post Mortem

### Accomplishments

Overall, we were pleased with what we could accomplish within our scope as a three-term MQP. Playtesters noted that our AR app was able to consistently track an image, even at varying distances or when the camera was not set perfectly perpendicular to the tracked image, and found it to be one of the most enjoyable aspects of the experience. We also worked together

to produce synergy between the AR and tabletop experience, by ensuring that the models reflect the written content, as well as by adding tools to the app which correlate with mechanics and challenges in the module, such as the destiny point tracker.

We produced a playable first arc of a GMless D&D module which was complete with a compelling narrative, branching routes, accessibility considerations for players of various experience levels.

This project was subject to a considerable amount of iterative design and took many shapes throughout its development. Each time we had to pivot our design goal or adjust scope as a result of technical hurdles, our team learned many lessons that furthered our understanding of our disciplines. Although we shifted the project's direction more than once, our workflow structure was consistent, allowing us a considerable degree of flexibility. As a result, we were able to develop a novel experience within our scope, and our work allowed us to strengthen our skills as problem solvers.

## Challenges

This project needed to be faster to acquire IRB approval, which was necessary to begin playtesting. Unfortunately, we could only complete the approval process after D-term, leaving us just over a month to complete our playtests and make last-minute changes. The process should have been done in the early C-term, which would have allowed us to implement more playtesting feedback into the app and create a better user experience.

Our progress in the First Term could have been faster, involving many shifts to project scope. While some MQPs take place over four terms, ours only took three terms to complete. While we could get our work done under these conditions, we had to scope our project quickly.

Our first term was conceptualizing the idea, leaving the remaining two terms to create a minimum viable product.

The three members of this project specialize in narrative writing, level design, and audio design. From the beginning, we knew that we were pitching a project that would require coding while being without a dedicated programmer. As a result, our audio designer became the primary programmer, and the level designer engaged in programming. In addition, there was no environmental artist for the first two-thirds of the project, leading the level designer to take on a third responsibility. In the late stages of this project, we were joined by an artist, but we should have attempted to recruit one earlier. We also should have sought out a programmer to join us, preferably one with previous experience in AR.

## Suggestions for Future Work

Our Project was very ambitious, and we could only include a few things we wanted. However, these concepts could enhance our experience if applied in future iterations. So, we would like to provide suggestions to anyone inclined to further the Project's development.

One of our primary suggestions is to provide additional means for users to learn the mechanics of D&D. The team's primary goal near the end of development was to provide an accessible means for players to understand the principles of the game in an engaging experience. Our design utilized tools for an interactive experience to get players accustomed to checks in D&D. We believe there is more to explore here, and future iterations can teach new players with features outside our tools.

By the final term of our Project, we had determined that Chapter 2 was out of our scope. This chapter included the module, maps, music, and other assets we could not fit into our

timeline. We wanted to further the experience and agency of the players by providing a complete D&D module for newcomers. Including Chapter 2's contents brings this Project closer to that goal, and it would require another team of vast disciplines to accomplish this goal. Designing the next chapter is more practical, as the map is already designed, and it would allow designers to focus on the player experience.

As mentioned, adding Chapter 2 comes with the benefit of the white-boxed Sewer Battlemap. We put much effort and planning into its design and were disappointed not to have it in the final version. We also want to give the Sewer Battlemap the same treatment that the Rooftop Battlemap received, as it is in an excellent state to be handed off to an environmental artist. This iteration would entail further polish, adjustment of the color palette, and selling the idea that the sewers have the mysterious allure we wanted.

Another suggestion is to include other maps we planned for the module chapters. Unfortunately, we did not have enough time within our scope to include either the chapters or their maps. However, our ideas for them would benefit a future iteration of the Project. The maps we could not include were a Market Plaza and an Alleyway that served as a nonspecific battle map. Both locations would also be great for displaying possibilities for using this app.

However, these maps can only be included if the player can swap maps. We suggest two paths to accomplish this. The first is to switch the tracked image to a standard grid on which any map could be cast. Users could switch which map is displayed through the app when they reach a certain point in the module. The main problem with implementing this feature is providing a means for the AR components to understand the orientation of the tracked image. This feature could be done by applying a gradient under the grid from one edge of the paper to the other or by

making a tile on each corner a contrasting color. This approach would make it easier for the app to determine how the player views the map.

Another way the user can switch maps is by including AR multitracking. Multitracking takes the same concept of how our app uses images to track where the map has to be placed, except we would expand the script to track multiple objects. The code for multitracking exists in the Project. However, it is disabled due to a significant bug in its current form. As a result, the code solution must align the AR map with the physical map, a vital image-tracking feature. A future team with more time could troubleshoot this problem, allowing the Project to expand to multiple maps.

Something that would also benefit maps would be an easy standard to set up their scenes in the app. This feature could benefit players looking to learn the mechanics of D&D by understanding how the layout of a map can alter gameplay. This addition would be more complex than it sounds, as players would have to ensure that their maps fit on a standard sheet of paper and fit within the grid. Solving these design problems did not fit our scope. We ultimately decided to disregard this feature as it was unimportant to our app. Still, there is a lot the user could gain by designing their own experiences through this app. Including this feature would give players a better understanding of strategy and enemy placement if they wanted to be a GM. We also suggest keeping this feature streamlined. We are not pitching a modular app for any tabletop experience; we provide a learning experience.

## 7. Conclusion

The goal of this project was to create an engaging experience in AR that would also answer. There has been a significant decline in AR development, and we wanted to decipher the strengths of AR and apply them to our design. We opted to apply a physical tabletop design as it had tangible applications we wanted to apply to our AR elements. Our project not only satisfies our initial goal of how phones could have positive applications in tabletop games but also proves that there are still novel experiences that can be achieved through traditional methods of AR. Although our project focused on AR's interactive and visual aspects, this project emphasizes the most crucial element of AR: its interaction with the physical world. We chose to design our app around a tabletop game that is traditionally played in a physical means, allowing us to incorporate elements of the physical world into the AR application. AR was developed to take information from the physical world and apply it to the elements of the digital and cast it back onto the physical world. AR can be nothing more than a gimmick without leveraging these strengths, as it has no application to the physical world. This technology has yet to be fully utilized for its potential as a platform for the interactive medium.

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## 9. Appendices

### Module Docs, Audio Files, and Survey

This link leads to a Google Drive folder containing the module narrative and 2D maps, the Chapter 1 music, and a copy of the survey given to playtesters.

https://drive.google.com/drive/folders/111vJ5WbfHKPRcsxhPvr0vbeZQicpJ9Hw?usp=sharing

## Collected Playtesting Results

What did you like most about the module?

5 responses

- Had an interesting story and a really cool AR mechanic
- I enjoyed the custom setting, and the 3D terrain was very cool
- I was curious about the monster the kids talked about
- The multitude of options I had story wise
- The AR map was neat.

What did you dislike?

5 responses

- Seemed a bit linear in nature
- The choose your own adventure style made the freedom of the game seem restricted
- Nothing in particular
- not very newcomer friendly
- The intended gameplay feels restrictive in an unconventional sense. The module says that one can come up with their own answer to each presented problem, but there isn't much reason to deviate from the provided answers.

What suggestions do you have to improve the module?

5 responses

could give players a bit more agency

Make it clear what happens when something doesn't go to plan

Maybe adding more options to some of the branches

More instructions for people unfamiliar with DND

The AR map needs to be more than just a map. Tools to assist in exploration, greater depth, and a built-in dice roller seem like logical additions.

On a scale of 1-10, how impactful or engaging did you find the AR elements to be overall

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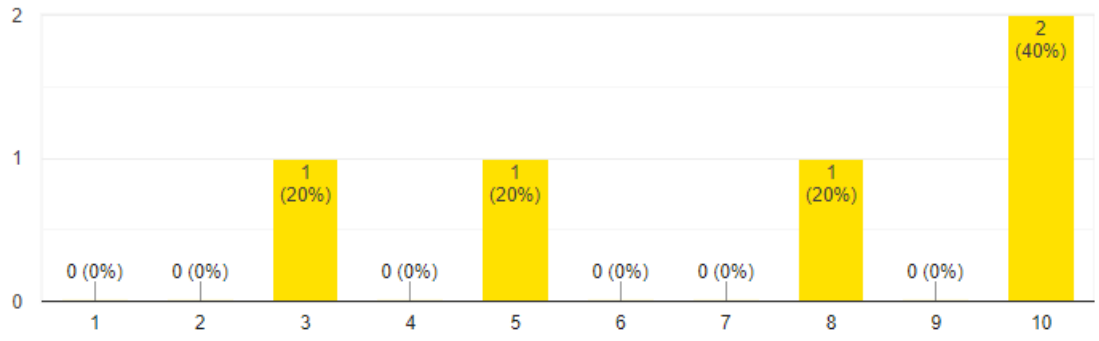
5 responses



How easy was it to get maps to appear using the AR app?

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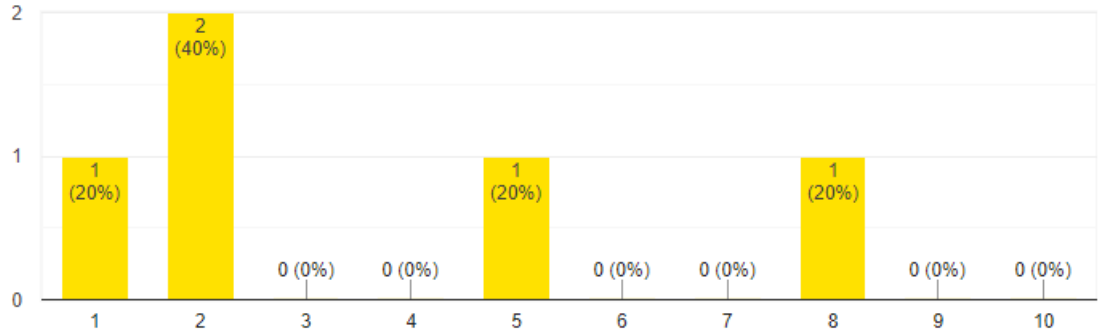
5 responses




How did you find the quality of the attached audio files?

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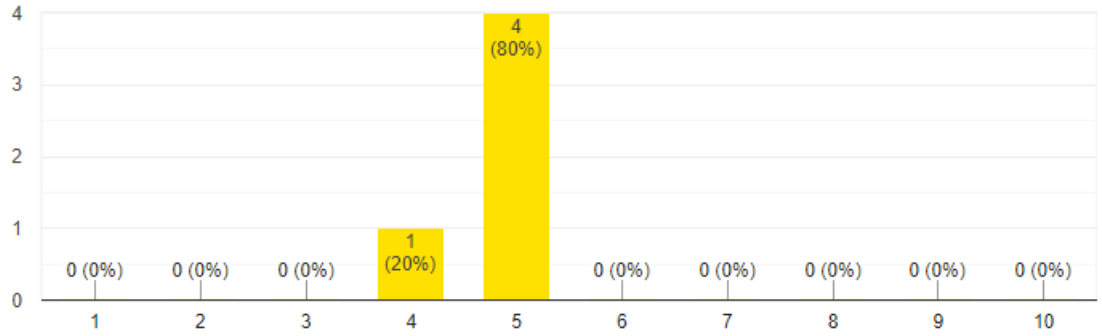
5 responses



Would you use them in your own campaign?

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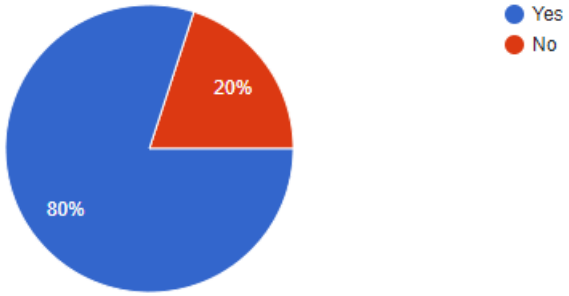
5 responses




How did you find the quality of the maps?

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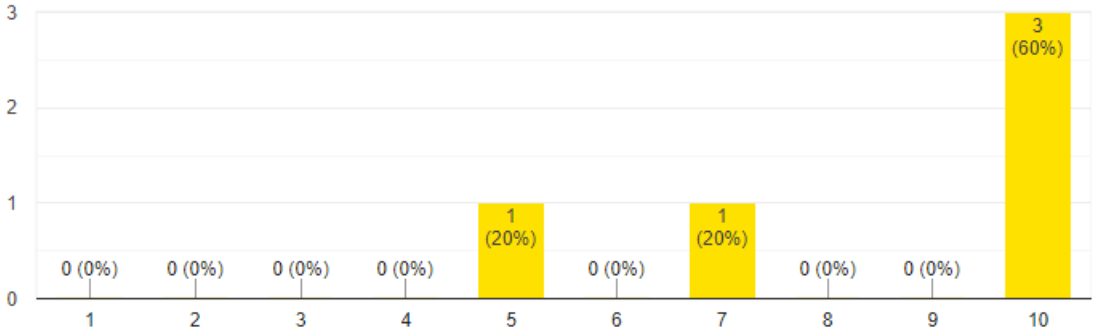
5 responses



Did you find the layouts of the fight maps to allow for creative or strategic combat opportunities?

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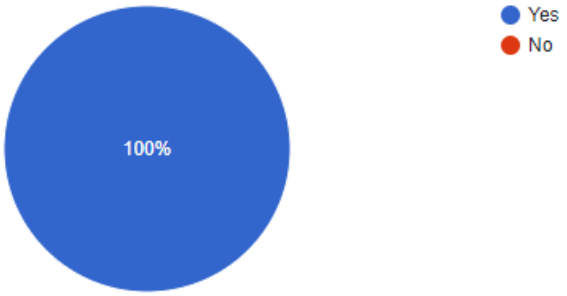
4 responses




As this is a GMless module, how navigable did you find it to be?

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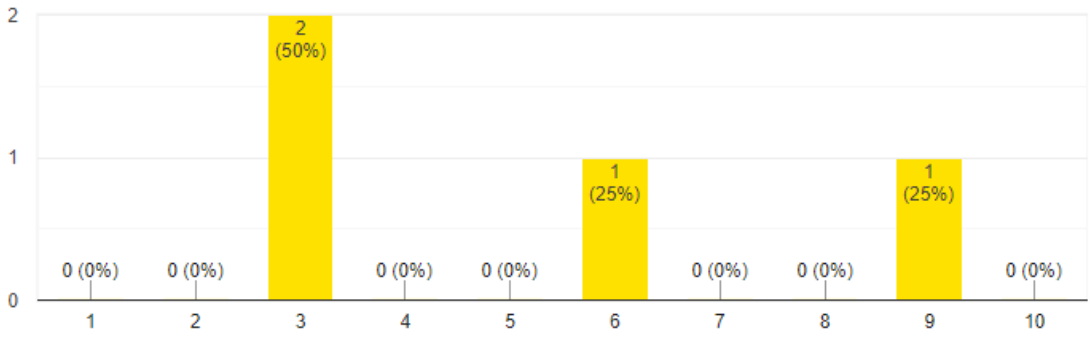
4 responses



What aspects of the module made it more or less easy to follow as a player?

4 responses

Easier, but at the cost of individuality

The tag system (A4/A10) made it easy to tell where to go next

Instructions on where to go and what to roll

The lack of a GM, while intended, removes key elements of exploration and discovery in open-ended tabletop games. This is a fundamental flaw.

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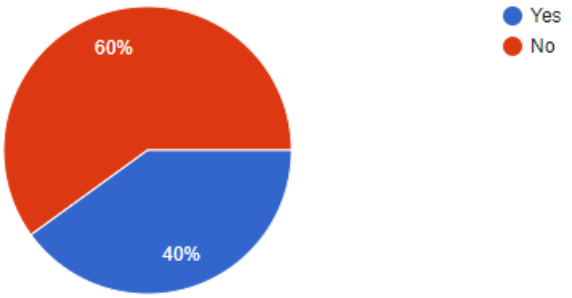
Do you find it difficult to find a GM/DM for tabletop games such as D&D?

5 responses



If you prefer to **not** GM when you play tabletop games, why?

3 responses

I am not the best at describing areas in detail

I don't play DnD so I have no idea how to GM

GMing is an absurd amount of work, which is typically done for pleasure, not profit. Most good DMs usually don't have the time to engage in the hobby as deeply as they would like.

How often do you play tabletop games that are in a GMless format?

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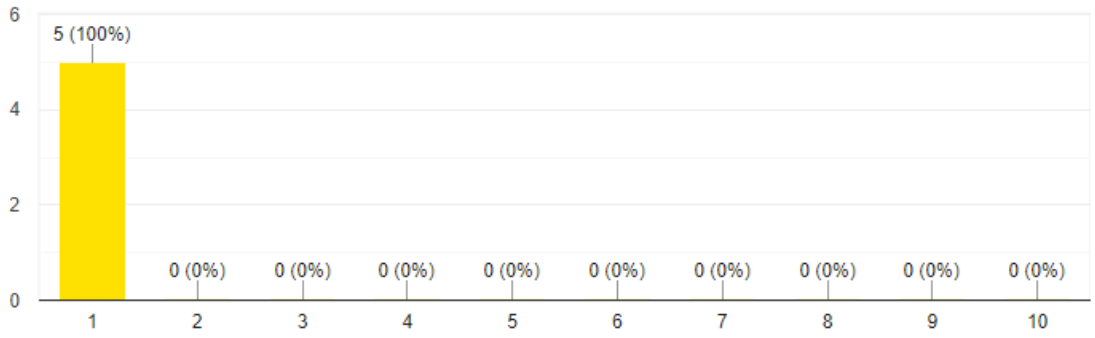
5 responses




Do you think GMless modules would be a viable solution to a shortage of GMs?

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5 responses