The Pythagorean Temple: Creating a Game-Like Summative Assessment

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Abstract: ChicagoQuest is a middle school where teachers, game designers, and curriculum designers collaborate to create a game-like curriculum that is relevant and engaging while teaching 21st-century skills. As part of the curriculum for our integrated math and English class, eighth grade students attempted to uncover the secrets of an ancient secret society called the Pythagorean Brotherhood, based on a historically real secret society. We decided to make an iPad game that related to the narrative of revealing the secrets of the Pythagorean Brotherhood that we could use as the final assessment of students' understanding of linear equations and the Pythagorean theorem for the trimester-long mission. In this postmortem of The Pythagorean Temple, we detail our design process, outcomes and next steps that came out of our first attempt at applying game-like learning and our curriculum design model to a digital game-like end-of-trimester performance task.

Introduction

At ChicagoQuest, teachers, game designers, and curriculum designers collaborate to create a game-like curriculum that is relevant and engaging while teaching 21st-century skills. The school is currently a 6-8 middle school with plans to add a grade each year through 12th grade. We employ a unique standards-based integrated curriculum that mimics the action and design principles of games by generating a compelling "need to know" in the classroom. Each trimester, students encounter a series of increasingly complex narrative challenges, games or quests, where learning, knowledge sharing, feedback, reflection and next steps emerge as a natural function of play. Our curriculum design model is based on that developed by the Institute of Play in conjunction with our sister school, Quest to Learn.

As part of Codeworlds, our integrated math and English class, we challenged eighth grade students to uncover the secrets of an ancient secret society called the Pythagorean Brotherhood, based on a historically real secret society. Students took on the role of archeological explorers who needed to uncover the secrets left by the Pythagorean Brotherhood by using math to decipher codes, discover patterns and follow clues. The narrative of the trimester-long "mission" was modeled after mystery-solving adventures such as those in Indiana Jones films and the Uncharted videogame series. Using this narrative as a backdrop, students used linear equations and the Pythagorean theorem in order to solve puzzles and uncover clues that led them to various locations in order to unlock the secret society's...secrets.

Developing the Game

The idea to develop a game to help assess students' understanding of linear equations and the Pythagorean theorem came out of our curriculum meetings in our in-house design studio, Mission Lab, where the game designers and curriculum specialists work with teachers to develop the curriculum. One of the main responsibilities of the curriculum specialists and game designers is to meet with each teacher (or pair of teachers) at every grade level and domain. The collaborative, organic design partnership between teacher, curriculum specialist, and game designer is at the core of the curriculum design model. As game designers, our role is to find ways to take the learning goals and standards and make learning more relevant, compelling, and fun for the students, in addition to shaping the overall game-like narrative of the classroom experience.

The Mission Lab team has a goal to make at least one digital game per trimester. We were halfway through the first trimester, and at that point in the school year we had primarily designed analog games for the classroom while making use of pre-existing digital games. We were looking for a promising candidate for our next digital game, and we were interested in using a game for assessment of what had been learned, rather than as a means of teaching or reinforcing. We also wanted to leverage the students' affinity for their classroom set of iPads. So, we decided to make an iPad game that related to the narrative of revealing the secrets of the Pythagorean Brotherhood that we could use as the final assessment for the trimester-long mission.

We decided to make an iPad game in which the player had to use their understanding of linear equations and the Pythagorean theorem in order to make their way through an ancient temple where the Pythagorean Brotherhood had hidden their most important secrets. We felt that it was a compelling narrative hook to have students in the role of archeological explorers uncovering a conspiracy. Also, given that there was actually a secret society formed around Pythagoras's teachings, we felt that we couldn't pass up the opportunity embed the Pythagorean theorem unit in a secret society narrative. The teacher was also excited about the Pythagorean Brotherhood mission concept. We feel that that is important because the teacher needs to be excited about the mission narrative in order to "sell" the narrative to the students. We felt that it was a natural fit for the assessment of the students' learning over the course of the trimester to be tied to the culminating event in the narrative.

Once we had decided that the iPad game assessment would be the students' final performance task for the mission, we wanted to figure out how to tie it to the mission narrative. We decided that the game would take place in the hidden temple where the Pythagorean brotherhood kept their most well-guarded secrets. Players would need to get past a series of obstacles in order to make their way into the depths of the temple. Our next step was to determine which skills we wanted students to use to play through the game. We worked with the teacher and curriculum specialist to determine which standards and skills they wanted the students to understand by the end of the trimester and determined which would benefit most from inclusion in the game. We decided that, due to time constraints, we would only incorporate linear equation-related skills for this iteration of the game. Because the Pythagorean theorem content came later in both the trimester and in the planned progression of the game, we decided to wait to incorporate that part of the game and assessment until the following year's iteration. We then diagrammed, discussed and created four digital prototypes that required the following skills: graphing linear equations, completing linear equation tables, converting between different forms of linear equations, and completing slope-intercept form linear equations. For each skill, we prototyped a mechanic that was well-adapted to both the skill and to the iPad interface. We looked at popular iOS games and other games to help inform our approach to making a usable and fun interface for the game. For linear equation graphing, we used a touch-and-release mechanic to position two points to define a line (see Figure 1). Another example is our use of an iOS-style rotary-swiping mechanic to fill in coefficients in the slope-intercept equation completion prototype (see Figure 2).

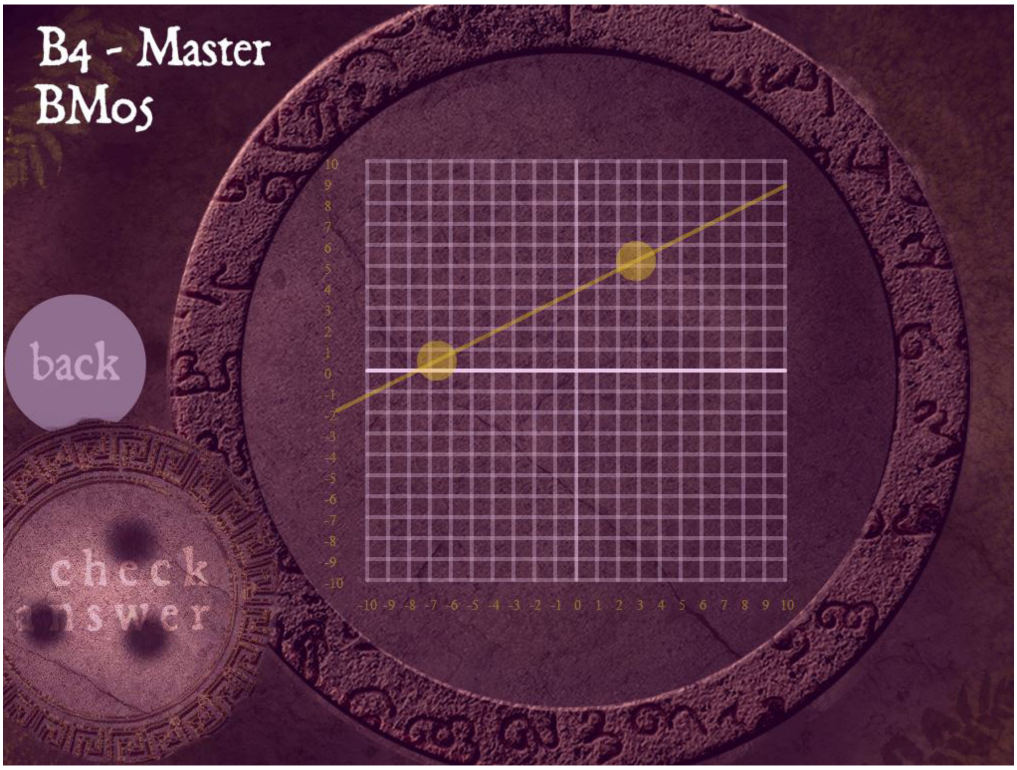

Figure 1: Defining a line by plotting points in The Pythagorean Temple.

Our next step was to find a way to sew together these different minigames to form a cohesive experience. We had noticed that students were really interested in 'infinite running' iOS games like Temple Run, so we wanted to try to incorporate a similarly action-oriented mechanic in our game. However, we knew that we didn't have time to make both a satisfying running mechanic and develop the math minigames. We decided to make a slower-paced game where players needed to move through a multi-floor maze of rooms in order to find their way to the door to the next floor of the temple. Each room would have several doors leading to adjacent rooms. The doors were to be locked, and players needed to complete challenges to unlock the doors. For example, to open one kind of door the students needed to place two points, by touching and dragging them on the iPad screen, on the coordinate plane in order to graph a specific linear equation. The goal was to give players choice as to the path they could take through a level in order to get to the exit, as well as choice in how many of the different types of challenges they completed. For example, a player could avoid some of the linear graphing doors by going through more rooms (and completing more challenges?), but any path through a floor of the temple required a player to complete some of each kind of challenge.

Figure 2: Completing slope-intercept linear equations with the iOS swipe mechanic.

We realized that this design required us to make a large space that would not be used by most players. A large maze with many possible paths means that most players won't explore most areas of the map, leading to extra work in terms of level design and mathematical challenge design. Creating many paths would allow for player choice, but it would not necessarily be very meaningful choice. We knew that we could create meaningful choice by placing power-ups, treasure, etc. around the map, but we also knew that we didn't have time to include such things in this first iteration of the game. This led to a hub-and-spoke redesign, where players had to unlock "wings" of each floor in order to access three different chambers. Each chamber had a set of challenges, and each challenge opened a small door that let in a shaft of light that bounced off of mirrors and into the central hub of the level (see Figure 3). If enough light was reflected onto an object in the central hub, a door in the floor opened and the player moved into the next floor down. This design eliminated much of the additional spaces and challenges we would have needed to create while retaining the choice in how the player progresses through the game.

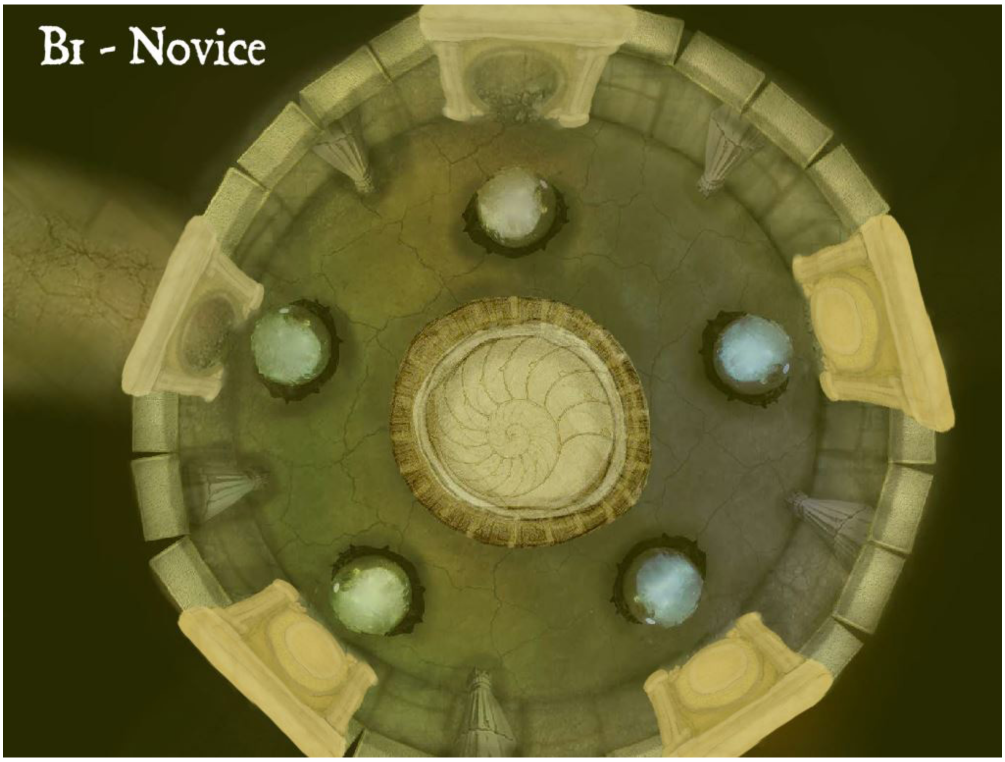

Figure 3: The central chamber of one of the floors of The Pythagorean Temple.

At this point, we began putting all of the pieces together. We built out the functionality of the individual light-door challenges. We built the “overworld” from which the light-door challenges could be accessed, and which showed the progress toward unleashing enough light to progress to the next floor. We produced art to create the appropriate ancient temple feel. We wrote code to pull in and parse the necessary input data and correct answers. This allowed us to turn a text file into a set of challenges that is imported into the application to fill in all of the challenges in the game. We worked with the curriculum specialist to determine how to scale the difficulty of these different challenges so that each of four floors of the temple could have its own difficulty level, with difficulty increasing as the player makes his or her way deeper into the temple. Once this was done, we were able to create a final challenge file that the app could interpret. We designed a “codex”, a hard-copy document with the appearance of an ancient tome. The codex included the prompts or clues for the challenges, so that when the player approached a door in-game, he or she could look at the symbols above the door and find that set of symbols in their codex. Each set of symbols in the codex was associated with a hint or problem the player used as a key to open the door (see Figure 4).

The Game in the Classroom

The execution of the game in the classroom was relatively straightforward. Students were told ahead of time that the game was to be their final task, and that they had to use their codex to find their way to the secret hidden deep beneath the temple. They knew some time in advance that their final assessment was going to be a game, and that it was going to be fun, challenging *and* part of their grade for the class. The initial plan was to have each student have their own codex and iPad, and to work individually to get as deep into the temple as they could, given the linear equation knowledge and skills they had acquired leading up to this point in the trimester. Due to technical difficulties in deploying the game to the iPads, we had fewer iPads than students. The teacher suggested that we have students work in pairs.

The student reaction to the game was interesting. Taking advantage of the core mechanics of the iOS interface resulted in students being able to pick up and play without a second thought. Because they had their codices next to them, they understood that they could use them to unlock doors as soon as they came to the first coded door. The students approached the game with the same willingness and focus with which they had approached other games where their performance was not assessed.

The students didn't have trouble interfacing with the game, but they did have trouble with the math. It turned out that many of the students didn't have a firm grasp on the content that their class had covered leading up to that point in the trimester. The most interesting thing about this scenario was that, unlike with a standard pencil-and-paper assessment, the students had an immediate "need to know" the content that they had failed to learn over the course of the trimester. They demanded to have the content taught to them in the moment. We had to find a balance between giving the students hints and letting the performance task serve its assessment purpose. We did this by directing them to their notes from the trimester, encouraging them to make use of a resource that they had created that they could use to help them with the task at hand.

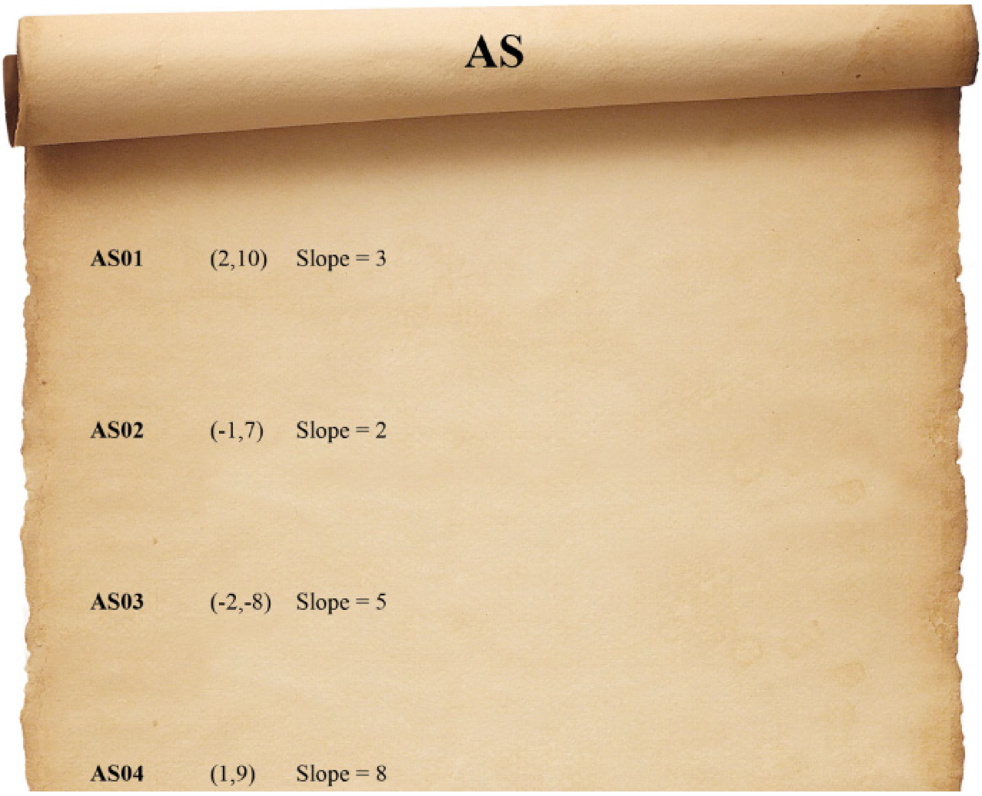

Figure 4: A page from the paper codex used to open the doors of the temple.

The teacher assessed each student by observing how deep into the temple they were able to travel in the allotted time. While developing the game, we worked with the curriculum specialist in order to create four different tiers of difficulty for each of the four mathematical challenges. The temple consisted for four floors, starting at ground level and going deeper underground. Each floor contained all types of challenges, but at a different difficulty level. The measure of performance used was simply which floor a pair of students reached.

Lessons Learned and Next Steps

We learned several lessons from this first attempt at making a digital performance task. When it came to content, students were not as prepared for the assessment as one would have liked, but we learned that having a performance task presented to students in the form of a digital game resulted in the students displaying more tenacity when unsure how to complete a challenge. Students also very actively asked for just-in-time explanations of the content tested by the game. This seemed to be because the students wanted to beat the game, rather than out of a desire to do well on the assessment. Several students, having made it very close to the end of the game, had to be verbally shooed out of the room to their next class because they couldn't pull themselves away. We came away wanting to find more opportunities to create that experience and attitude earlier in the trimester. Students also seemed to benefit greatly from working in pairs, which we discovered accidentally as a result of technical problems.

This first attempt at making a digital game performance task has us excited about next steps and improvements that we can make to the game. First, we want to change the way we introduce the game. Our current plan is to present the game to the students when they are completely incapable of completing it in order to create a strong need to know. Then we will present smaller chunks of gameplay to the students throughout the trimester. For example, as part of the lesson for each topic we could present students with a smaller temple that contains part of a key that needs to be assembled before they can gain access to the final challenge. This way we can harness the students' tendency to ask for just-in-time explanations of the content well before the "boss."

There are many improvements that we could make to the game in order to increase its usability for teachers and students. We need to make it easier for teachers to create on their own problem sets by finding a more user-friendly method of creating the text document that holds the problem set data. If we made it easier for the teacher to create new problem sets, it would allow us to get more out of the game without much additional time spent by Mission Lab. In addition to allowing Mission Lab to move on to other projects, when teachers are comfortable working with the games and materials we develop for them, it allows them to more effectively incorporate the games into their lessons. The trimester-long mission, of which this game was a part, covered linear equations and the Pythagorean theorem, but the game doesn't yet include any challenges related to the Pythagorean theorem, so we would like to expand the kinds of challenges included in the game. In the next iteration, we plan to go through the same process of isolating the skills we would like students to demonstrate, creating game mechanics that align with and test those skills, and building prototypes of those minigames before incorporating them into the game. We would also like to add a layer of polish to the game in the form of sound, characters, and visual player feedback to make the game even more compelling.

The ability to use this game for assessment needs to be expanded. Currently, the floor that a student reaches in the four-floor temple is used as the measure of their learning. We want to capture and make use of the data that players are producing, such as how many times they fail on a challenge and which types of challenges students find most difficult. We could do a lot with this data. As game designers, we can improve the design of this game and future games by looking at where players get stuck or confused. We could do this by creating a database that records player actions for later reference. Teachers could make more granular assessments of student understanding by observing which kinds of problems are most challenging for any given student. We could do this by creating a companion application that the teacher could use to keep track of student performance on the fly.

We feel that this game makes clear the potential to make teaching and assessment easier and more compelling for students and teachers through game-like learning. Students were engaged and hungry for information. The teacher was able to easily spot and support students who wanted to understand and succeed. Creating a game specifically for assessment resulted in something that we feel can be used to engage students and gauge their understanding throughout the learning process. We hope to apply some of these lessons to future iterations of this game as well as future projects.