

Worked Example: *Cosmos*

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Abstract: We propose, in this session, to illuminate the development process for a Massively Multiplayer Online Game for science and mathematics learning, with the working title, *Cosmos*. Because the size of the project encompasses a number of complex design and research questions, we would like to invite the GLS community to work through our thinking with us—to challenge us and contribute to our thinking. Which details get worked will be decided in part with the members of the community that attend the session, but we will be prepared to discuss everything from general pedagogical frameworks for science learning to specific quest mechanics, and everything in between.

Introduction

Cosmos is a Massively Multiplayer Online Role-Playing Game (MMORPG) for science and mathematics learning, recently funded by the Bill and Melinda Gates Foundation. Development began in December, and a great deal of work has already been done to develop the world for its inhabitants and their activities. Using an experiential learning framework, players will complete embodied tasks and investigate problems big and small, both on their own and with one another. The curriculum for the first wave of development will focus on the Core Curriculum standards for geometry, statistics, and probability and the Next Generation framework for biology. Furthermore, the curriculum will connect players with an identity as a science learner and concepts of systems thinking through the Nature of Science.

Cosmos will be an excellent Worked Example session because the project will be at a prime moment to invite the Games, Learning, and Society community in to discuss the game's central design, narrative, learning, and technological conceits. Several potential examples are presented within this paper, but for a project this large, only a few aspects will be unpacked in the session. Those aspects will be chosen based on the aspects the investigators deem most in need of discussion at that phase of the project as well as the expertise and interests of the session attendees.

Investigating the World of [*Cosmos*]

Cosmos aligns the needs of a learning environment with the affordances of MMOGs. The unique affordances of massively multiplayer environments have been shown to foster *scientific thinking*, *scientific identity* and *inquiry skills*. While a true educational MMOG has yet to be created, several initiatives have created Multi-User Virtual Environments (shared virtual worlds, with tasks, but lacking some of the individual structure and all of the collaborative components) such as *Quest Atlantis*, *Whyville*, and *River City*, which suggest the potential of this format for learning (Kafai, Quintero & Feldon, 2010; Barab, 2007; Ketelhut 2007; Ketelhut et al. 2007; Nelson et al. 2007). Due to being massive and persistent, the open ended game play of an MMOG encourages a sustained investment in “*systems based reasoning, model-based reasoning, [and] evaluative epistemology in which knowledge is treated as an open-ended process of evaluation and argument*” (Steinkuehler & Duncan, 2008). Moreover, this reasoning is often done collaboratively (both synchronously and asynchronously) with peers. *Cosmos* takes a unique approach in the way it deeply integrates STEM practices as core game mechanics in a collaborative, mentored space that allows for innovative assessment and just-in-time scaffolding. This means not just the investigative aspects of STEM, but also the emerging technology and engineering literacy standards and 21st century skills like collaboration, all key to the practice of science today.

Cosmos is set in a robust, fantastic, and alluring virtual world with a great number of natural properties and phenomena, modeled on real-world scientific principles. Students will need to investigate these phenomena in order to solve the game's puzzles and to advance in the game. Players' central task in the game will be to manipulate, test, explore, predict, question, observe, and make sense of *Cosmos*' virtual world. In order to make this compelling, the world will be a multi-layered model consisting of multiple complex systems and simulations. Some content will be high fidelity models of systems from our world, and some will be more fantastic systems (still obeying known scientific laws) with their own unique features that players must discover. The processes of

investigation will resemble those of contemporary practitioners however, and are still modeled on established scientific laws and principles. For instance, the world models ecosystems that could be tracked and influenced by biologist characters. Players will not simply memorize facts, but they will use scientific methods of investigation and inquiry to penetrate these simulated systems. While the individual animals and plants may be fictional, they will be based on real principles of ecology.



Figure 1: A hypothetical street scene from Cosmos.

Because the various tasks in *Cosmos* will require the use of *real* learned skills, we can assess how the player is doing in terms of their knowledge and skill development in each content area. This is a mastery-focused pedagogy, requiring players to thoroughly master a topic before moving on, instead of moving on when the pace of the class demands, regardless of the students' understandings. All of this information can be summarized and accessed by the teacher to provide data on student performance on the required topics. Through this data, the teacher may provide additional in-game (directly themselves or via other students in the class who have mastered the content) or out-of-game assistance for those students who are struggling, thus creating a tightly linked feedback system. Teachers may optionally assign "grand" quests in topic areas, which act as a summative assessment for the unit, in which students must demonstrate their mastery of the topic. Take the following sample narrative, for example...

Example (To Work)

Cathy is a high school math teacher preparing to use *Cosmos* in her class this year. She goes to the *Cosmos* website to create her class and choose the quests (tasks) and talents (skills) for her class based on her curriculum. She answers a few questions about the grade, topics and textbook she uses, and *Cosmos* suggests the Architect talent tree. The talent tree is a sequencing of skills common to many MMOs. In this case, the sequence is the progression of math topics across the course. Students are required to master a topic before moving on to the next. Within this tree Cathy has the option of reprioritizing skills (placing them higher or lower within the tree) with some restrictions on topics that build upon each other, requiring one to come first.

When the students embark on the game, they will need to progress up the talent tree, building the necessary skills to advance to the next level and acquire more skills and explore new lands. Students

who do not perform well enough on quests in a particular skill area will not earn enough experience points (XP) to move on to the next talent, and instead will need to complete more quests in the areas in which they are building skills.

For example, consider the case of Susan, embarking on this sequence in Cathy's class. Susan's first assignment is to create a Figurer character. She winds up doing this on one of the library computers after school. As the adventure begins, a cinematic introduces her to the world of *Cosmos*, establishing the story of the world and the role of a new kind of adventurer in investigating and protecting the world. Her character awakens in a cave, where she performs some simple operations in order to prove her worth to the Figurer's Guild and gets used to the controls and abilities. After completing these initial trials, she encounters a large number of basic operations, and proceeds about the life of a beginning Figurer.

After reaching level 10, an hour and a half after starting, she is oriented to the basic workings of the world and her basic palate of abilities. At level 10, she is invited by one of the leaders in the community (her teacher, Cathy) to join the Architect specialization along with her classmates. The Architect path and its attendant quests, carefully chosen and organized by her teacher, will now provide a free-but-focused space in the world for her to adventure in. A typical adventure for an Architect might look something like the following: On her way to deliver a message to her non-player character mentor in the central city, she happens upon two brothers who are clearly fighting. They have an Architect symbol lit up over their heads to indicate that they have a quest solvable by Architects. Upon talking to the brothers, she discovers that they are arguing about how to divide up the farm they've inherited. Neither brother thinks the other is giving him a fair deal. The brothers indicate the irregular property line and ask for her opinion, since Figurers are well respected in the world of *Cosmos*. Having recently completed "squares" as a portion of her training, she uses her abilities to quickly create a small square and apply a grid of identical squares over the property to investigate the overall area of the property (the land is flat). After some tinkering with the length of the square's sides, she discovers that indeed the property can be measured in squares without any left overs, so she draws a property line for the brothers that gives them equal portions of land. Having satisfied the brothers, she receives experience and a small allotment of gold, in addition to a new usable ability called "area." This ability will allow her to even more quickly create grids of regular shapes for similar problems.

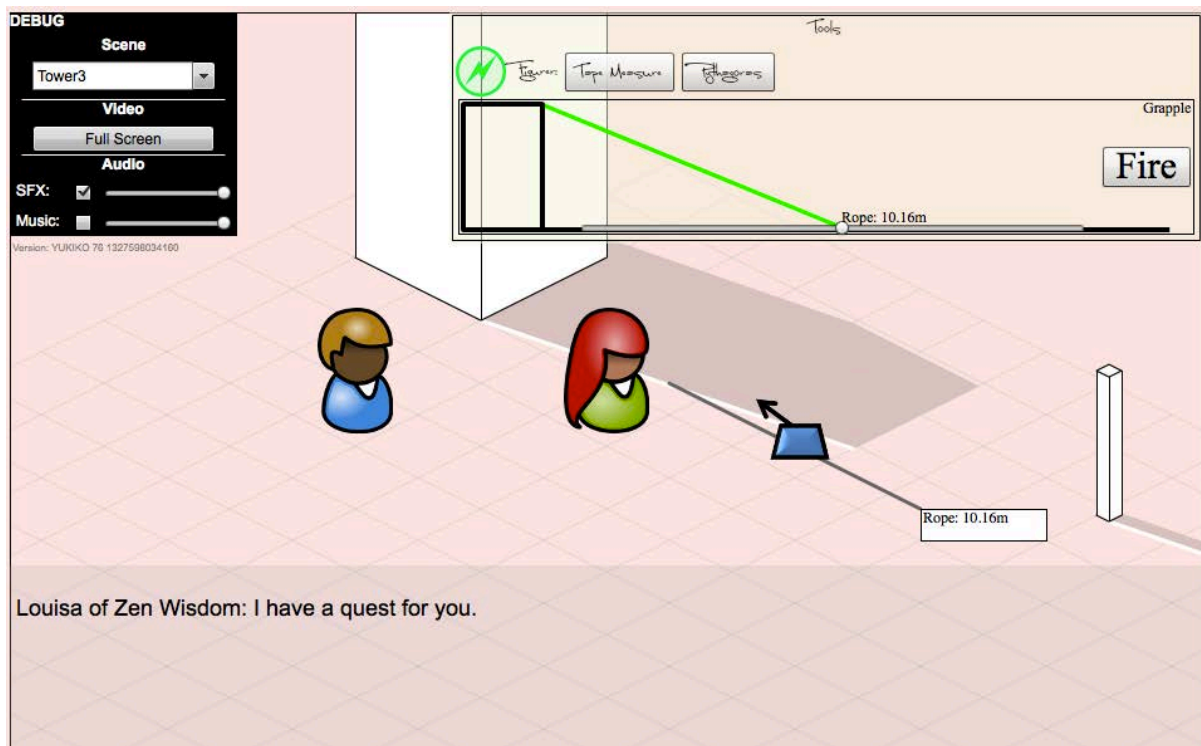


Figure 2: An early prototype of the Tower quest.

A week later, Susan struggles with another quest however. For this quest, she must scale a tower that sits in the middle of a clearing. The nearby shopkeeper will only sell her exact amounts of indestructible rope though, and she has had difficulty figuring out how much rope she needs. After trying to reach the window with her existing grappling hook and failing, one of the nearby non-player characters offers her a suggestion that she think of the height of the tower as a leg of a triangle, while another non-player character discusses properties of right triangles. She opens her "Triangles" palate to do some exploring, but unfortunately she's just not sure how to find the length of the other two legs. She persists for a while and gives up. She makes a note in her online logbook that triangles may be involved, and heads back into town to talk to friends. None of them have gotten to that quest though, so she logs off for the night.

Over the weekend, while watching her classmate's soccer game, she notices her shadow. She realizes that her height and the length of her shadow form two legs of a triangle! She borrows a friend's smartphone and opens the *Cosmos* mobile logbook application. She hastily jots down, "Shadow forms one leg of the triangle, but...how to get the hypotenuse?!"

Cathy meanwhile, looking at the summaries of the class's progress over the weekend, notices the flag next to Susan's name. The flag indicates that while Susan has typically had a high quest completion to time spent ratio, she has been stuck on one quest for some time. She is directed to Susan's logbook for this quest and sees that Susan has associated the quest with triangles and has a good theory about the tower's shadow, but has not yet completed the quest. Cathy sends an in-game "gift", an ancient text describing a related parable, in her guise as Morgana, the leader of the class's Figurer's Guild. The text was chosen from a list of options of supporting materials for that quest through the teacher interface in *Cosmos*. She also decides to add a personal message, "It looks like you're having struggles of epic PROPORTIONS."

The next time she logs in, Susan receives Morgana's gift and understands her message loud and clear. After looking around the clearing for a bit for something she can measure to create a proportionate triangle, she realizes that her avatar and its shadow create a proportionate triangle. After measuring herself and her shadow, she measures the tower's shadow and finds the answer to the tower's height in her proportions tool. Not long after, she is headed back into town to make a deal with that buttoned up shopkeeper.



Figure 3: A mock up of the teacher tools.

While Susan and other students in the class have been working on *Cosmos*, Cathy has been getting summarized reports and indicators of difficulties through the *Cosmos* website. At the highest level, Cathy can see how far everyone has progressed within the talent tree, indicating areas of strength and weakness, and new areas they decided to pursue. She can go further for particular students (as she did with Susan) to examine quest summaries that indicate how and why students have failed on those quests. While the in-game “class trainers” may have pointed the students at some helpful resources for the quests along the way, she can further support this system by providing extra assistance either in-game or in person, or by assigning group quests with other classmates who might help a struggling student.

Working the Example

The preceding example is, of course, filled with assumptions about the mechanics, systems, and ideas that an experiential learning MMORPG should inherit from traditional MMORPGs. It is an open question, for instance, as to whether an MMORPG should inherit an experience point-derived leveling system for its feedback and character progression mechanisms. For our session, we will unpack the systems most relevant to our project at that moment and to the assembled audience, inviting the audience into our design decisions. Care will be taken to make distinctions about what might be correct for our experiential learning MMORPG vs. another type of learning MMORPG, and we will discuss the formal properties of commercial MMORPGs as well. Some possible topics in addition to drilling into specific hypothetical questing mechanisms and prototypes include:

- *Sustainability*: A central conceit of MMORPGs is that they persist, continuing to be developed and expanded well beyond the initial life of the originally shipped title. This poses new and difficult questions for a research project surrounding social issues like access and equity, business concerns such as the transition from university property to some managing body, and research/design questions like whether to implement different versions of the game on different shards, even though it may produce unbalanced gameplay or confusion in the player community.
- *User feedback from very early user testing*: Early testing of the game will have occurred and still be underway. This will dig in not only to how players responded to various prototypes, but

what we will have learned about our player base and how our cultural model is adapting to the input of a nascent player community.

- *Considering disciplinarity, epistemology and class-based RPGs*: In this thread, we might consider our model in which players are playing through the lenses of mathematics and biology and how that relates to the collaborative work that emerges in science as it is practiced by professionals. We will be prepared to talk about mechanics that allow an entire shard to progress through scientific revolutions together based on their collective discoveries. In essence, these shards would be able to progress through a *Civilization IV*-style Tech Tree, but by the actions and decisions of all, not just a single player.

Conclusion

The timing of the Games, Learning, and Society conference would be a perfect spot in the development of this very large and complex project to invite in our colleagues in the community for a discussion about its development and its core principles. Few places other than GLS would provide the right types of criticism and insight into such a big project. In turn, we hope to use our project as a means to discuss current research in the field and the development of large, complex projects that may have a life beyond research.

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