Mission HydroSci: Meeting Learning Standards Through Gameplay

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Abstract: Mission HydroSci (MHS) teaches water systems and scientific argumentation towards meeting Next Generation Science Standards. MHS is a game-based 3D virtual environment for enacting transformational role-playing, wherein students must learn new knowledge and competencies in order to successfully complete the game missions. MHS was developed for middle school science as a replacement unit of about 6 to 8 hours and uses analytics and a teacher dashboard to help support teachers support their students.

Introduction

Mission HydroSci (MHS) is a game-based 3D virtual environment for teaching and learning key concepts and knowledge of water systems as well as building competencies in scientific argumentation in ways that support meeting Next Generation Science Standards (NGSS). Meeting these new science education goals for middle school students requires rich learning contexts for exploring substantive science ideas through engagement in scientific practices. Our goal is to meet these educational goals for all learners by using online learning to serve those in distance education and rural communities as well as more traditional and wellresourced classrooms, and to use gaming to engage and support students who typically do not see themselves as successful science learners.

MHS is a research and development project funded by grants from the U.S. Department of Education. The grant support has enabled a team of researchers, science educators, learning and game designers, creative arts professionals and software developers to build MHS through an iterative process. The process started with envisioning a powerful fit between emerging technological capabilities and the requirements of teaching and learning to NGSS. Next came conceptualizing a complete system to engage and teach students a robust curriculum and then building and testing each component of the system. The building and testing process has included prototyping, creating design documents, such as requirements specifications and storyboards and building initial versions which then can be taken to usability testing and further refined. Once we felt a substantial portion of MHS was playable and met our requirements specifications for teaching and learning activities through implementation of the curriculum as a game, we conducted usage testing in live classrooms. The usage testing taught us about the practical challenges of using a game in classrooms as well as identifying many areas of gameplay that needed improvement. Our intention and obligation to the funding sources is to undertake a field test using a randomized control trial (RCT) to rigorously evaluate the impact of MHS game play. The RCT will be undertaken in Winter, 2019. However, to test the feasibility of conducting a large field test in classrooms we undertook a feasibility field test in the Spring of 2018. This report and showcase describes MHS and presents some insights about the use of MHS in classrooms from interviews with 12 teachers who participated in the 2018 feasibility testing.

Rationale for MHS

While MHS is a research project with goals of understanding and testing the potential impacts of a gameplay approach on teaching and learning and of developing gameplay strategies that map to teaching and learning approaches, it is also a product development project aspiring to build a game that middle school science teachers will use to meet important learning objectives in their science curriculum in ways that align with the NGSS. MHS targets general and earth science courses by meeting learning objectives for understanding water systems and building competencies in scientific argumentation. The MHS game provides an active learning environment for meeting these learning objectives by engaging students in a narrative about needing to investigate water resources and use scientific argumentation to complete missions critical to the survival and accomplishments of the members of their scientific enterprise. The enterprise is set on an earth-like planet in the future as the science cadets (our player and a set of non-player characters who serve as guides, partners and sometimes antagonists) explore mysteries and prepare for survival on the planet. Along with the narrative gameplay MHS includes learning progressions for water systems science and scientific argumentation, a visually exciting environment, substantial interaction and feedback, and applies transformational role-playing as an approach to integrate learning within gameplay.

The theory of transformational play (Barab, Gresfali & Ingram-Goble, 2010) shows how specific design strategies can optimize the potential of games and gameplay to lead to desired learning outcomes. The design strategies to enact transformational play include the student taking on the role of a protagonist, who must use subject matter knowledge to make decisions and take action during play, and having these actions and decisions transform the problem-based situation. In turn the student's understanding of the subject matter is transformed and so is the student's identity. Virtualization and role-playing experiences in MHS are intended to make realistic actions possible and bring about the consequences of actions to dynamically impact the world and the learner.

Building competence with scientific practices, such as scientific argumentation, requires learning a progression of competencies, thus multiple practice settings and iteration with feedback must be provided. The game experience helps sustain the student through the many activities as well as makes it OK and natural to fail and try again. MHS is a first person narrative adventure with a sustained learning experience of 6 to 8 hours of instructional time for gameplay and 1 to 2 hours of supplementary classroom or discussion board activity for the teacher to clarify, supplement, and extend the learning from the gameplay.

Game Play

Unit 1

Unit 1 introduces students to (1) gameplay including game controls, characters and narrative, (2) scientific argumentation as a process of using evidence to judge between competing claims and (3) the argumentation engine that will be used to conduct arguments during game play. The design task of unit 1 is to help the player get off to a good start, but also to set the stage for engaging at one's own pace, so as to learn how to succeed in the game and not just to move through the game. The tutorial nature of the starting tasks are counter balanced by interesting and fun visuals, learning about interesting NPC characters, and an exciting start to the game.

The unit starts with the player awakening on a space station orbiting an alien but earth-like planet. The player is introduced to ARF who will be an assistant for the player's exploration and activities. ARF is presented as a buddy, given an avatar of a dog, and a high form of artificial intelligence to assist the player. The player also meets Dr. Toppo who is the mission leader and sets up challenges for the player throughout the game. After learning some basics of how to navigate and play MHS as well as being introduced to other NPC's and tools to be used throughout the game, the space-craft if rocked with an explosion and our player must escape the station and fly to the alien planet.

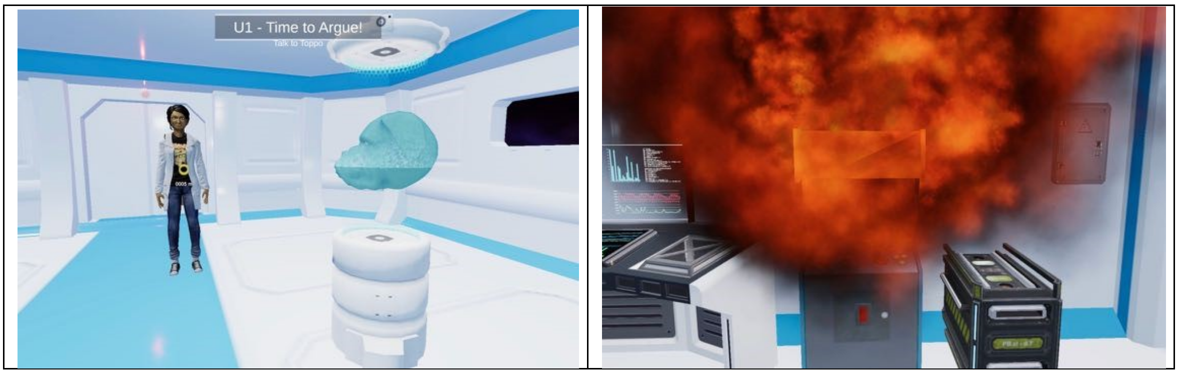

Figure 1. Meeting Dr. Toppo and ARF on the spacecraft and the explosion.

Unit 2

Unit 2 teaches players about topography and using a topographic map as well as understanding watershed and how the relative size of the watershed is related to the amount of water flowing through it. After crash landing on the alien planet our player practices some of the skills they learned in unit 1 while collecting scrap to repair a broken hoverboard and tracking down the communication equipment which they will need to move rapidly on the large terrain and find the rest of their team. In order to find the team they must use a topographic map and respond to clues and feedback framed using topographic terminology. Once they have located the team, our player is assigned the task of finding which watershed is larger and thus best for setting up the base camp for the expedition. After traveling to key waterfalls and gathering evidence our player engages in an argument where she must use evidence to support the claim of which watershed is largest.

Figure 2. Finding the team and reaching the waterfall to collect data about watersheds.

Unit 3

Unit 3 teaches about surface water with the learning objectives of having the player be able to predict the spread of a dissolved material through a watershed and identify the direction of water flow based on a map of a watershed. This is enacted narratively through one of the NPCs, Sam, who needs to set up her camp but her supplies are scattered all over the terrain. Our player must find the supplies and figure out which waterways to use in order to float them back to Sam's camp. Upon completing the task, our player returns to the base only to find that Sam's base is polluted and she asks our player to solve what's causing the pollution by tracing the source of the pollution. The player does this by throwing sensors into the nearby river and eventually will find wreckage from the space station explosion. Our player works their way up the river and then must create a good argument using reasoning to connect evidence with a claim in order to get the pollutant removed. Next, our player discovers that the aliens had left irrigation devices to support growing food in gardens, which will be extremely important for the success of the expedition. Unfortunately, the pumps are old and need to be replaced. By succeeding at solving the first of the dungeon-like puzzles the player unlocks new pumps and then must use their knowledge of surface water flow to pick which irrigation systems to restart.

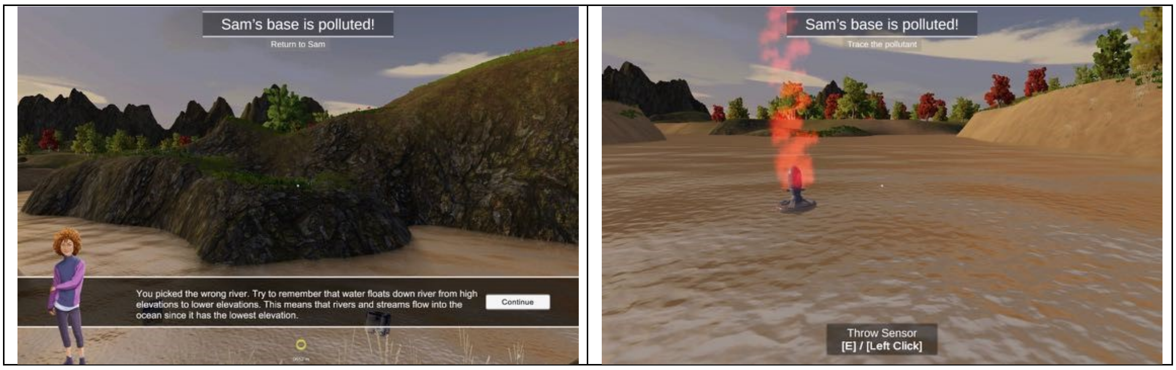

Figure 3. Sam telling you that the crate was tossed in the wrong river and tossing sensor in river to collect evidence for finding the pollution.

Next Steps

As noted in the introduction, the MHS team is planning a substantial field test of MHS for the winter/spring of 2019. To reach the field test we have prioritized several objectives. First, we need to achieve technical soundness, optimization to perform on as low a performance computer as possible, and clear direction for what systems will work. Second, improvements across a range of quests and tasks to better achieve learning outcomes. Third, making argumentation a better fit to the rest of the gameplay and providing support for students who are likely to struggle with the competencies. Finally, support for low readers by adding audio for dialog, low experience gamers by adding better feedback, clearer graphics, more tutorials and simplifying some game mechanisms and activities, as well as support for high gamers by enriched graphics and rewards and side quests. More information about MHS can be found at MHS.missouri.edu or by contacting the authors.

References

Barab, S., Gresfali, M. & Ingram-Goble. A. 2010. Transformational play using games to position person, content and context. *Educational Researcher 39,* 7 (2010), 525-536.

Griffin, J., Kim, S. M., Sigoloff, J., Sadler, T. D., & Laffey, J. (2016, August). *Designing scientific argumentation into Mission HydroSci.* Proceedings of the Games + Learning + Society Conference. Madison, WI

Laffey, J., Sadler, T., Goggins, S., Griffin, J. & Babiuch, R. (2015). Mission HydroSci: Distance Learning through Game-Based 3D Virtual Learning Environments. In Russell, D. & Laffey, J. (Eds.), Handbook of Research on Gaming Trends in P-12 Education. (pp. 421-441). Hershey, PA: IGI Global. doi:10.4018/9781-4666-9629-7

Laffey, J., Griffin, J., Babiuch, R., Sigoloff, J., Kim, S. M., Sadler, T. D., & Goggins, S. (2016, August). *Mission HydroSci: Designing a game for next generation science standards.* Proceedings of the Games + Learning + Society Conference. Madison, WI.

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By State*s. Washington, DC: The National Academies Press.

Osborne, J., Henderson, B., MacPherson, A., & Szu, E. (2013). *Building a learning progression for argument in science.* Paper presented at the annual conference of the American Educational Research Association Conference, San Francisco, CA.

Shulman (Eds.), *Issues in education research: Problems and possibilities* (pp. 399-409). San Francisco: Jossey-Bass Publishers.

Hawkins, J., & Pea, R. D. (1987). Tools for bridging the cultures of everyday and scientific thinking. *Journal for Research in Science Teaching*, *24*, 291-307.

Lave, J. (1987). *Cognition in practice*. New York: Cambridge University Press.

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