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The Mystery of Lehigh Gap: Game-based VR for Informal Learning

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Abstract. Game-based Virtual Reality (VR) holds much potential to enhance informal education settings, whether in libraries, museums, environmental centers, or at home. We have designed and developed *Mystery of the Lehigh Gap*, a VR game for adolescents and adults to learn about the historical changes that occurred in the Lehigh Gap, Pennsylvania, USA due to a zinc smelting plant that operated from 1898-1980. We present the design principles that guided our project's development, which were derived from the research literature on designing learning for informal science education environments, and the affordances that gamified VR can provide. Our iLRN poster with accompanied video presents the first section of the *Mystery of the Lehigh Gap*. It highlights the narrative context and a series of mini-games in which players learn about historical mining, transportation, and industrial processes at a zinc smelting plant that converted a pristine landscape with vegetation to a barren moonscape. During our poster session, we will discuss our design and development work.

Keywords: game-based VR, environmental education, game design.

Introduction

Learning about one's watershed with game-based VR can have a positive impact on engagement and learning [1], particularly in informal learning environments and at home. Engagement is critical to learning in informal STEM education [2]. The level of engagement with exhibits and artifacts, however, often varies for adolescents and adults in informal education centers. Game-based VR learning activities require interactivity and during informal education, learners are engaged by experiences that offer interactivity [2],[3]. According to *Learning Science in Informal Environments* [2], a goal of informal education is to introduce new media technologies (for example, game-based VR) into

learning environments to enhance and modernize the quality of the visitor experience and improve learning.

Games have potential to advance multiple learning goals. Studies have demonstrated the potential of digital games to support learning in terms of conceptual understanding (e.g., [4], [5]), process skills and practices (e.g., [6], [7], epistemological understanding (e.g., [8, 9]), and players' attitudes, identity, and engagement (e.g., [10], [11]. Furthermore, games have shown promise to promote motivation in learning with individuals from non-dominant racial, ethnic, and economic cultural backgrounds [12].

Game-based VR presents several characteristics of great appeal to learners and can be an enhancement to informal education settings, whether in libraries, museums, environmental centers, or at home. Features such as active control of the user experience and authentic representations of real-world situations can increase engagement and learning. Furthermore, gamified headset VR focuses users' attention on learning tasks and does not deflect attention [1]. In a VR game environment, authentic imagery, content, animations, video, and narration can be incorporated to provide learners with a highly immersive learning experience. Since VR technology allows for such supports in an immersive environment, it can be designed to promote improved access to environmental content, especially when learning about historical changes over time with regards to how anthropogenic activities affect a natural environment.

We have designed and developed *Mystery of the Lehigh Gap* for adolescents and adults to learn about the historical changes that occurred in the Lehigh Gap, Pennsylvania, USA due to a zinc smelting plant that operated from 1898-1980. The design principles for our project draw heavily from the research literature on designing learning for informal science education environments and the affordances that gamified VR can provide. These include:

1. *Situate learning experiences both locally and historically*. Learning experiences should reflect a view of science as influenced by individual experience as well as social and historical contexts [2].
2. *Design for diverse populations*. Learning environments should be both accessible designed to engage participants' cultural contexts, including everyday language and local cultural practices [2].
3. *Use multiple and varied representations*. Use effective combinations of imagery, 3D visualizations, animation, audio, and text to enhance learning and transfer (see [13]). Concrete, sensory, and immersive experiences can promote deeper understandings and sense-making of concepts [14].
4. *Engage learners in challenging tasks*. Distinct challenges within a learning game keep learners engaged and challenged. Designing for the right challenge-skill balance promotes engagement and an intrinsically rewarding experience for the learner [15].
5. *Feature authentic issues*. To make learning engaging, learners need to feel the

relevance and authenticity of the learning activity [16].

6. *Provide a strong narrative*. A game designed for informal use requires strong narrative elements to generate excitement, interest, or enthusiasm for learning [17]. "Mystery" narratives use questions, problems, or missions to enhance learner motivation [18] (Wilson et al., 2009).
7. *Provide supportive guidance and motivational feedback*. Guidance in the form of advice, feedback, prompts, and scaffolding can promote deeper learning [19]. Support is also enhanced by different forms of engaging feedback such as badges or points [20].

Our iLRN poster with accompanied video will present the first section of the *Mystery of the Lehigh Gap.* The VR experience begins with a series of cut scenes to introduce the player to the mystery: how the north side of the Kittatinny ridge went from pristine landscape with vegetation to a barren moonscape and then to a grassland (see Fig.1.). First, the player is introduced to a short animated video that presents the geologic formation of the Lehigh Gap (see Fig. 2.). After the video, the game shifts to the year 1845 where two non-playable characters (NPC) townspeople discuss a zinc mine discovery. The game then time travels to 1853 where Joseph Wharton, an authentic historical figure, discusses zinc ore mining and the idea of forming a zinc ore business. Then, the player engages with two mini-games to mine zinc ore (see Fig. 3.) and anthracite coal, the fuel source for a zinc smelting plant. After that, players time travel to 1912 where NPC Stephen Palmer discusses the formation of his New Jersey Zinc Company plant. There, the player engages with two other mini-games that highlight the process of transporting anthracite coal via canal boats (see Fig. 4.) and zinc ore via trains to the plant. Finally, players go inside the plant where NPC workers discuss the smelting process to make zinc ingots. The player starts furnace firing by playing a mini-game to heat up a plant furnace to 2700 degrees and then engages with a zinc smelting mini-game to make a zinc ingot (see Fig. 5. and 6.).

Users of our initial protype mini-game found the games engaging and reported that the games helped them to understand how raw materials were mined and transported to a zinc smelting plant. The players noted that the games enhanced their understanding of the industrial processes involved with zinc ore. In addition to describing the game, our iLRN poster will also present the VR game's UI features. During our poster session, we will discuss how VR games can enhance informal education settings, whether in libraries, museums, environmental centers, or at home.

Fig. 1. Images from the opening cut scene to introduce the mystery.

Fig. 2. Images from the formation of the Lehigh Gap video.

Fig. 3. Image showing the zinc ore mining mini-game.

Fig 4. Image showing the anthracite coal transportation mini-game.

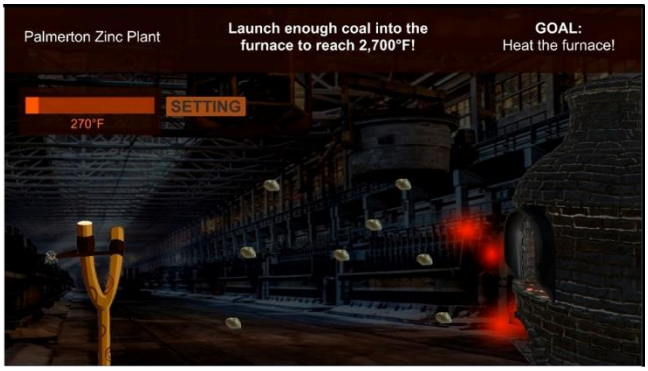

Fig. 5. Image showing the furnace firing mini-game.

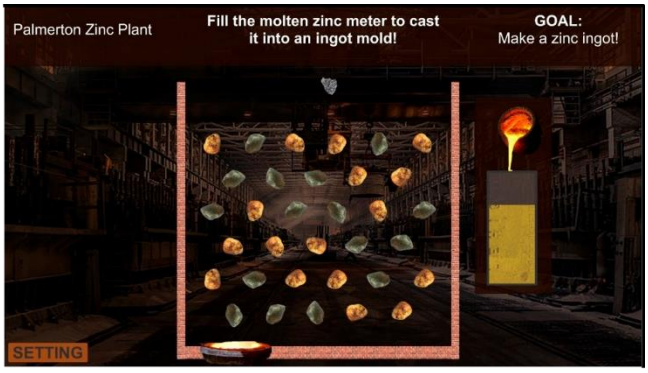

Fig. 6. Image showing the zinc smelting mini-game.

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