Work-in-Progress–Immersive Virtual Reality Design Considerations to Promote Learning for English Language Learners

Robson Araujo Junior
Department of Education and Human Services
Lehigh University
Bethlehem, PA, USA
0000-0002-8692-4823

Alec Bodzin
Department of Education and Human Services
Lehigh University
Bethlehem, PA, USA
amb4@lehigh.edu

***Abstract*—This work-in-progress paper describes an immersive virtual reality (iVR) learning game for informal education to promote enhanced engagement, improved spatial thinking, and broader understandings of the Lehigh River watershed's cultural history, geography, and environmental issues. Our instructional design includes game design features in addition to learning elements. We provide design guidelines for adolescents and adults who are English language learners, including (a) autonomous learning, (b) fostering learners' use of metacognitive strategies, (c) adaptive, supportive, and motivational feedback to maintain engagement, d) sustained time on task, and e) content knowledge learning and language comprehension.**

Index terms—immersive virtual reality, English language learners, design principles, environmental education

I. Introduction

Exploring the Lehigh Valley Watershed is an environmental education immersive virtual reality (iVR) learning game for informal learning settings (e.g., STEM education centers and public libraries) to promote enhanced engagement, improved spatial thinking, and broader understandings of the Lehigh watershed's cultural history, geography, and environmental issues. This is the first of a series of five iVR gaming experiences that we are developing about environmental issues and impacts in the Lehigh Valley watershed for adolescent and adult learners who live along the Lehigh River.

The first iVR instructional narrative storyboarding and game design are underway. Prototype testing is planned to take place beginning August 2020. Participants include Pennsylvania residents of the Lehigh Valley, mostly from Lehigh and Northampton counties, who are thirteen or older. Lehigh Valley demographics are 68.8% White, 20.2% Hispanic, 8.5% Black, and 12.5% other. The Lehigh Valley includes urban (cities of Allentown, Bethlehem, and Easton), rural, and suburban populations. Thus, our target population includes both adolescents and adults who are English language learners (ELLs).

II. Lehigh River Watershed iVR Games

The iVR gaming learning experiences focus on promoting users' spatial knowledge of the Lehigh Valley watershed using environmental case studies which impact the watershed and water quality within it. Each iVR is ready-to-use. Instructions are provided within the game experience, which contributes to:

1. *fostering students' autonomy*.
2. *aligning with learner-centered approaches*: Where instructional VR learning materials act as facilitators of content knowledge, and language learning [1].

The scope of the instructional materials in the Lehigh Watershed iVR learning games is similar to a thematic reading course. Thus, word frequency lists are being used to manage the language content coverage and to promote learning of local environmental specific issues and academic language. Once a set of lists is chosen, they not only become a vocabulary matrix of what needs to be included in the iVR game, but also informs what should not be included in it [2].

A. iVR Learning Goal

This multidisciplinary (History, Topography, and Environmental Studies) iVR learning experience will demonstrate the environmental importance of nine pre-selected sites in the Lehigh River watershed. First, learners will be introduced to the region with a fly-by upstream, followed by an immersive guided exploration of each area while canoeing downstream the Lehigh River. Ultimately, learners will recommend the addition of a boat ramp in the sites they believe are best deserving of better tourism infrastructure along the Lehigh River water trail.

B. Game Design Elements and Learning Principles

The following design elements from the instructional design literature have been adopted to ensure that the iVR game learning activities are engaging and culturally relevant for our diverse audience that includes ELLs. These include design for game-based learning [3], [4], locally and historically situated learning experiences [5], design for diverse populations [6], multiple and varied representations [7], [8], learners' autonomy and engagement development through challenging tasks [9],

978-1-7348995-0-4/20/$31.00 ©2020 Immersive Learning Research Network

compelling narratives [10], authentic issues [11], on-demand supportive guidance [12], and motivational feedback [13].

Similarly, our iVR work applies learning theories, principles, and methods from the research literature on transformational play [14], design-based research [15], [16], video games, affinity spaces, and 21st century learning [17], resonant games [18], and design thinking for education and multimodal integration of STEM curricula guidelines [19], [20].

III. Usage of Word Frequency Lists

The use of frequency word lists can systematically scaffold the development of content materials for ELLs [2]. Using lists also allow the instructional material designer to determine the content to be taught, practiced, and assessed. Therefore, the use of word lists helps to delineate the language learning goals of the iVR games. The following lists have been used as reference for our development work:

- Michael West's *2000 headwords of the General Service List (GSL)* [21]
- The *570 Academic Word List (AWL)* [22]
- The *first 3000 from the British National Corpus/Corpus of Contemporary American English*: These were chosen for being an alternative corpus for West's seminal GSL [2], [23]
- The *New GSL (1000/2000,2800)* and the *New AWL (960)*: More recently developed by Charles Browne, Brent Culligan & Joe Phillips [24]

IV. Format and Presentation of Content and Task

Each Lehigh Watershed iVR game has a set format of content presentation. That is advantageous for language learning because each game's unique activity patterns serve as an instructional scaffold [2]. To provide repeated sequencing or increased opportunities for learners to encounter the selected content to be learned, the idea of implementing an extra collectible system in the games emerged. This mechanism is similar to a digital portfolio (e.g., a photo album, a sticker sheet, or a card collection) that would be completed as players interact with each content feature in the game.

Students will get some of these collectables as they progress in the gameplay, which increases the encounter with the target vocabulary or concepts by, at least, one more time. Should they not have their collection completed by the time they finish their iVR experience; the non-playable character (NPC) that mentors students during gameplay (e.g., in-game content expert guides) reminds the learner they can collect the rest by revisiting each location. In short, increasing learners' exposure to varied vocabulary and concept representations will likely enhance the amount of specific content learning [25]. The rationale for this in-game mechanic addition is:

1. *Using mnemonics to favor language learning* [26].
2. *Schema scaffolding through item categorization* [27] of:
   a. key locations,
   b. built environment vs. natural elements, and
   c. academic/technical vocabulary of tools or procedures.

V. Monitoring and Assessment

In order to check if tasks within the iVR game's learning objectives have been met, we, as researchers, need to collect learners' evidence of the "enduring understandings" [28] the material intends to promote. Hence, the need for assessment measures. The following are some ways to assess learners at the beginning, middle, and end of their gameplay, which under a research design lens functions similarly as pre/posttests for measures of individual performance, and includes Likert-scale affective/behavior items for collecting data regarding individual attitudes towards the intervention [29].

A. In-game Assessment for English Language Learners

We use the format of image based Completely Automated Public Turing Test to Tell Computers and Humans Apart (CAPTCHA) [30], [31] (figure 1) to tie together concepts, content understandings, and imagery. In this type of activity, the learner has multiple chances to select the correct number of images that refer to the key word in the title. During the initial tutorial dialogues in the iVR, the virtual mentor will request the learner's assistance to help them calibrate some system or app by check the status of the captcha system. Another example of quick diagnostic/achievement assessment is a pre-reading activity called *"I don't know, Maybe I know…, I know, Now I know!"*(figure 2). These types of activities could as well be prompted both at the beginning and end of gameplay. Thus, the implementation of a pre-test / post-test data collection procedure could be embedded in a game experience.

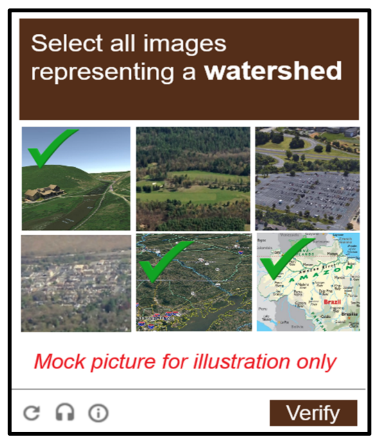

Fig. 1. Mock visual representation of an imagery CAPTCHA web validation system. Accessibility options are available including voice over, reset button, more details.

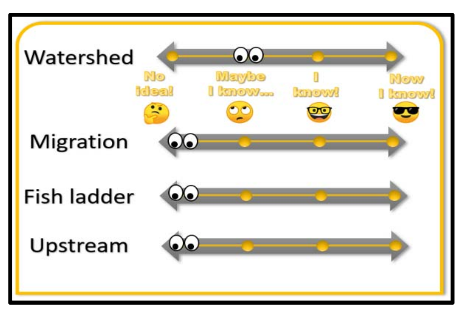

Fig. 2. Adapted 'pre-reading' language activity to address the specific vocabulary needs of our iVR games. Emojis were used as a visual stimulus to engage learners with something that is pervasive in their lives.

Moreover, the inclusion of active monitoring features besides the progress badge board (i.e., a passive monitoring feature) are used to enhance students' metacognitive performance. These include (a) a panel called "my notes" located on the pause menu that displays a graphical checklist of places visited (figure 3), and (b) an interactive 'magnet-style' map (figure 4). Besides being a multimodal format of self-monitoring activity, the magnetic board provides strategic repetition of content vocabulary with imagery, emoticons and content language chunks. Therefore, 'freer' types of activities become another way of presenting specific content, reinforces intended learning, and could serve as a formative assessment tool.

VI. ACOMMODATIONS FOR DIVERSE LEARNERS' NEEDS

Should learners need extra support in the iVR, the virtual tutor will be on call for individual help requests. In addition, a desktop version of the iVR is available online for individuals who cannot use VR headsets due to dizziness, headaches, nausea, or personal choice. Other specific accommodations we are using in our development work include:

- *American with Disabilities Act compliance*: The design and development of the iVR follows the WCAG 2.0 guidelines to at least reach levels A and AA of accessibility.
- *Some physical disabilities:* No use of colors red and green in texts and important visual elements to avoid the most common types of color blindness and the use of gaze system (i.e., movement and selection with head movements only).
- *Language learning needs:*
    a. Translation on demand functionality (initially for Spanish, French, and Portuguese),
    b. three levels of narration speeds,
    c. highlighting for texts (figure 5), and
    d. closed captions for dialogues.

Potential areas of difficulty with the content and correction guidelines. When stating the environmental importance of each location, if learners select incorrect answers, they will receive hints from the expert guide NPC, until they choose the correct one. Since this may be a learners' first time wearing a VR headset, individual support is expected (even with guided instruction and instructor modeling). This usually happens during their first time using the iVR.

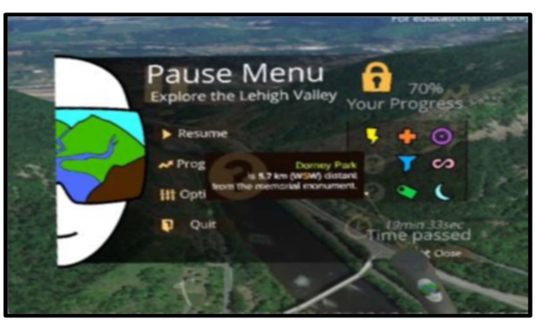

Fig. 3. Screenshot from the Oculus GO iVR version of the working prototype [32]. The pause menu contains **progress monitoring features** and hints to assist the learner during their gameplay.

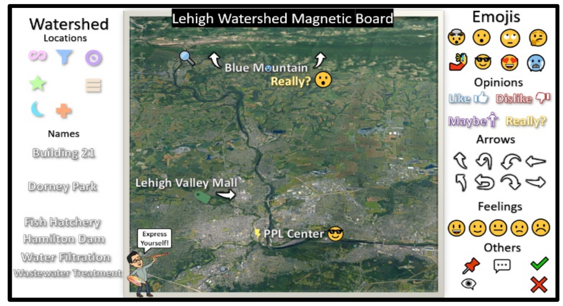

Fig. 4. Visual concept of the magnetic board activity for extra monitoring features and more opportunities for content knowledge and specific target vocabulary learning.

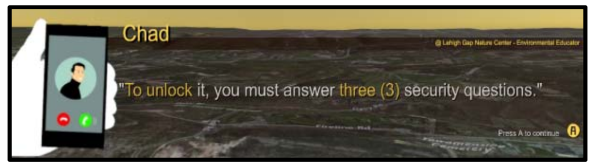

Fig. 5. Screenshot from the desktop VR version [32]. This is an excerpt of the first dialogue of the game, when the player learns about their quest to search for the key and the details of how to deactivate the LGNC's security alarm. It is possible to see the **word highlighting feature** to assist learners' **attention to important details**.

VII. CLOSING THOUGHTS

The instructional gaming materials from the Lehigh Watershed VR project are designed specifically for the nonformal STEM education learning environments in which they will be enacted. Our iVR design and development work adopt design principles for learning, game design, and language curriculum development [2]. These include a) metacognitive strategies (e.g., ways of monitoring one's progress), b) autonomy (e.g., students are able to complete the tasks on their own pace), c) ongoing motivational and supportive feedback to keep learners engaged, d) sustained time on task due to the innovative iVR game-based approach, and e) comprehensible content knowledge input deriving from the analysis and adaptation of texts and authentic materials.

The use of AntWordProfiler [33] allowed the preparation of linguistically accessible instructional materials. Choosing the lexical approach as content framework for the development of the Lehigh River watershed iVR learning games contributed for a better selection of vocabulary groups to be presented and, most importantly, reinforced throughout the learning experience. Knowing what not to include in the iVR learning material [2] is also a great benefit of using frequency word lists.

REFERENCES

[1] S. O'dwyer, "The English Teacher as Facilitator and Authority," *TESL-EJ*, vol. 9, no. 4, pp. 1-15, 2006.

[2] I. S. P. Nation and J. Macalister, *Language Curriculum Design.* Taylor & Francis, 2009.

[3] Z. Alaswad and L. Nadolny, "Designing for game-based learning: The effective integration of technology to support learning," *Journal of Educational Technology Systems*, vol. 43, no. 4, pp. 389-402, 2015.

[4] L. Nadolny, Z. Alaswad, D. Culver, and W. Wang, "Designing with game-based learning: Game mechanics from middle school to higher education," *Simulation & Gaming*, vol. 48, no. 6, pp. 814-831, 2017.

[5] C. S. Wallace and L. Brooks, "Learning to teach elementary science in an experiential, informal context: Culture, learning, and identity," *Science Education*, vol. 99, no. 1, pp. 174-198, 2015.

[6] F. L. Vallera and M. D. Lewis, "Andragogical design considerations for online multicultural education," in *Handbook of Research on Cross-Cultural Online Learning in Higher Education*: IGI Global, 2019, pp. 364-383.

[7] C. Dede, T. A. Grotzer, A. Kamarainen, and S. Metcalf, "EcoXPT: Designing for deeper learning through experimentation in an immersive virtual ecosystem," *Journal of Educational Technology & Society*, vol. 20, no. 4, pp. 166-178, 2017.

[8] M. A. Rau, "Conditions for the effectiveness of multiple visual representations in enhancing STEM learning," *Educational Psychology Review*, vol. 29, no. 4, pp. 717-761, 2017.

[9] E. Lee and M. J. Hannafin, "A design framework for enhancing engagement in student-centered learning: Own it, learn it, and share it," *Educational technology research and development*, vol. 64, no. 4, pp. 707-734, 2016.

[10] O. De Troyer, F. Van Broeckhoven, and J. Vlieghe, "Linking serious game narratives with pedagogical theories and pedagogical design strategies," *Journal of Computing in Higher Education*, vol. 29, no. 3, pp. 549-573, 2017.

[11] E. Hu-Au and J. J. Lee, "Virtual reality in education: a tool for learning in the experience age," *International Journal of Innovation in Education*, vol. 4, no. 4, pp. 215-226, 2017.

[12] K. Scheiter et al., "Adaptive multimedia: Using gaze-contingent instructional guidance to provide personalized processing support," *Computers & Education*, vol. 139, pp. 31-47, 2019.

[13] L. Linnenbrink-Garcia, E. A. Patall, and R. Pekrun, "Adaptive motivation and emotion in education: Research and principles for instructional design," *Policy Insights from the Behavioral and Brain Sciences*, vol. 3, no. 2, pp. 228-236, 2016.

[14] S. Barab, P. Pettyjohn, M. Gresalfi, C. Volk, and M. Solomou, "Game-based curriculum and transformational play: Designing to meaningfully positioning person, content, and context," *Computers & Education*, vol. 58, no. 1, pp. 518-533, 2012.

[15] S. Barab and K. Squire, "Design-based research: Putting a stake in the ground," *The journal of the learning sciences*, vol. 13, no. 1, pp. 1-14, 2004.

[16] T. Anderson and J. Shattuck, "Design-based research: A decade of progress in education research?, " *Educational researcher*, vol. 41, no. 1, pp. 16-25, 2012.

[17] J. P. Gee, "Affinity spaces and 21st century learning," *Educational Technology*, pp. 27-31, 2017.

[18] E. Klopfer, J. Haas, S. Osterweil, and L. Rosenheck, *Resonant games: Design principles for learning games that connect hearts, minds, and the everyday*. MIT Press, 2018.

[19] F. L. Vallera and A. M. Bodzin, "Knowledge, Skills, or Attitudes/Beliefs: The Contexts of Agricultural Literacy in Upper-Elementary Science Curricula," *Journal of Agricultural Education*, vol. 57, no. 4, pp. 101-117, 2016.

[20] F. L. Vallera and A. M. Bodzin, "Integrating STEM with AgLIT (Agricultural Literacy Through Innovative Technology): The Efficacy of a Project-Based Curriculum for Upper-Primary Students," *International Journal of Science and Mathematics Education*, pp. 1-21, 2019.

[21] P. Nation, *Managing vocabulary learning*. SEAMEO Regional Language Centre, 2002.

[22] A. Coxhead, "A new academic word list," *TESOL quarterly*, vol. 34, no. 2, pp. 213-238, 2000.

[23] Nation, I.S.P., "The BNC/COCA Level 3 partial word family lists" (5 June, 2018). Distributed by Victoria University of Wellington. http://www.victoria.ac.nz/lals/staff/paul-nation.aspx

[24] C. Browne, "A new general service list: The better mousetrap we've been looking for," *Vocabulary Learning and Instruction*, vol. 3, no. 1, pp. 1-10, 2014.

[25] P. Nation, "How vocabulary is learned," *Indonesian JELT*, vol. 12, no. 1, pp. 1-14, 2017.

[26] A. D. Cohen, "The use of verbal and imagery mnemonics in second-language vocabulary learning," *Studies in second language acquisition*, vol. 9, no. 1, pp. 43-61, 1987.

[27] M. Driscoll, "Psychology of Learning for Instruction International Edition: Pearson Allyn and Bacon," 2005.

[28] G. Wiggins, G. P. Wiggins, and J. McTighe, Understanding by design. ASCD, 2005.

[29] J. W. Creswell, Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research., 4th ed. United Kingdom: Pearson, 2012.

[30] K. C. Madathil, J. S. Greenstein, and K. Horan, "Empirical studies to investigate the usability of text-and image-based CAPTCHAs," *International Journal of Industrial Ergonomics*, vol. 69, pp. 200-208, 2019.

[31] L. Von Ahn, M. Blum, and J. Langford, "Telling humans and computers apart automatically," *Communications of the ACM*, vol. 47, no. 2, pp. 56-60, 2004.

[32] A. Bodzin, R. Araujo Junior, D. Anastasio, T. Hammond, S. Kangas, E. Lindstrom, S. Rutzmoser, & F. Vallera, (2019). "A virtual reality game to identify locations in the Lehigh river watershed," in Proc. 5th Immersive Learning Research Network Conf., London, UK, 2019, pp. 148–150.

[33] L. Anthony, "AntWordProfiler (Version 1.4. 1)[Computer Software]. Tokyo, Japan: Waseda University," 2014.