INDEXICAL STORYTELLING IN COLLABORATIVE LEARNING ENVIRONMENTS IN STEM EDUCATION

Designing InViTE Collab - Interactive Virtual Teaching Environment for Collaborative Learning.

Raghad El-Shebiny

York University, Toronto, CA | Supervisor: Melanie Baljko | 2nd Reader: Kurt Thumlert

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Abstract

In this Major Research Project, I explore the concept of Indexical Storytelling as applied to teaching and learning. The Research Through Design and Student-Centered Educational Design methodologies are used to frame the design and building of a prototype of a new tool called *InViTE Collab – Interactive Virtual Teaching Environment for Collaborative Learning*. This design concept is a tool that supplements the use of a Learning Management System (LMS) by providing an environment that is interactive and that encourages collaborative learning by providing a game-like environment with task-based and narrative learning elements. This design concept reimagines traditional course content as collaborative or individual learning tasks that students can complete in an online open-world sandbox game. As students complete their tasks and go through the course game world, they can pick up virtual 'tools' that help them complete their current and subsequent tasks. Students can also use their avatar and their tools to alter the online environment and, in doing so, leave indices for others. Through these indices, students can "see" the prior and contemporaneous activity, interact, and collaborate with others in the learning environment, such as other students and the instructor(s) who are online simultaneously, contributing to the experience of online co-presence. Indexical Storytelling and games in post-secondary STEM education have many benefits, such as better student engagement, focus, and overall performance, as outlined in the paper. To explore the design concept, I instantiated a prototype called *InViTE Collab* and gathered feedback from current students. The main question targeted by this research is: **To what extent does the use of Indexical Storytelling in Virtual Learning Environments in Post-Secondary STEM programs afford better understanding and learnability?**

1. Introduction

This project aims to explore the idea of Indexical Storytelling, as described by Fernandez-Vara (Fernández-Vara, 2011), as a support for learning in Post-Secondary STEM Programs. The project centers around the designing of a tool called, InViTE Collab - Interactive Virtual Teaching Environment for Collaborative Learning.

In this paper, I first provide some background information (in Section 2) on where my project idea started and is now rooted. As well, I describe some prior works that have informed my project development and build the base of why I have chosen this specific topic. I demonstrate the knowledge gaps in the literature and describe how I plan to proceed in filling this gap with my work. Then I describe the methodologies used to explore this idea (in Section 3) that uses the Research through Design (RtD) and Student-Centered Educational Design methodologies. An initial design concept and structure is introduced with the first instantiation of the concept (in Section 4). I then iterate over the concept and build off the Initial design to generate more prototypes and explore different directions to move forward (In Sections 5 and 6). Following the iterations I discuss the implications of this project for my target audience (post-secondary STEM students) and suggest some directions for future work.

The base of all of the iterations can be described as a tool intended to supplement the use of a Learning Management System (LMS) (such as Moodle, Blackboard, Microsoft Teams) with an environment that is more interactive and better encourages collaborative learning by providing a game-like environment with task-based and narrative learning elements. This tool is meant not to just deliver written content to students, but instead to advance the idea to take certain kinds of written content and reimagine it as collaborative or individual learning tasks that students can complete in an online multiplayer sandbox game world. In the context of an undergraduate course (and within modules of that course), students can sign-in online and navigate through the game world and play their way through the modules of the course in the game world and complete their learning activities and assessments (lectures, assignments, etc.…) through game tasks set up by the course director. The game worlds will look like different ‘lands’ (with topographic, geographic, and story-based characteristics). In the context of a group assignment, students will have to be synchronously co-present in the game world to access and complete the task. The approach will help ensure even workload for the students, as the challenges will be set up in a way that the students will not be able to complete unless they work together. As students complete their tasks and go through the course game world, they will be afforded the opportunity to pick up game-world ‘tools’. These tools are both symbolic and practical in that they will show they have completed the task and help in the completion of subsequent tasks. The tools are a representation of the acquisition of learning tools and are designed to align with the course module’s learning objectives. Students, when using the tools that were picked up the game world, are able to alter and make changes in the online environment using these tools and, in doing so, leave indices for other people who come into the game world. The explanation of indices and examples can be found in the background section below. Through these indices, students also be able to “see” the prior and contemporaneous activity of others, and interact and collaborate with others (students, instructors, etc.…) who are online at the same time, contributing to the experience of co-presence.

2. Background

A. Indexical Storytelling

Many researchers have identified the importance of storytelling in education, whether in K-12 or higher education (Collins, 2006; Robin, 2008). Abrahamson even goes to state that storytelling is "the foundation of the teaching profession" (Abrahamson, 1998).

Indexical Storytelling is defined as "the construction of a game narrative mainly through indices. The story… is put together through different pieces…" (Fernández-Vara, 2011). Indexical and environmental storytelling both can benefit and improve learning spaces. They both have been used in classrooms (especially in elementary school settings), even before technology and video games existed. To illustrate the difference, we can consider two examples. If you look at how elementary school teachers manage the decoration of their classrooms to make sure the environment reflects the course that they are teaching and how they facilitate teaching, you will find many examples of both environmental and indexical storytelling. When the students walk into a room, they immediately know what subject they will be learning based on the environment around them. This form of storytelling can also stimulate the curiosity of the students allowing them to build more solid connections between the content of their class and how these topics fit into their narrative of the outside world. That is environmental storytelling. Every time the students are in that room, if they make something that relates to the lesson (e.g., some sort of drawing, or poster, etc.), that can get added to the room's décor. Then, when the next set of students enters the room or when the same set of students comes back the next time, the prior work is still there. It lets them know what happened in the room while they were out and gives them information about what they will be doing during their time in the class that day. That is indexical storytelling.

Fernández-Vara (2011) was the first scholar to begin using the term indexical storytelling and she was the one who first drew a distinction between indexical and environmental storytelling in the context of gameplay. The author identified that Indexical Storytelling[1] is what "specifies the ways in which story and game are integrated together based on leaving traces in the Gameworld." (Fernández-Vara, 2011). These traces can then be used by the player to reconstruct the history and stories in a game. Fernández-Vara defines two main categories of history in the context of a game: one, history of the game world; and two, history of the player. The author shows how indexical storytelling can be found in both categories of history and provides the names of several games which serve as illustrative examples for each of the different points. History of the game world, that is, the imprints of user actions over time?, was described as the easier of the two history types for finding examples of indexical storytelling, since it is the one most commonly used (Fernández-Vara, 2011). Although environmental and indexical

[1] The author, Fernández-Vara, capitalizes the terms Indexical Storytelling and Environmental Storytelling.

For the purposes of this MRP and research I will not adopt this convention (these terms are not proper nouns,

according to common grammar practices).

storytelling are used by some interchangeably, they are quite distinct. To the author, indexical storytelling can be considered as a part of environmental storytelling. Fernandez-Vara defines environmental storytelling as "a way to provide narrative context" (Fernández-Vara, 2011), whereas indexical storytelling is described as "[referring] specifically to generating stories through traces, both on the part of the designer and on the player… [and] is actually more story-building, both on the part of the designer and the player—the designer creates the elements of the story and integrates them in the world, the player has to interpret them and piece them together" (Fernández-Vara, 2011).

The main difference between environmental and indexical storytelling is in the role of the player. Environmental storytelling is done solely by the designer through devices such as placing elements in world scenes in specific ways to tell a certain story, whereas indexical storytelling involves the player as well because it consists of a second 'layer' over the environmental storytelling in which the players leave "indices" or "traces" in the world scenes (Fernández-Vara, 2012). These indices in the world persist and exist in the space (left as a marker) even after the player (who left them) exits the world. These traces are left and can be found by other players and in future sessions. They add to (or change) to the storyline that the designer originally created. This project is focusing on drawing on narrative tools, like indexical storytelling as described by Fernández-Vara, that can be used in games to create and facilitate a more interactive, dynamic, and collaborative learning environments. This project pulls on the application of the narrative in game worlds to consider the possibilities of applications of interactive and multimodal storytelling in STEM education.

There are many instances of environmental and indexical storytelling in environments beyond games (both video and non-video games), namely film and art, theme parks, as well as some classrooms. The synopsis of prior research in this section shows that indexical storytelling has not been discussed in the environment of university-level STEM courses that are mediated by a Learning Management System (LMS).

Some examples of similar previous research in games include: Game Spaces Speak Volumes & Environmental Storytelling (Fernández-Vara, 2011, 2012); Experiential Narrative in Game Environments (Calleja, 2009); Game INDEXICAL STORYTELLING: A story without words (Karlsson & Sääf Malm, 2021); Master's Thesis: Environmental Storytelling in Storyworlds (Andersen, 2019). There are also examples of non-video games that use indexical and environmental storytelling that are not as well documented in the scholarly literature; one example is escape rooms, and, more specifically, themed escape rooms, which is the most common kind of escape room. In essence, escape rooms are puzzle games and/or maze games, with both genres being present and most commonly. The story of each escape room is told through the environment and is informed by the players' histories. The experience of the escape room changes every time it is played, depending on who the people in the group are and what they do.

There are a few examples of scholarly research papers on how environmental and indexical cues in an environment can contribute to the story telling aspect in Film and Art. Two relevant examples are Content Potentials in Transmedia Storytelling (Johansen, 2014) and Stories for Eyes, Ears, and Muscles: The Evolution of Embodied Simulations (Grodal, 2009). Both instances highlight the importance of including multiple senses and different media to create a more complete and engaging storytelling experience, connecting storytelling and simulation. Grodal

(2009) speaks to how the relationship between games/interactivity and narrative shows that there are motivational and psychological reasons why linear storytelling is better for understanding; and why people usually tend towards them.

There is a large body of evidence to demonstrate the use of indexical storytelling in Theme Parks. We can focus on two of the biggest and most popular theme parks: Disney World (Orlando, FL) and Universal Studios (Orlando, FL). There are also other examples of smaller theme parks that use the same techniques as the bigger ones, such as Gatorland (Orlando, FL) and Weeki Wachee Springs (Orlando, FL). The book Theme Park Design & the Art of Themed Entertainment (Younger et al., 2016) provides an overview of some of the ways designers make decisions and the decision rationales. It speaks to many aspects of theme park design, including the ride design, land design (architecture and landscaping), the design of the educational elements in each of the other aspects of the design, and how all of these contribute to the entertainment, learning, believability, and immersive aspects of the theme parks. It uses examples from the existing structures and provides observational evidence (e.g., what the designers noticed the park attendees were doing and how they were responding to the different design choices). In terms of elements of indexical storytelling (i.e., the traces that others have left or are leaving in the space that can be found by others when entering the space), Younger et al. (2016) identified the following: people singing along to music, interactions you may have with other attendees, conversations you may overhear, things people have dropped or left behind, the pins you find at the pin trading posts (in Disney World), the food you eat, and even the interactions you have with cast members on rides or at different parts of the park. All of these are unique and can be different even when visiting the park at different times in the same day. These elements make each experience and interaction at the park unique to the experiencer. These experiences and interactions happened the way they did because the people (who were there beforehand or at the same time) did the exact things they did. If they had taken different actions, the experiences and interactions would be different. Thus, each new interaction within a given space provides the possibility of a new storyline, a new future experience, a new set of future interactions.

There are also many instances of educators using successful combinations of games, computer-based learning environments, and storytelling (environmental and verbal) to create more engaging work and a better learning environment for their students. Some examples of works that summarize these instances include: Augmenting the Discourse of Learning with Computer-Based Learning environments (Pea, 1992); Games in education – Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis(Merchant et al., 2014); and The Effective Uses of Digital Storytelling as a Teaching and Learning Tool (Robin, 2008). Drawing on the work of Kieran Egan in his books Primary Understanding (Kieran Egan, 1988) and Teaching as Story Telling (Egan, 1989) stating that narrative and storytelling is among the oldest cultural cognitive tools humans have dating back to before written history and literacy. Pea (1992) looked at the introduction of new computer-based learning tools that afford students better interactivity in the classroom and investigated the extent to which this helped support student learning**.** They raised the need to redesign the school environment to include more interactivity and technology centered learning. Merchant et al. (2014) discussed the benefits of using games and game environments in all educational spaces, K-12 and higher education. They collected 13 studies done on the use of games in education, 29 studies on the use of simulations in education, and 27 on the use of virtual worlds in education.

They then performed a meta-analysis of the results of these studies to ultimately reach unified results that showed that three categories --- games, simulations, and virtual worlds --- improved learning outcomes. Of the three categories, "games show[ed] higher learning gains that simulations and virtual worlds" (Merchant et al., 2014). The results showed that games and virtual worlds were the more effective of the three categories in terms of the overall learning outcomes. Even though there is an apparent benefit to including both games and virtual worlds in K-12 and higher education, the existence of all 3 categories is not mutually exclusive. Narrative, simulation, and virtual worlds can all co-exist within the same game. Robin (2008) discussed how the use of different media (e.g., multimedia, images, video, audio, etc.) could be used to tell better multimodal stories than narratives based on words/text only. The benefits outlined include better communication, better learnability, and better retention of the content. The work described the benefits to instructors and students, the implementation of this method of teaching and learning, and what is needed to make the teaching and learning digital. The author outlined the specific technologies needed to use digital storytelling in the classroom. In the context of this MRP proposal, the main take away from this work is the evidence that the use of multimedia and multimodal storytelling in education does yield better results in learning outcomes and, as well as it creates opportunities for students to construct and situationally design new knowledge using multimodal literacies and multimodal ensembles, as well as narrative tools (The New London Group, 1996). All the previous research affirms the idea that narrative systems and environmental storytelling resources enrich virtual and simulation learning environments by supporting meaningful engagement and connection with course content for a deeper learning experience.

B. Human Perception and Understanding in Virtual learning Environments

The overview of the research literature in Section 2A. shows little to no research on the effects of using Indexical storytelling in virtual environments for educational purposes. There are many examples of Indexical and Environmental storytelling research in the fields of games and game design, film and art, theme park design and education and how each of the fields has been influenced by adding elements of Environmental and Indexical storytelling.

The traces left behind by players in a game using Indexical storytelling can then be used by the player to reconstruct the history and stories in a game (Fernández-Vara, 2011). These can be split into two main categories: one, History of the Game World; and two, history of the player. They show how Indexical storytelling can affect either category with examples of which games the different points can be found in History of the Game World is mentioned as the easier of the two to find examples of Indexical storytelling in since it is the one most commonly used (Fernández-Vara, 2011). There are three further classifications for the games based on the behaviour that the player is expected to have in the game: Detective Work, Interpretation of Remains, Signage and Tutorials. Detective Work is where the player has to figure out what happened in the world they are in before their entry using the environment. Interpretation of Remains (inscriptions and the traces of events) is where the world is (re)constructed using past sessions, especially if it is an online world that anyone's game session remnants are visible to everyone who signs on. Signage and Tutorials is more explicit as it can be an actual sign that tells the player where they are and where they should be going next, this classification is most important for navigation and orienting oneself in the game world. There are many contentions for using signage in place of

tutorials as they become extradiegetic elements in the player's frame. That breaks the illusion of immersion in the game and storyline. Of the three classifications the design of the platform for this research uses a mid of Detective Work and Interpretation of Remains. Signage and Tutorials will mainly exist within the game tasks/assignments tied to the learning.

Calleja, the author of *Experiential Narrative in Game Environments*, defines virtual environments as "computer generated domains which create a perception of traversable space and afford the exertion of player agency. They are populated by objects and often human or AI controlled entities with whom players can interact with" (Calleja, 2009). The paper cites a GDC, Game Developers Conference, talk by Bioshock creative director, Ken Levine, where he differentiates between two modes of narrative: the push narrative and the pull narrative. The push narrative is described as the "more traditional" mode where the player has no part in writing the story but rather the story is pushed on them. Whereas the pull mode focuses on the actions of the player and their interaction with the designed environment. This research will focus more on the pull narrative mode as it relies on the indices left behind by the students in the open-world sandbox game environment to construct the narrative of their educational experience. Sandbox environments (like MineCraft) enable people to explore and text boundaries, in ways that are not always controlled by narrative structures or if/then systems of feedback and action, or allow users to have more agency in the story co-making (Gee, 2003).

INDEXICAL STORYTELLING: A story without words (Karlsson & Sääf Malm, 2021) is a small-scale study on how Indexical storytelling in a 3D scene affects a player's understanding of the story. The study had 10 participants that navigated through the 3D scene and underwent a semi-structures qualitative interview process. This allowed the researchers to see how much of the narrative the participants were able to understand from exploring the scene. They started with a pilot study to test their procedure identify any procedural flaws before the final testing for the main study. The analysis of the main study was split into four main parts: demographics; Indexical storytelling; colour psychology; and supernatural elements. The results showed that the player's background (what kinds of games they played and how much they played) influenced their understanding of the narrative of the scene. They found that participants with similar backgrounds had drawn similar conclusions and stories about what the narrative of the scene was.

Master's Thesis: Environmental Storytelling in Storyworlds (Andersen, 2019) is another study that was done to answer the question: "How does the choice and design of environmental storytelling elements influence the creation of emergent narrative in a storyworld format?" Anderson (2019) created and tested a prototype that uses Environmental and Indexical storytelling to see how these provisions affected the emergent narrative. They used 5 categories to describe a storyworld for analysis. The categories are Timeline, Setting, Characters, Rules, and Themes. They used between-group testing where they showed 2 groups of participants different versions of "the design of the environmental storytelling element." The participants are asked to go through a virtual environment then construct a storyworld after based on the environment they walk through. The storyworld is constructed by writing a small description in each of the 5 categories. The results show that using Indexical storytelling in the environment allowed for easier construction of a narrative. Which in the context of this paper translates to better understanding and learnability.

The *Content Potentials in Transmedia Storytelling* paper (Johansen, 2014) talks about interactivity and narrativity in transmedia storytelling and how the narrative properties can be enhanced if the narrative content took different forms of representation. It asks the questions of: what do these different forms of representation look like; and what kind of impact can these different forms have on the interactivity of a narrative in a transmedia environment? The main question of this research is: "What are the distinct qualities between interactivity and narrativity in transmedia storytelling?" The aim of this research was to "[examine the question] through a theoretical analysis with specifically assigned work questions leading each stage of the work as a result of an inquiring approach to the subject." The theoretical results of this research paper show that there are three main qualities that are not individually applicable to every case of transmedia storytelling but show the relationship between interactivity and narrativity. The first being "the possibility to make non-configurable media [, non-interactive pieces,] part of an interactive narrative". The second is "the possibility to shape content to specific representational formats." The third and last is "the potential for delivery channels to function both as fictional artifacts as well as mediators to fictional content." The work suggests that non-interactive elements in an environment can still contribute and shape the narrative of an interactive environment.

The *Stories for Eyes, Ears, and Muscles: The Evolution of Embodied Simulations* chapter (Grodal, 2009), in the books *Embodied Visions: Evolution, Emotion, Culture and Film* (Grodal, 2009) and *The Video Game Theory Reader (Wolf & Perron, 2004)*, speaks to how there are many different ways that storytelling can be presented, through games, film, written stories, etc. It outlines how interactive media relies on the relation between games/interactivity and narratives. It also discusses how this relationship shows that there are motivational and psychological reasons why linear storytelling is better for understanding; and why people usually tend towards them. The paper concludes that "[f]ilm and video games afford first-person perceptions, video games afford motor interaction, written stories afford complicated deviations from canonical representations, and so on. The media forms are therefore not only representations but also forms that afford new activities" (Grodal, 2009). This is based on the author's definition of what a narrative is meant to influence in the audience: perception, emotion, cognition, and motor actions (abbreviated as "PECMA"). The author also states that "[m]ediated representations may be experienced as "un- told," as a simulation of an experiential sequence, but also as "told," as a communicative text" (Grodal, 2009). This touches upon the idea of Indexical Storytelling and it contributes to the audience's experience.

The book *Theme Park Design & the Art of Themed Entertainment* (Younger et al., 2016) goes through some of the ways designers make decisions and why they do so. It speaks to many aspects of theme park design including the ride design, land design (architecture and landscaping), the design of the educational elements in each one, and how all of these contribute to the entertainment, learning, believability, and immersive aspects of the theme parks. It uses examples from the existing structures and what the designers noticed the park attendees were doing, how they were responding, to the different design choices. Some of these design choices in terms of Environmental storytelling are aspects like the little details in the designs on the fountains, lamp posts, buildings, the sounds coming from the hidden speakers everywhere, and even the ground that give the attendees the feeling of being transported to a new land. And in terms of Indexical storytelling, given that the main distinction is the traces that others leave in the space that you find when you enter the space. Things that can be considered Indexical elements are people singing along to music, interactions you may have with other attendees,

conversations you may overhear, things people have dropped or left behind, the pins you find at the pin trading posts (in Disney World), the food you eat, and even the interactions you have with cast members on rides or at different parts of the park. All of these are unique and can be different even if you visit the park at different times in the same day. These elements make each experience and new interaction at the park unique. But they would not have happened the way they did unless the people who were there before you, or where there at the same time as you, did the exact same things they did. Each new interaction with the space provides a new storyline, a new experience.

Augmenting the Discourse of Learning with Computer-Based Learning Environments paper (Pea, 1992) looks at the introduction of new computer-based learning tools that afford students better interactivity in the classroom and seeing how this helps support student learning. This paper speaks to the redesign of school environment to include more interactivity and technology centered learning to transform environments for deeper learning and engagement. A later article by the same author, Seeing What We Build Together: Distributed Multimedia Learning Environments for Transformative Communications (Pea, 1994), speaks to analyzing the tools have been designed to support computer-supported collaborative learning and how they were designed. As well as whether these designs promote the "togetherness" of collaborative learning. The author identifies that communication as a key practice to enhance collaborative learning with two key definitions of communication: transmission communication view and ritual communication view. The transmission view of communication centers around a transactional exchange or imparting of information. Whereas the ritual view as more of a societally or religiously centered form of communication, "not an act of imparting information, but the representation of a shared belief" Or the sharing of skills and skilled practice through situation action and mentorship (Lave & Wenger, 1991). The ritual view is where societies create the symbolic forms of communication, like songs, dances, art, and theatre, etc.… Looking further into the ritualistic view of communication, the aspects of Indexical Storytelling begin to emerge. When instructors are looking to share some new piece of complex, abstract information, which could be considered a transactional form of communication, they tend to find something that can relate or connect the topic back to something in the ritualistic form of communication. Students are therefore able to connect better with and are more likely to retain the abstract information and are engaged in practices that connect abstract knowledge with practice, doing, and situated action or manipulation of tools toward concrete user goals. The use of Indexical Storytelling in games follows the same path of linking the abstract to concrete game tasks that link directly to the course content.

The Effective Uses of Digital Storytelling as a Teaching and Learning Tool chapter (Robin, 2008), in the book *Handbook of Research on Teaching Literacy Through Communicative and Visual Arts, Vol. II (Flood et al., 2015),* looks how using different multimedia, images, video, audio, etc., to tell stories can be better. The benefits outlined include better communication, better learnability and retention of the content. This is described as opposed to only using words to describe concepts and stories. The chapter speaks to the benefits to instructors and students and how this method of teaching and learning can be implemented and what is needed to make it digital. The chapter speaks to how using storytelling can be a useful tool for teachers to aid in the delivery of complex, abstract topics and content to students by providing a concrete and relatable way to their students. This mode of delivery has been proven by many researchers to increase the information retention in students. The author then goes on to outline how students can use

storytelling to help them learn. As well as how the use of storytelling can help them breakdown the information in their lessons and formulate an explanation and narrative that is directly related to their experiences. The chapter concludes that the use of multimedia and multimodal storytelling in education does yield better results in learning outcomes.

The prior research done on this topic has its limitations in that it only looks at studies and results done in different contexts; it only maps the results from similar previous work to the relevant context, education.

C. Games in Educational Spaces

In the Games in education – Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis (Merchant et al., 2014) paper, the authors speak to the benefits of using games and game environments in educational spaces, K-12 and higher education. They collected 13 studies done on using games in education, 29 studies on using simulations in education, and 27 on using virtual worlds in education. They then ran a meta-analysis on the results of these studies and compared them until they reached unified results. Their results showed "statistically significant positive effects of games, simulations, and virtual worlds on student learning"(Merchant et al., 2014, p. 35). Meaning that the 3 categories — games, simulations and virtual worlds —improved learning outcomes with "games showing higher learning gains than simulations and virtual worlds" (Merchant et al., 2014, p. 29). The results show that games and virtual worlds were the more effective of the 3 categories in terms of the overall learning outcomes. There is an apparent benefit to including both games and virtual worlds in K-12 and higher education.

D. Active Learning

Bloom's Taxonomy (Forehand, 2005) introduces 3 domains of learning: Cognitive, Affective, and Psychomotor. Cognitive engages and activates problem-solving and critical thinking skills, it is a knowledge-based domain. Affective plays on the emotional aspects of a student's formed connections with the content presented, it is an attitudinal-based domain. Psychomotor connects the physical movement with the information being shared in a class, it is a skills-based domain. The Cognitive domain is generally where most educational design focuses. It contains a Hierarchy of Learning [See Figure 1]. This diagram clearly shows where each teaching/learning activity falls and identifies what is classified as passive and active learning. Figure 2 also identifies how likely the students are to retain the information depending on what level of engagement they are getting with the course content. The extensive research and studies done on the validity of this concept show that when instructors move towards active learning and active engagement with the course material (including the Affective and Psychomotor domains as well), students pay better attention in class, they are more engaged, and are much more likely to retain the information learned. As a result, students' grades and overall performance in a course tend to improve.

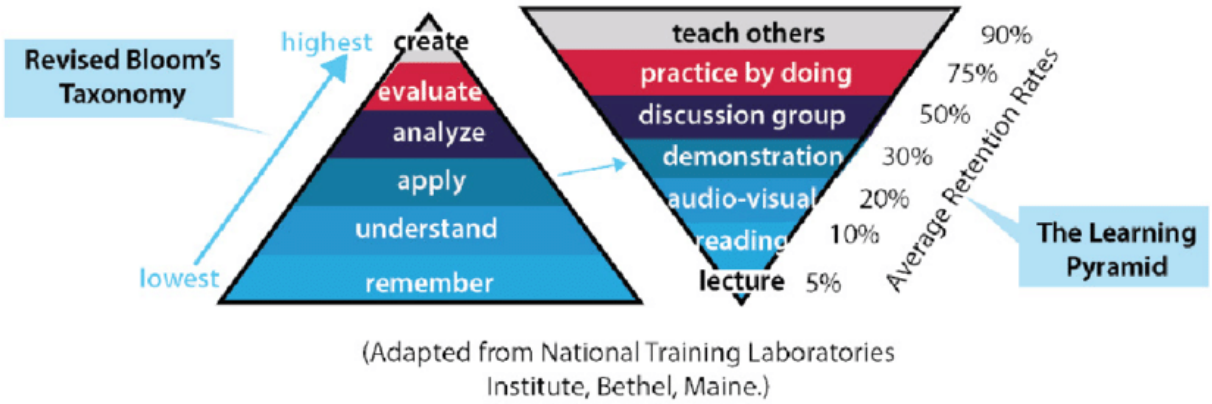


Figure 1. Revised Bloom's Taxonomy (Shachter, 2021)

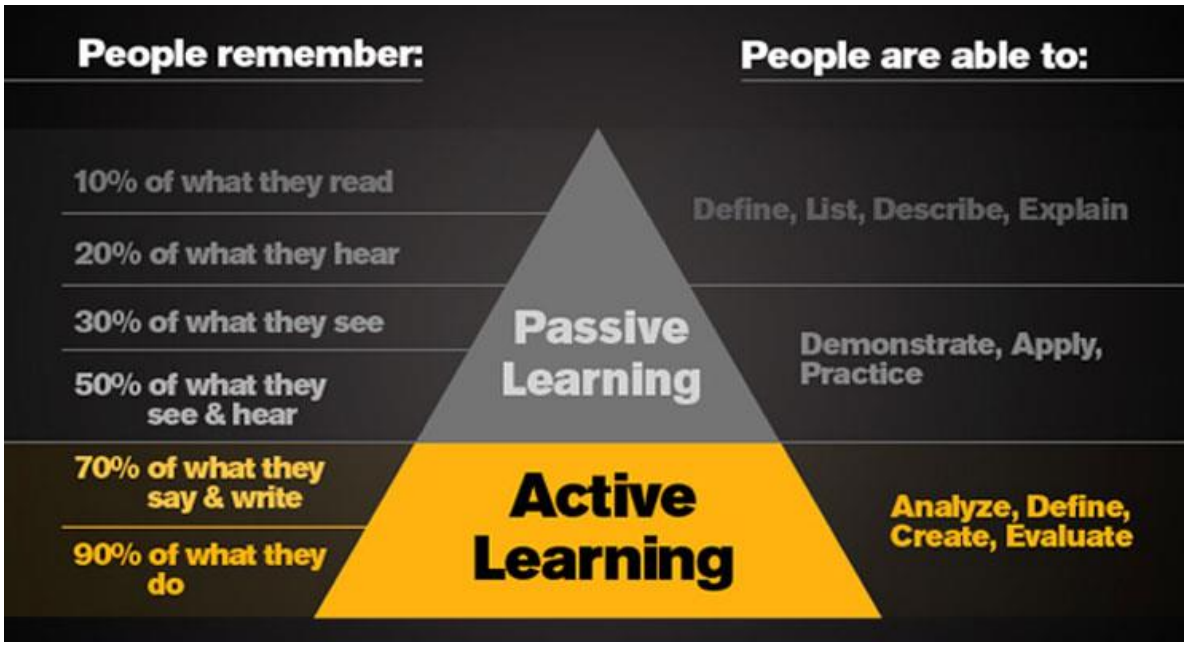


Figure 2. How does Active Learning Support Student Success? (Sandercock, 2013)

E. Student Centered Educational Design

A major component of game and software design is focusing on the users, through what is called User Centered Design: "[i]f user centered design is done correctly, your application becomes an outcome of actively engaging users…"(Lowdermilk, 2013). The same idea of including users in the design process of a game or tool, which is essential for its success, can be applied to educational design. This has been given the name Student Centered Educational Design. Student-centered learning environments include "interactive, complementary activities that enable individuals to address unique learning interests and needs, study multiple levels of complexity, and deepen understanding" (Hannafin & Land, 1997). Involving students as directly and often as possible in the educational design process can help students connect better with the

content. This process, like any design process, is iterative. This means that, with each iteration and every new group of students, the delivery of the course content will change depending on many different factors. Some of these factors include: previous experience, skills, learning styles of both the students and instructors. Thinking of Educational Design from the perspective of User Centered Design, recognizing who the users of the system are, identifying (or enabling them to articulate) their needs and goals, involving them more directly and often in the design process, and adjusting the design of the tool/game to better match the target audience, can greatly improve student experience and performance. Looking at the experience and environment being designed and implemented for each class and implementing Student Centered Educational Design evolves the whole course experience for both the students and instructors. Understanding the different types of students in a classroom and involving them in the design process will help Educational Designers and Instructors figure out what modes of delivery and assessment styles work best for each group of students. The aim of this research is to use this concept to design a platform that uses Indexical Storytelling to involve the students more in the design of their educational experience, setting them up as the secondary storytellers alongside their instructors (the primary storytellers).

3. Design Challenge/Opportunity

The review of prior research reveals a gap in knowledge about the benefits of virtual environments that use Indexical storytelling in an educational context. This research project investigates the question: **To what extent does the use of Indexical Storytelling in Virtual Learning Environments in Post-Secondary STEM programs afford better understanding and learnability?**

To investigate this question, I use a Research Through Design (RtD) approach. This is "an approach to conducting scholarly research that employs the methods, practices, and processes of design practice with the intention of generating new knowledge" (Zimmerman & Forlizzi, 2014). This practice enables this research to generate new insights through the design process. It follows the iterative approach of traditional design work to continually improve and readdress the design challenges and opportunities of the research work. It "asks researcher to investigate the speculative future, probing on what the world could and should be." (Zimmerman & Forlizzi, 2014). This is precisely what this project aims to do. Use the design of our tool to generate new ideas, evaluate and reflect on the iterations, and speculate as to what can be built off of this work in the future.

The RtD method follows five steps: Select, Design, Evaluate, Reflect, and Repeat. Step 1, Selecting a research problem to investigate. Step 2, starting the Design process with a literature review to find a gap in the field (Section 2), then framing the design question and focus of the project (Section 3) and generating a list of framing or target criteria (Section 3C). Then, beginning different Design activities (Section 4). Step 3, evaluating based on the target criteria (Section 4F). Following that comes Step 4, Reflecting and re-evaluating Section 5A. Finally Step 5, Repeat (Sections 5 & 6).

Step 2 of the RtD method, Design, starts with evaluating the gap in the field, and responding to that gap by developing a design concept of using Indexical Storytelling in Virtual Learning Environments. To frame the project (Step 2), I will use a multi-step iterative approach wherein a new tool is designed using Indexical Storytelling. Then the tool is presented to students and

instructors for feedback, which, once collected and analyzed, generates results to which help us understand the effects of such a tool on the educational experience (Step 3, evaluate). Then, Step 4 is to reflect on testing results and analysis and re-evaluate the design, and finally we move on to Step 5, repeat. Developing new versions of the prototype starts each of the next iterations. There is a conjecture that these environments in an educational context will yield the similar results as they do in the contexts of games, art, film, and theme parks. We use the research done on how technology-enhanced education helps, and we assume that Indexical storytelling is included under the 'helpful technology' umbrella. Given that using Indexical storytelling in an educational virtual environment for students in higher education is relatively underdeveloped area of research, there are many opportunities to advance in this research area. This MRP is following 3 cycles of the iterative approach described by RtD above.

This research aims to develop a prototype demonstration of a game that answers the Design Challenge Question: To what extent does the use of Indexical Storytelling in Virtual Learning Environments in Post-Secondary STEM programs afford better understanding and learnability?

A. Aspects of the Design Challenge/Opportunity:

Opportunities for Storytelling in Educational Spaces

The summary of prior research, presented in Section 2, suggests that the use of storytelling as a teaching and learning tool has a beneficial impact on students' understanding and success. This is because it provides students more concrete and relatable examples of the theoretical course content through connecting the content with real world examples through storytelling. This suggests an approach of providing students with game tasks that help connect the theory to more concrete examples from real life that introduce new and complex course concepts.

Opportunities for Indexical Storytelling in Educational Spaces

The design of the MRP tool takes the aspects of using storytelling in educational spaces and adds a layer of indexicality on top. The ability to interact with the environment and leave behind indices for others to interact with, affords students the opportunity to become secondary storytellers in their own educational journey - the ability to "read and write" elements into their LMS environment. Students can see, read, interact with, and add items to and from the world built by their instructor(s). Students will also be able to leave traces behind in the environment for others to interact with, thus changing the initial state of the LMS and evolving the storyline.

Opportunities for Task-Based Active Learning

Re-introducing Task-Based Active Learning into university education brings back the same benefits seen when using this style of teaching with grade-school children. The literature reviewed in section 2 shows that humans learn best through doing and are able to retain learning better when Active Learning is implemented. Including multiple senses when learning a new concept helps the brain understand better and retain the information longer. The goal of this tool design is to combine reading, visuals, movement, the senses of curiosity and exploration as aids to solidify theoretical learning concepts through more practical examples.

Opportunities for Games in Educational Spaces

Using games in teaching adds an extra layer on top of task-based active learning by implementing more interactivity, agency, and incentive. It also adds a component of fun. All of these elements combined add to the student's ability and willingness to focus, interact, and participate in class.

Opportunities for Student Centered Educational Design

As in any user-centered design, the end users are included in the design process from start to finish. In this project, the users are engaged in the beginning of the process through testing sessions to clearly identify the users' needs and to solidify the initial assumptions of the design. Following the initial stages of prototyping, the users are to be engaged again to test the usability of the tool. As well as evaluating whether the tool has met the needs identified in the first engagement. This research is surrounding designing a better student experience for Engineering and STEM students. The research aims to get participant inputs on education and the prototype. The main goal of this research is to give students a voice to make a difference in how your education is designed. The tool designed aims to create a more useful and efficient online learning management system that supports more interactivity, collaboration, and project-based course design for STEM programs at the university level.

Opportunities for Augmenting The Classroom as an Instance of Spatial Media

The work summarized above in Section 2.A — particularly of Pea (1994), Merchant et al. (2014b), Robin (2008), as well as the work of Karlsson et al. (2021b) and Pearce (2007) — on spatial media and narrative environments, respectively, provide a concrete basis as to why it is necessary to build more games (as tangible problem spaces) and interactive storytelling into educational spaces. However, despite the early inroads of these concepts in K-12 education, the literature does not reflect an extension into post-secondary education (PSE). Robin also points out that "students at all levels, from young elementary-age children to adults enrolled in graduate-school programs, will find that digital storytelling can be an effective way to construct new learning and communicate knowledge and understanding" (Robin, 2008).

B. Initial Design Concept: The Classroom as an Instance of Spatial Media

The opportunities discussed in the preceding section illustrate the potential benefits to be gains from the use of the games and storytelling *in combination* to help support learning and to provide a more engaging and interactive experience for students. It is this potential that is the focus of this research.

To investigate these potential benefits, I will develop a prototype tool. My goals for the tool are as follows. First, the tool should demonstrate the use of Indexical Storytelling and demonstrate how it can be used in the digital, collaborative environments created for instructional and learning management in STEM courses. Most PSE STEM course delivery is mediated by a Learning Management System (LMS), such as Moodle. An LMS provides a digital, collaborative environment. Thus, the tool should address the connection with an LMS, either to replace the LMS and/or to supplement extant LMSs. For my design concept, I will use the title of *InViTE Collab: **In**teractive **Vi**rtual **T**eaching **E**nvironment for **Collab**orative Learning*.

My initial design concept is as follows: *InViTE Collab* is a game world that uses *indexical storytelling* and shows how it can improve the learner's journey as it guarantees an individualized and unique experience, a unique storyline. This unique storyline —unique because everyone involved contributes elements to it — will always be relevant to students' experience and environments outside of the classroom. This implementation of Indexical Storytelling in an online educational environment keeps the educational content relatable to current events and to student experiences as it is constantly evolving with the students who enroll; even when the same initial state is used over different years since the students themselves are not the same in each iteration of the class. Students are able to work on game tasks (individual or group) that provide hands-on interaction with course content applications. Students have access to a digital storage space that only they can access or manage, a digital backpack.

Summary of Design Concept Elements (v.1)

Design Concept ID	Design Concept Description
DC1.1	Digital environments that afford collaboration and support instructional and learning management in STEM courses
DC1.2	Indexical Storytelling can be used in these environments
DC1.3	Digital, collaborative environments that connect to LMS
DC1.4	Digital environments that afford individualization to learners
DC1.5	Individual/group game tasks that provide hands-on interaction with applied course concepts
DC1.6	Private digital storage/backpack

C. Relevant Evaluation Criteria

R1. Target Criteria

Criteria ID	Criteria Name	Description	Priority
R1.1	Customizable Characters	The ability to customize how the character looks to better match with the student's sense of self and identity	2
R1.2	Playable 3rd-Person Characters	The ability to see the student's virtual character full (3rd person view) in the game world	1
R1.3	Individual/Solo World vs. Group/Collaborative World	Having a separation of Individual (private) space and Group (public) space	1

		for student interactions and learning.	
R1.4	Cooperative Games/Tasks for Group World Activities	Group tasks must take the format of a cooperative game task where the students are forced to work together to complete the task for a more even workload distribution.	3
R1.5	Modular Course Build Platform	Similar to website-builders. Users pick features and pieces from a set list	2
R1.6	Main Menu Screen	An initial screen/Landing page where students and instructors can see an overview status of their course(s)	1
R1.7	LMS Integration	The ability to link this tool with current LMSs	4
R1.8	Indexical Storytelling Support	The ability to leave behind indices and interact with what is left behind by others.	1

Table 1. Target Criteria Table 1 – Initial Target Criteria

R1. Target Criteria Rationale

1. Customizable Characters

The objective for the tool to afford customizable characters is motivated by the following:

- student identity and taking authentic roles as skilled practitioners and learners.
- Building student awareness of their student identity as capable practitioners and learners
- Ensuring that students understand the importance of experimenting with roles and identities and how this MAY affect the shaping of their educational experience and their future experiences self-efficacy.
- Giving learners a virtual identity gives them the freedom of self-expression and provides them with an authentic space to explore different modes of inquiry – or experiment with alternative roles and identities - in a way that will help them be more agile and flexible within their own self-directed learning experiences regardless of the constraints of any particular environment.

2. Playable 3rd-Person Characters

The objective for the tool to afford playable 3rd- Person characters is motivated by the following:

- 2nd life in an educational setting gives students the space to have more control to make decisions regarding their personal and educational identities (especially in cases where students have more limitations to expressing themselves in real life)
- Having 2nd life for education, removes some of the limitations and dangers of hands-on learning in certain STEM fields (chem labs, building/designing structures, material design, fluid dynamics, etc.…) example: XR sandbox project (Tennakoon et al., 2022)
  It also supports people to take risks – and fail – and learning with and through failure where actual learning happens.

3. Individual/Solo World vs. Group/Collaborative World

The objective for the tool to afford Individual/Solo World vs. Group/Collaborative World is motivated by the following:

- Individual/Solo World gives students a private space for exploration and 1-on-1 feedback from instructors
- The Individual World gives students a space to learn and be more confident when making mistakes
- The separate worlds also give students an isolated space for collaboration that doesn't get mixed up with their individual work
  The Group/Collaborative World is where students work collaboratively on a task that matches the lessons and the tasks in the Individual World.

4. Cooperative Games/Tasks for Group World Activities

The objective for the tool to afford Cooperative Games/Tasks for Group World Activities is motivated by the following:

- Allows for an easier distribution of group task workload across all students
- Helps balance out students' work so that no one student gets overloaded or too far behind the rest of the class
  Affords for more elements of fun and interaction to the theoretical content

5. Modular Course Build Platform

The objective for the tool to afford Modular Course Build Platform is motivated by the following:

- Allows for an easier interaction with the platform for instructors who are using this tool for their class(es).
- Gives new users an easy intro into the tool and pre-built modules for easier course set-up
  Makes the tool more customizable to many different courses and fields so that each course can be customized with whatever modules are needed.

6. Main Menu Screen

The objective for the tool to Main Menu Screen is motivated by the following:

- Allows users to be able to see all the details of their course(s) without having to go through all of the world(s)
- Can alert users immediately to any incomplete work or upcoming deadlines. Course progress is viewable at a glance.

7. LMS Integration

The objective for the tool to afford LMS Integration is motivated by the following:

- Creates an easier and smoother transition from standard LMSs for new users
- Offers an alternative to users who only want to use this tool for specific course modules alongside their standard LMS
- Allows for an initial low-stakes integration into new courses, programs, and institutions.

8. Indexical Storytelling Support

The objective for the tool to afford Indexical Storytelling Support is motivated by the following:

- Creates a more engaging environment with inputs from different students
- Offers the concept of object permanence in the online environment
- Affords students the opportunity to become secondary storytellers in their educational journey
- Allows for a unique experience every time students log on or take the course.

4. First Instantiation of the Design Concept: Prototype 1 (Lo-Fi)

A. Refined Design Concept

InViTE Collab is a game in which the game world is designed to support a pre-existing university level course. The gameplay path through the world follows and aligns with the learning path and the modules of the course. In this concept, the students in the course are reimagined as game players, and the module content will be imported into InViTE Collab and augmented to include tasks that the player will complete.

During task completion, players can pick up tools and information that will help them proceed and unlock all the parts of the world map. These tools and information will be directly connected to the learning outcomes of the modules in the course.

The world will be designed by the course director/teacher to meet the needs of the course. This initial state provides the starting point of the storytelling aspect. As students go through the world, complete tasks, and interact with each other and the world they will leave indices in the space completing the storyline.

To visualize the concepts better, I am using a mapping from traditional education to a reimagined educational context [see Figure 3]. This mapping shows how the traditional educational structure can be translated to the new proposed design: course directors can be seen as Game Designers and the primary storytellers; Instructors are the facilitators; technology and resources used for course delivery can be translated to the player toolbox and items a player can pick-up and interact with; course syllabus as the world map; course modules or chapters as the different levels or lands; and the students as the players and secondary storytellers.

In my initial design concept, students will have access to four lands:

- Learning Land: In Learning Land students have the opportunity to go through ungraded course content where they learn about new concepts.
- Individual Assessment Land: Individual Learning Land gives space for students to complete any individual assessments that test their learning.
- Group Assessment Land: Group Assessment Land is where students work together on group assignments that are modeled as cooperative-style games
- Sandbox Land: Sandbox Land is a space for students to explore any new concepts, tools, or mechanics with their classmates in an open setting.

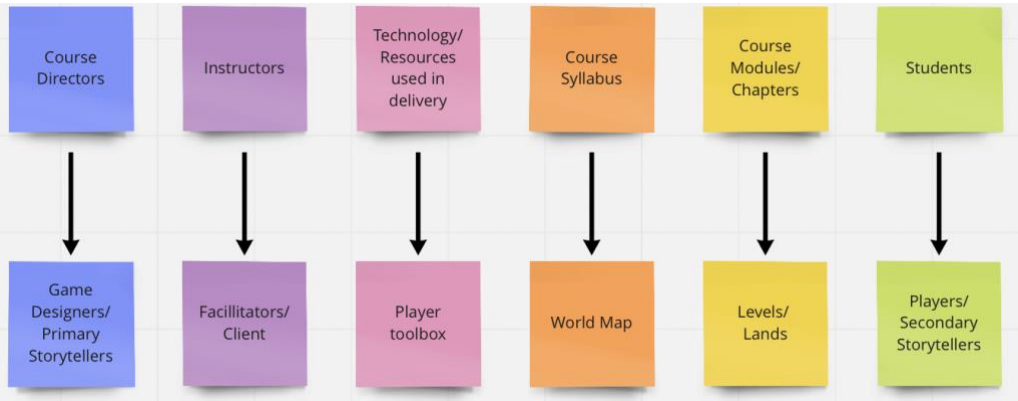


Figure 3. Traditional Educational Structure to New Educational Structure Design Mapping

Summary of Design Concept Elements (v.2)

Design Concept ID	Design Concept Description
DC1.1	**Digital environments that afford collaboration and support instructional and learning management in STEM courses**
DC2.1.1	Game World mapped to the Course Learning Environment
DC2.1.2	Gameplay Path(s) mapped to Course Learning Path(s)
DC2.1.3	Players in this environment are the Students
DC1.2	**Indexical Storytelling can be used in these environments**
DC2.2.1	Digital game tools that are earned up at the completion of tasks
DC2.2.2	Ability to alter the environment using the tools picked up
DC2.2.2	Ability to pick-up/drop/move items around in the world
DC1.3	**Digital, collaborative environments that connect to LMS**
DC1.4	**Digital environments that afford individualization to learners**
DC2.4.1	Different Lands/Worlds that afford a separation of Learning, Assessment, Individual, and Group spaces.
DC2.4.1.1	4 Different Lands: Learning Land, Individual Assessment Land, Group Assessment Land, and Sandbox Land.
DC1.5	**Individual/group game tasks that provide hands-on interaction with applied course concepts**
DC1.6	**Private digital storage/backpack**
DC2.6.1	Digital Toolbox that stores all the tools that a student earns (Digital Backpack)

B. Inspirations

This section presents the different inspirations that help visualize and contextualize what this tool is meant to look and feel like.

Visual inspiration/Mood Board:

1. Disney World



Figure 4. Animal Kingdom – Avatar Land

2. Skylands



Figure 5. Skylands Image 1



Figure 6. Skylands Image 2

Art Style



Figure 7. Image Cluster of cottage core games.

Character Style



Figure 8. Image of different character options



Figure 9. Image of Character Customization screen

C. Visualization of the Tool

This section presents the initial sketches of the visualization of what the tool's UI and Lands can look like based on the inspiration images above.

World/Interface Sketches

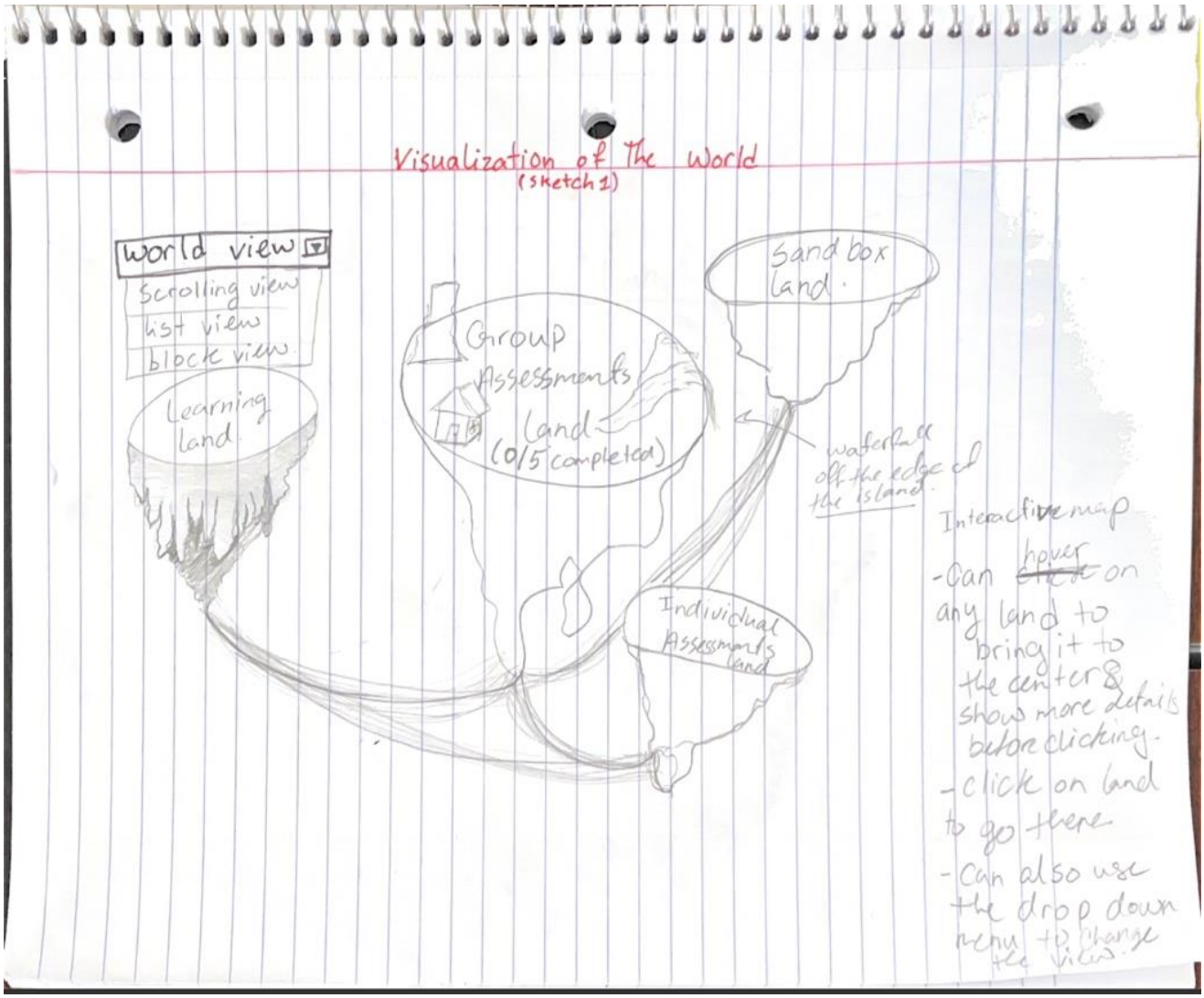


Figure 10. Main Screen – World View Option

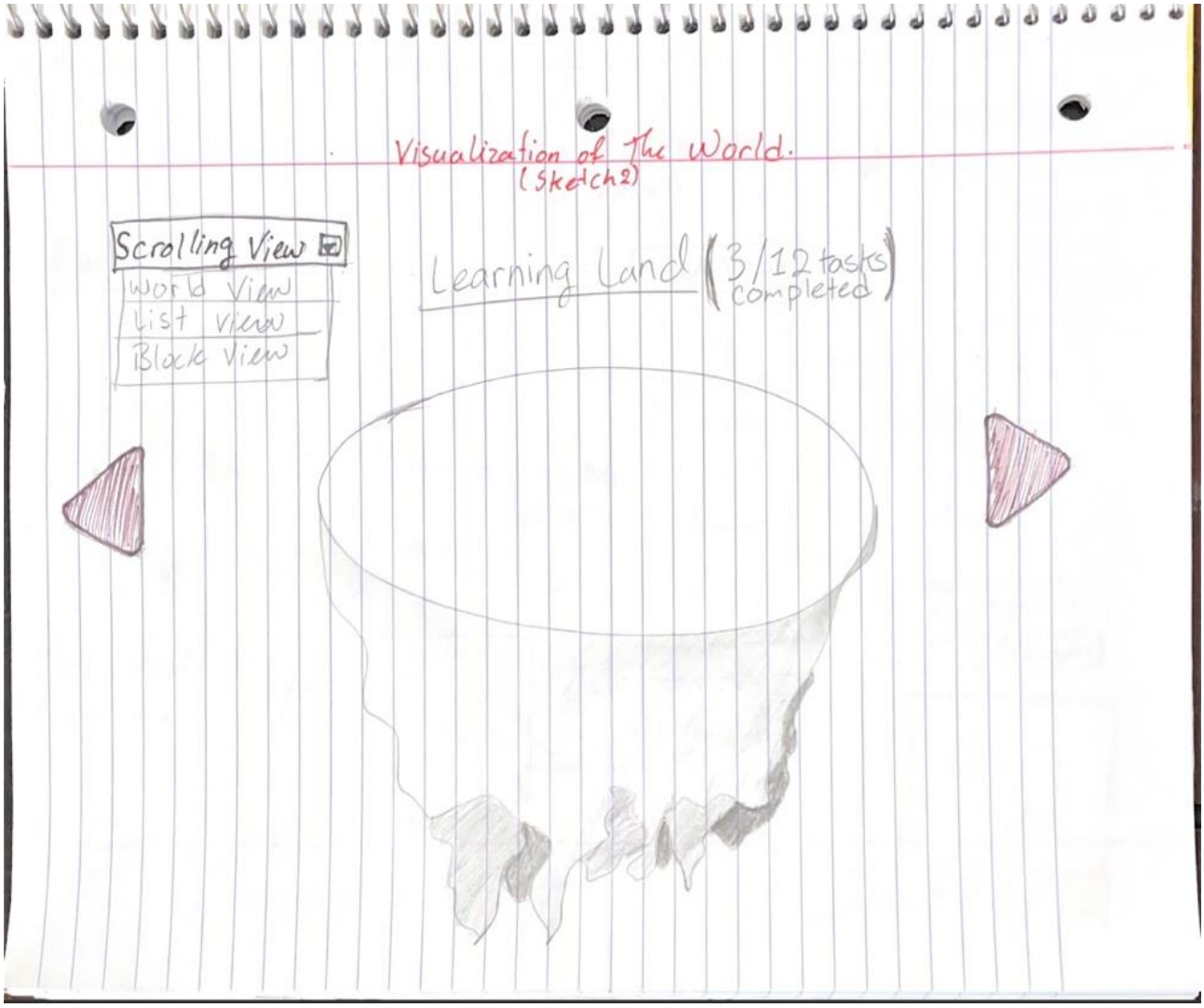


Figure 11. Main Screen – Scrolling View Option

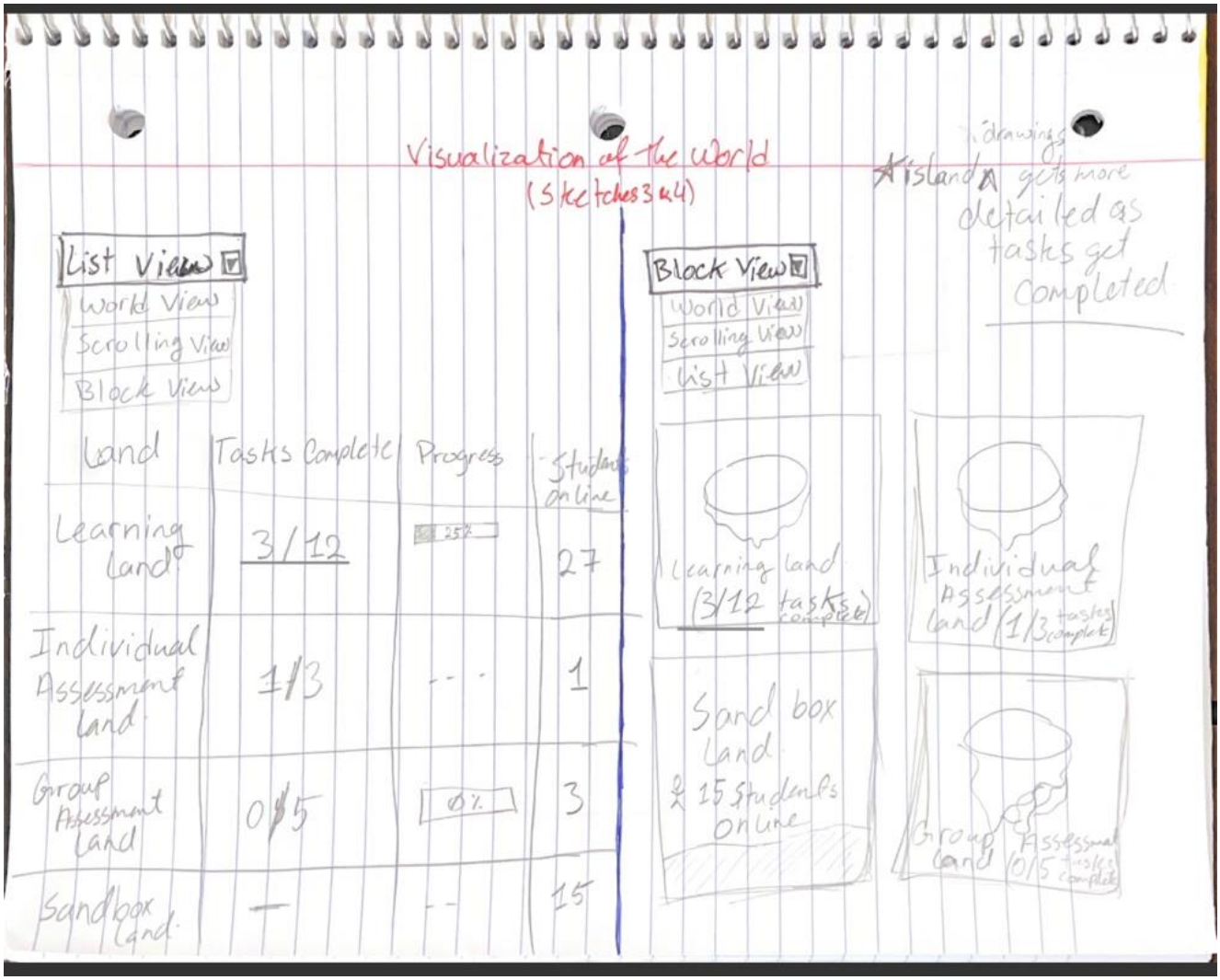


Figure 10. Main Screen – List and Block View Options

D. User Personae

This section presents some of the different types of users that are envisioned to be interacting with our tool.

i. "Sam" Persona

Name:	Sam	**Bio:** Sam is a Civil Engineering student in their 4th year of study. Sam also has dyslexia and has always had trouble with traditional education. He has always had to take extra steps to get academic accommodations in place to successfully complete his courses
Age:	21	
Occupation:	Student	

Wants and Needs:

- Wants to become a civil engineer.
- Wants to feel more included in the education system
- Needs to have fewer extra steps to be able to complete his courses
- Wants to be on the same track as his peers and be able to graduate at the same as them.

Frustrations:

- Always has to take extra steps to get academic accommodations
- Feels behind his peers, as he cannot take on the same course load as everyone
- Courses seem to be mostly focused on text and lecture-based learning, which is a challenge with his dyslexia
- Feels left out of everything his peers are doing (academic milestones and celebrations, courses, graduations, etc.…)
- Has to take extra time to complete all his graduation requirements

ii. "Olivia" Persona

Name:	Olivia	**Bio:** Olivia is a mature student who, with the advancements in technology, decided to go back to school to study Computer Science. Olivia did this with the intention of learning new industry relevant skills to shift careers and work in tech.
Age:	30	
Occupation:	Student	

Wants and Needs:

- Wants to learn about development and tech to make her career change
- Needs a comprehensive education that will best prepare her for going into industry

Frustrations:

- Is not sure if going back to school is the best decision, or if it will provide more benefit than online self-study
- Is worried about being able to connect with her peers who are not the same age.
- Is surprised to see that education doesn't seem to have changed much since her first post-secondary experience.

iii. "Tyler" Persona

<table>
<tr><td>Name:</td><td>Tyler</td><td rowspan="3">Bio: Tyler is a Computer Engineering students in his second year. Tyler has ADHD which has always impacted his learning. He also struggles with social anxiety, as a side effect of his ADHD. This makes it harder for him to connect with his peers and to make friends. Due to his ADHD, Tyler requires more time to study the material as he loses focus often during lectures. His social anxiety also makes him more hesitant to ask questions or ask for help from his instructors.</td></tr>
<tr><td>Age:</td><td>18</td></tr>
<tr><td>Occupation:</td><td>Student</td></tr>
<tr><td colspan="3">Wants and Needs:
Wants to be a programmer
Needs a more inclusive educational environment that feels more comfortable and does better in
Needs an easier way to communicate with peers for group projects that accommodate for his social anxiety.
Wants alternative ways to learn aside from the traditional lecture format to help him focus and be more engaged</td></tr>
<tr><td colspan="3">Frustrations:
Has a hard time focusing and being engaged in courses that are mainly lecture and reading based
Has a difficult time communicating and working with other students, TAs, and instructors because of his social anxiety
Has to keep re-applying for academic accommodations to be able to successfully complete his courses.</td></tr>
</table>

iv. "Nour" Persona

<table>
<tr><td>Name:</td><td>Nour</td><td rowspan="3">Bio: Nour is a course director and has been teaching the same course for a number of terms. Nour is noticing a decline in student attendance, participation, and engagement. This dip is causing Nour to worry about her students' performance. She is now looking for new ways to deliver her course material in a more engaging and interactive way that grabs her students' attention.

For the upcoming term, Nour is teaching Digital Logic Design.</td></tr>
<tr><td>Age:</td><td>47</td></tr>
<tr><td>Occupation:</td><td>Instructor/Course Director</td></tr>
<tr><td colspan="3">Wants and Needs:
Wants a new tool to deliver her course material in a more interactive and engaging way for her students.</td></tr>
</table>

• Wants to ensure her students have a deeper and more meaningful connection with the course content
Frustrations: • Worried about student overall performance and lack of engagement with the course materials • Worried students are not able to connect with the material because of the content delivery method.

E. Use Case Scenarios

This section presents some of the use case scenarios of how our users can interact with the platform and how it can help in each situation. The scenarios use the User Personae from the previous section.

Scenario A: Nour Designs a Course on InViTE

Nour is a course director of the Digital Logic Design course, which has a lot of theoretical content. In prior term, she observed that her students don't seem very, interested in the content nor are very engaged with that they are meant to be learning. Because of that Nour, is looking for a new tool that can help her transform her theoretical content into applied practical experiences for her students. Nour came across a new tool, called InViTE Collab, that says it does just that, so she reached out to the tool developer to get more information. During her conversation with the tool developer, Nour learned that this tool is an online open-world game where students learn theoretical course content through both individual and group game tasks. Nour decides to give this tool a try and works with the developer to set up her course for the next term. She redesigns her course to activities that apply, demonstrates, and explains the theoretical content. She then submits her lesson plans to the developer to have her tasks implemented into the game world.

Scenario B: Nour interacts with InViTE during Course Delivery

After Nour finishes designing her course with the developer, she launches the game module to her students. She demos the tool to her students and shows them the basics of how they can interact with the system and the mechanics of how to play. Once the students logged into the tool, Nour starts seeing all the indices they are leaving behind in the game worlds on her instructor view graph. She can see who is logged on, what land they are currently in, what tasks they have completed, and what they are doing through her instructor portal. Nour is also able to go into the different lands to experience the world and tasks as her students do and leave comments and feedback for them. She is also able to pace her students and unlock lessons and activities at the appropriate times.

Scenario C: Tyler engages with new course content in InViTE (in Learning Land)

After struggling for years in the traditional educational system because of his ADHD, Tyler just logged on to InViTE Collab, a new teaching tool that is being used for one of his courses. He finds he is more engaged with the content than he would be in a lecture. He was able to personalize his avatar to what he wants to look like in the game world, as well as pick the home screen view that works best for him, the world view, as he is more of a visual learner. Tyler

remembered that in the initial “how to play” screen and introduction their instructor gave about the tool there was mention of a virtual backpack that he is able to access. He opens his virtual backpack and finds it empty as he has not yet completed any lessons or tasks yet, but there was a note saying, “Complete tasks to collect tools and items”. He saw that his instructor, Prof Nour, has put up one new lesson for the class to complete in Learning Land. He clicks on Learning Land to complete a task relating to the module they are current on in his course. He is really engaged by this new tool as it seems like a video game, which makes doing his course work more interesting and fun. He is a bit skeptical about what the learning task will be, but he is curious to find out. He starts the game task where he is asked to do a walkthrough of a conflict scenario between group members. He is assigned a role and is currently speaking with another character, an AI bot. The scenario describes a project they are working on together and what his role in the group is. He then starts speaking with the other character and right away they find themselves in a disagreement. There are multiple options to choose from on what to do next, he chooses what he thinks would be a funny response to see what happens. The character seems to get more agitated and the conflict gets worse. Tyler decides to go back and chose another option, and the character responds to that as well. As Tyler is going through this task, he is learning about different ways to diffuse and mitigate conflict in groups to help keep their project going. He also learns when to speak up and ensure that he also has a voice in the group project. After completing this task, Tyler notices that he now has a new tool in his virtual backpack and that he now has new tasks in the Individual and Group Assessment Lands.

Scenario D: Sam engages with individual assignments in InViTE (in Individual Assessment Land)

Sam’s dyslexia has always made his educational experience more difficult than his peers. He always has to fill out a lot of forms to get academic accommodations in place for his courses, especially the theory-heavy courses. Being a Civil Engineering student, there is a lot of courses that requires him to sit in lectures all day long, read lots of books, and read very text-heavy lecture slides. Most of his courses also tend to be exam-based. But one of his courses is using a new tool called InViTE Collab. This tool takes theoretical course content and presents it as a game task. This new formatting of the lectures has been helping Sam a lot since he can play through the task to learn instead of having to sit through a 3-hour lecture. Being able directly apply the theoretical content through the different activities, that show the real-world applications, has helped Sam be more focused and he is able to learn better. When Sam logged in this morning, he saw that he has two incomplete tasks in the Individual Assessment Land, so he clicks on the land to go to his task. Sam goes to attempt one of the tasks and finds a list of items needed for this task, he realizes that he does not have all of the items needed to attempt this task, as well as a message saying, “Complete Activity 2 in Learning Land to start this task.” He then goes to attempt the other task, he checks the list of tools required to complete the task, so he checks his virtual backpack and sees that he has all the required tools. He picked up all the required tools from previous task in the Learning Land, so he can proceed to start this task. After completing the assessment, Sam unlocks a new tool that goes into his virtual backpack. He thinks this tool will be required for his next task but isn’t sure what the tool does yet. So, Sam heads over to Sandbox Land to test out this new tool and see who of his peers also finished the task to see what they can do with it.

Scenario E: Olivia engages with other students in InViTE (in Sandbox Land)

Olivia, as a mature student, is worried about being able to connect with her peers. She noticed that there is something called Sandbox Land in the new tool being used for her course, InViTE Collab. So she decides to go and explore what it's all about. Once she logged on and navigated to Sandbox Land, Olivia found many of her peers online working together to test out some of the tools they have picked up from their tasks. Students are also conversing with each other through the drawing wall. She can see things that students online now are writing as well as things left behind by other students from previous days and their instructor. This encourages her to participate in the conversations and add things to the wall herself as well as explore all the tools she picked up from her tasks. Seeing all of the communication and collaborative explorations that are happening there, she is encouraged to participate and approach her peers. Using this tool makes her feel more confident to approach and connect with her peers.

F. Assessment and Self-Reflection

This section refers back to R1, Target Criteria Table 1, and evaluates whether the different criteria were met in Prototype 1 (P1), as well as updating the table to add any new criteria that were not in the list previously.

R2. Target Criteria

Criteria ID	Criteria Name	Description	Priority	Met in P1?
R1.1	Customizable Characters	The ability to customize how the character looks to better match with the student's sense of self and identity	2	Yes
R1.2	Playable 3rd-Person Characters	The ability to see the student's virtual character full (3rd person view) in the game world	1	Yes
R1.3	Individual/Solo Worlds vs. Group/Collaborative Worlds	Having a separation of Individual (private) space and Group (public) space for student interactions and learning.	1	Yes
R1.4	Cooperative Games/Tasks for Group World Activities	Group tasks must take the format of a cooperative game task where the students are forced to work together to complete the task for a more even workload distribution.	3	Yes
R1.5	Modular Course Build Platform	Allows for an easier interaction for instructors who are using this tool for their classes. Similar to website-builders. Users pick features and pieces from a set list	2	Yes
R1.6	Main Menu Screen	An initial screen/Landing page where students and instructors can see an overview status of their course(s)	1	Yes

R1.7	LMS Integration	The ability to link this tool with current LMSs for easier and smoother transitions from standard LMSs	4	Yes
R1.8	Indexical Storytelling Support	The ability to leave behind indices and interact with what is left behind by others.	1	Yes
R2.9	Humanoid Characters	Having a variation of Humanoid Characters	3	New

Table 2. Target Criteria Table 2 – Updated Target Criteria after Prototype 1 (Lo-Fi)

R2. Target Criteria Rationale

9. Humanoid Characters

The objective for the tool to afford Humanoid Characters is motivated by the following:

- So that students are able to connect and relate more with their online avatars, their online self
- Helps with students' expression of their identity.

5. Second Iteration of the Design Concept: Prototype 2 (Unity)

A. Refined Design Concept

In this iteration of the design of the tool, InViTE Collab, the major change to the concept from Prototype 1 (Section 4) is in the layout of the Lands/Worlds. The new design gives students access to three worlds: Main Lobby; Individual Learning World (ILW); and Group Learning World (GLW). The Main Lobby is a sandbox space where students are able to explore any concepts, tools, or mechanics on their own –which acts in some ways as a student's 'notebook'. In the Individual Learning World, students learn new course concepts by doing different tasks and picking up new tools that relate to the task or content and help them complete future tasks. this serves a game-like function in introducing students to the environment and tools that will be used for complex challenges (Gee, 2003). The Group Learning World is where students go to complete group tasks with their peers, and students must use the tools they picked up from their lessons in the ILW to complete their tasks.

In order to better visualize what tasks can look like in this environment, I imagined two example collaborative tasks:

a) Learning the concepts of game mechanics, iterative design processes, and game balance through modifying Tic-tac-toe [See Appendix H for Lesson Plan]: This task takes a simple game (tic-tac-toe) and uses it to apply the concepts of Game Mechanics and Game Balance. The goal of this task can be viewed in 2 different ways: the first being that students must find an interesting combination of mechanics using tools provided in the Gameworld (dice, coin, extra board sticks to make bigger grids, etc.…) to create a new version of Tic-tac-toe while improving upon the gameplay and outcomes; the idea is to create a dynamic system with algorithmic tensions supportive of meaningful game play where the end win condition is not "CAT" - a CAT game is the 'tie' resolution once the player understands the basic strategy – so the goal becomes to hack the game rules, assets, player relations, win conditions or 'pitch' in order to create a more interesting game that will not resolve in a predictable tie. This design task (which requires design thinking, playtesting, and design iteration) works better in an online collaborative setting, InViTE Collab, because it provides more opportunities for experimentation with many different combinations of game mechanics and remote collaboration.
b) ITP conflict Management Task: This task takes the ITP Conflict Management Module, which is all text based and requires a long time to read and complete all of the questions and turns it into an interactive AI-enhanced practice-based Task. In this task, students interact with an AI Bot that runs the students through different scenarios that embody all of the questions from the original ITP module. After working with the bot individually, students can either return to the bot and run through different scenarios to expand their knowledge; or they can go to the group task and run through different scenarios with their peers to practice better conflict management in groups. This Gameworld task takes a theoretical, text-heavy course module and turns it into a practice-based, hands-on learning experience for students

Summary of Design Concept Elements (v.3)

Design Concept ID	Design Concept Description
DC1.1	**Digital environments that afford collaboration and support instructional and learning management in STEM courses**
DC2.1.1	Game World mapped to the Course Learning Environment
DC2.1.2	Gameplay Path(s) mapped to Course Learning Path(s)
DC2.1.3	Players in this environment are the Students
DC1.2	**Indexical Storytelling can be used in these environments**
DC2.2.1	Digital game tools that are earned up at the completion of tasks
DC2.2.2	Ability to alter the environment using the tools picked up
DC2.2.2	Ability to pick-up/drop/move items around in the world
DC1.3	**Digital, collaborative environments that connect to LMS**
DC1.4	**Digital environments that afford individualization to learners**
DC2.4.1	Different Lands/Worlds that afford a separation of Learning, Assessment, Individual, and Group spaces.
DC2.4.1.1	~~4 Different Lands: Learning Land, Individual Assessment Land, Group Assessment Land, and Sandbox Land.~~
DC 3.4.1.1	3 Different Worlds: Individual Learning World, Group Learning World, Main Lobby.
DC 3.4.1.2	Example Tasks Across the Worlds: - Individual Learning World: Learning about Game Mechanics and Game Balance through Modifying Tic-Tac-Toe - Group Learning World: Students work in groups to design with new Mod-ed versions of Tic-Tac-Toe [see Lesson Plan in Appendix H]
DC1.5	**Individual/group game tasks that provide hands-on interaction with applied course concepts**
DC1.6	**Private digital storage/backpack**
DC2.6.1	Digital Toolbox that stores all the tools that a student earns (Digital Backpack)

B. Prototype Planning

1. Main Lobby Sandbox (Local Individual Space)

Description – The Main Lobby Sandbox space is a sandbox for students to try different things that no one else will see (no other students or instructor); it simulates in some ways a student's notebook in the world.

Learning Player Mechanics – Walking, running, picking-up items, dropping items, moving items, drawing, and any other mechanics that get implemented to any future tasks.

Required Learning – No new learning elements here. This is only a private practice space, not unlike the dynamic tutorial section of common digital games that enable players to navigate tools, resources, and the affordances and constraints of the wider game environment.

Indexical Storytelling elements – Can be left by the Individual Student.

Tools acquired from task – No tools will be acquired here. This space acts as a start screen and sandbox for students to test out the tools acquired in other tasks.

2. Individual Learning World (ILW)

Description – The Individual Learning World (ILW) space is visible only to the individual student and their instructor. Each student has their own ILW. The ILWs are where students learn about new concepts through Individual Learning Tasks that directly correlate to Group Projects/Tasks in the Group Learning World.

Player Mechanics - Walking, running, picking-up items, dropping items, moving items, drawing, and any other mechanics that get implemented to any future tasks.

Required Learning – Students encounter new elements/materials related to their course here. This is where all required learning happens. Some tasks in this world can have other pre-requisite tasks to enforce the correct/appropriate sequencing of tasks.

Indexical Storytelling elements – Can be left by the individual student and the instructor(s).

Tools acquired from task – Tools will be acquired here after a student complete their tasks with each new concept. The tools acquired here will aid the student to complete their tasks in the Group Learning World.

3. Group Learning World (GLW)

Description – The Group Learning World (GLW) space is open to all students and the instructor. Everyone can see and interact with all items, indices, and tasks in this world.

Player Mechanics - Walking, running, picking-up items, dropping items, moving items, drawing, and any other mechanics that get implemented to any future tasks.

Required Learning – Students must complete any related tasks in the ILW prior to completing the Group Tasks.

Indexical Storytelling elements – Can be left by all students and the instructor(s), for example, leaving graffiti or other semiotic traces in the environment.

Tools acquired from task – N/A… No new items acquired, only more items of the same tools from the connected lesson in ILW.

4. Example GLW Task: Tic-tac-toe

**Lesson Plan [Appendix H]

Task - Given tic-tac-toe as a starting point, the task is to create a hack/change the game as a group to make a new variation/make it "new" while altering the mechanics and game balance so it will not resolve in a tie or cat game, but in a more dynamic condition as determined by the designers (e.g., player vs player win condition, players vs system win condition, or other non-cat state.

Player Mechanics and Range of Actions- Being able to leave images, graffiti, make and watch other people's videos/tutorials, playtesting, and then voting on best hacks/mods.

Required Learning - Understanding game mechanics, system rules and constraints, and game balance/tension concepts. Knowing how to playtest and administer playtests (using different testing tools and processes), how to gather and analyze testing results for design iteration and refining rules of the game as a complex system.

Indexical Storytelling elements – Teams leaving and sharing their modified games, tutorials, tests, and instructions for the rest of the class to see and interact with and learn from; students leaving feedback for teams after their own playtesting; leaving comments, ratings in the form of words, images (memes, gifs, emojis), and/or graffiti.

Tools acquired from task – Same Items as in ILW Lesson: Dice, Coin, Pen/brush, Tic-Tac-Toe board sticks, extra X and O pieces.

5. Project Management (ITP metrics) Conflict Management (ILW Task)

Task - Structured roleplaying activity using SUIT (Share, Understand, Integrate, Team Decision) and covers the 'difficult conversations' slides from ITP metrics website: in this module students get introduced to an AI character that plays through a preconstructed conflict scenario, the student is then going to walk through the scenario with the AI character and try to resolve the conflict and figure out the tools/things they can use with their team members in the future.

Player Mechanics - Walking, running, picking-up items, dropping items, moving items, drawing, ability to speak and respond to NPCs (non-playable characters) in the game, and any other mechanics that get implemented to any future tasks. The NPCs use a mix of conversational-generative AI; meaning that the students will be able to type or say their responses and the NPCs will respond according to the characteristics set for them by the scenario they are running through and adds in their own personality traits. This makes their responses vary in each run of the scenarios.

Required Learning – N/A

Indexical Storytelling elements – Redoing this module doesn't reset the AI character history, but instead builds on it. Previous interactions with the AI will be recorded and stored in the character history to build next interactions with student based on them.

Tools acquired from task – Microphone to speak, props for roleplaying activity, any other necessary tools.

6. Project Management (ITP metrics) Conflict Management (GLW Task)

Task - Structured roleplaying activity using SUIT (Share, Understand, Integrate, Team Decision), different students in a team get randomly assigned roles in the given conflict scenario, then they go through the scenario and try to resolve the conflict with the tools they learned in the Individual Learning Module.

Player Mechanics - Walking, running, picking-up items, dropping items, moving items, drawing, ability to speak and respond to NPCs in the game, and any other mechanics that get implemented to any future tasks.

Required Learning - Project Management (ITP metrics) Conflict Management (Individual Learning Module). Being able to apply resolution strategies and tools in practice with others.

Indexical Storytelling elements – Roleplaying props from each character and the roleplaying scenarios presented to the students and left behind or swapped. Providing opportunities to share and learn from other groups' scenarios and modes of resolution.

Tools acquired from task - Same Items as in ILW Lesson: Microphone to speak, props for roleplaying activity, any other necessary tools.

C. UX Testing Session

Purpose

This is the UX Testing portion of the research project. Participants were asked to review and test the usability of the tool that was developed for this research project. As with playtesting a game system, this was undertaken to help identify which aspects of the InViTE Collab tool are helpful (support dynamic individual and group learning), and which elements need to be redesigned or addressed in future iterations. The participants were also asked a set of questions at the end of the usability testing session to reflect on the usability of the tool and usefulness in university level courses. The participants could comment on the design and development of the tool, the user experience with the tool, and the design and implementation of the educational material in the created environment. The UX Testing proposal was submitted to the Ethics Committee and they granted approval of the proposed process.

Data Collection Methodology, Methods, and Process

Intake:

Students from EECS 4700 "Digital Media Project" and EECS 4461 "Hypermedia and Multimedia Technology" were sent a recruitment email [Appendix A] and invited to participate in the study's anonymous testing sessions on a voluntary basis. 5 students were selected to participate in the testing sessions on a first-come-first-served basis. Each participant was compensated for their participation. To keep the process anonymous, participants were given a participant code to be used as their identifier for the research, ex. PC1, PC2, etc.

Initial:

After signing the Informed Consent form [Appendix B], participants were given a participant code (PC-XX) to keep their data anonymous. The recording was started, and then the participants were given a list of instructions on how the session will go [see Appendix C]. There were 2 parts to this session. The first was an unguided walkthrough of the tool using the Think-Aloud

protocol for comments from the participants. The second was a Usability testing Interview and Debrief with questions about the design of the tool, usability, educational background information about the participant, and usefulness of the tool. Once the recording was started participants were asked to not state any identifying information about themselves or others (peers, TAs, Profs., etc.…). During the unguided walkthrough of the tool, they were asked to state any questions, comments, concerns, or thoughts they had out loud. The interviewer did not ask or answer any questions at this time, except for any hints that were needed to keep the walkthrough going.

During:

1. Think Aloud protocol:

Participants were provided a laptop with the tool prototype(s) and were asked to do an unguided walk-through and articulate any comments, questions, and/or thoughts that came to mind as they went through the InViTE Collab environment

2. Interview and Debrief:

After doing the unguided walk through of the tool, participants were asked questions [see Appendix D] regarding the tool's usability, their understanding of the environment, their educational background, and how they see this tool fitting into future education practices.

3. Participant Comments and Responses:

Participant comments and responses to the questions from Appendix D are recorded in the Interviewer Notes [Appendix F] and the Participant Response Table [Appendix E].

Follow-up:

When the participant was done the walkthrough of the tool, felt that they had a good understanding of the environment and the tool, and the Interview and Debrief concluded, they had the chance to ask any further questions they may have had about the tool or research. When the session ended, whether they had completed all the tasks in the session or not, they were compensated for their participation.

Results

Part 1: Walkthrough

All of the data that was collected is provided in Appendix G (for Walkthrough Videos) and Appendix H (for Interviewer Notes). Below is a summary of the Walkthrough results.

For the walkthrough portion of the testing sessions, all the participants had similar results. All participants were able to pick up on the basic mechanics easily (walking, running, jumping, picking up items, going through the portals to the different worlds, switching items held in hand, etc.…). Some of the participants had little-to-no knowledge and experience with other video games or other similar virtual environments. Some of the other mechanics (such as dropping items from inventory, drawing, using the pointer, moving items around in the scene, etc.…) proved to be a bit more challenging, because they had some bugs in the implementation and were a bit less intuitive than the basic mechanics.

Overall, participants enjoyed the environment and the ability to draw and move items around. They found this environment engaging. The concept of having this 3D space to communicate and collaborate with their peers was very appealing to them.

The participants all demonstrated that they understood what they were supposed to do in the environment, given the conditions and learning supports I developed (documented in the previous section). Some (PC2, PC4, and PC5) thought it would be helpful to have some kind of visual tutorials to explain. For example, the pen/brush drawing tool would have benefited from a tutorial, since all participants needed some hints and some guidance to learn how to use this drawing tool.

For the prototype testing, participants needed to test out the mechanics, implementation of the controls, and interactions with items in the game world. The participants got the impression that they had to play a game of tic-tac-toe to unlock something or to receive some more task instructions (in the game). In the fully implemented version of the environment students would play through a game of tic-tac-toe to unlock the next steps, tools, and learn about the new concepts. But for the prototype, this feature was not implemented, so it served no purpose to actually try playing a game of tic-tac-toe.

Participants noted some bugs in the game, like items falling through the floor, the icons in the backpack did not symbolically? match the items when being used or manipulated, slow mouse tracking, the lines drawn on the wall were going through the wall in some of the walkthroughs.

Participants noted that they were not sure what they were supposed to do at the beginning when they first launch the tool. They also were not sure how to know if they had completed a lesson or not. They wanted to have something to signal what was completed and what tasks were still outstanding. This tells me that further scaffolding is required, including more direct guidance to act or do or perform a particular task.

Participants also noted that the prototype was text heavy which seemed to them like the opposite of what the tool is trying to do.

Part 2: Participant Responses

All of the data that was collected is provided in Appendix E (for Participant Responses to the Interview/Debrief Questions) and Appendix D (for answers to the Interview/Debrief Questions). Below is a summary of the observations.

Based on the participant responses to tool and their answers to the Interview/Debrief Questions, it was clear that the participants were all able to grasp a general sense of what direction the tool is heading. Even the few who didn't grasp the full understanding or intention, when asked what was missing, they described or anticipated features that were part of the original design description but were still yet to be implemented in the next iterations of the prototype.

Q1. What did you understand about the tool from the walk through?

When asked what they understood about the tool, participants compared the tool to a 3D Miro, Minecraft, a gamified 3D group project tool, and a 3D Collaborative space.

Q2. How would you describe this tool to a friend?

When asked how they would describe this tool to a friend, participants said: “It’s like having a meeting for a project virtually” (PC1); a drawing simulator, a 3D group collaboration space, “like a 3D google docs” (PC5).

Q3. Was there anything that stood out to you about the tool (good or bad)?

Participants were then asked what stood out to them about the tool, they said: some of the controls were not very intuitive, some of the mechanics seemed confusing to them, the footprints being left behind is a “cool idea” (PC2); the symbolism of boundaries using clouds to show what spaces were locked was a good idea; and the positioning of the items in the world provided a clear idea of where to go next. The game was compared to Minecraft with the picking up and dropping mechanics/conventions One participant also said that there was nothing really guiding them towards the portals or to let them know they had to go through the portals, again indicating a need for more scaffolding or interactive supports provide clearer direction or prompting

Q4. Have you ever heard of something called Indexical Storytelling?

Four out of five participants said they had not heard of Indexical Storytelling before the session. One said they had heard the term but was not sure entirely what it meant. So the term was explained to them as described in the earlier sections of this paper.

Q5. Did you notice any elements of Indexical storytelling in the environment created? Can you name a few?

After the concept of Indexical Storytelling was described to the participants, they were asked if they noticed any such elements in the environment that they tested out today. Participants mostly focused on the same indices that were built into the prototype, the footprints (their own and the other players’ in the GLW), as well as the projects and comments posted on the backside of the project wall in the (GLW). Participants also noted the Indexical Storytelling elements they were leaving behind like their footprints, the drawings they are leaving on the walls, the items they are moving around, removing, and/or adding to the environment. They also noted the persistence and consistency of the items (picked-up or moved) and states (common rules and procedures) of each world as they move from one to the next.

Q6. Do you think the scene told a story?

When asked if they thought the scene told a story, participants had a mix of opinions between yes, no, and I’m not sure.

Q7. What story could you tell (make up) from the scene(s) you walked through today?

The participants were asked to make up a story, if they didn’t already see one in the prototype. Most told the story of a student in an online classroom environment; some were confused in the beginning of the ‘story’, and some knew what they needed to do. Some needed more guidance as to what was being asked of them (by the Task Master). Some participants mentioned that the students’ objective is to work collaboratively and communicate with their group members, others focused on the tic-tac-toe game as the main objective of the whole tool, and others mention that this is an educational tool and tic-tac-toe is simply one of the tasks.

Q8. Did you notice any learning/educational elements in the scene? What are they/ can you name a few?

When asked about what educational elements they perceived in the environment, a majority of the participants focused on the Task Master and compared that character to a teacher providing instructions and guiding them. A couple of participants noted the wall in the ILW as the lesson and the task in GLW as the assignment and the information on the backside of the wall is other students' submissions.

Q9. What information did you understand from the learning/educational elements? What do you think you were being taught?

Most participants answered the question about what they understood from the learning/educational elements in the previous question. Only 1 participant chose to expand on their previous answer here: they said that they understood that tic-tac-toe was just the medium or application of the lesson but what they were being taught is actually how to use the drawing tool and how to use it to collaborate and to understand object manipulation.

Q10. What are 3 things you liked and 3 things you would change about this tool?

Participants were then asked for three things they liked and 3 things they would change about the tool. Most participants focused on the development of the tool and the usability of the system. They commented that they would like to see some of the bugs in the code fixed, suggested modifications to polish some of the mechanics, alternatives to the controls, etc.... What they liked about the tool was also relatively consistent across all the participants: having a 3D environment to explore course concepts, having a Task Master to give instructions, how the tool was immersive, and the use of clouds to show that there is a limitation to where they can go in the world. Participants liked some of the tool icons from the inventory, the pointer tool to identify the objects being pointed at, the footprints of other students, and having a 3D environment where they could manipulate the objects and make changes to the environment.

Q11. The System Usability Scale answers were consistent in evaluating the current prototype of the tool.

Statement	PC1 Answers	PC2 Answers	PC3 Answers	PC4 Answers	PC5 Answers
Question 11. The System Usability Scale					
Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree					
i. I think that I would like to use this tool frequently.	Neutral	Strongly Disagree	Neutral	Strongly Disagree	Disagree
ii. I found the tool unnecessarily complex.	Agree	Strongly Agree	Disagree	Strongly Disagree	Agree

iii. I thought the tool was easy to use.	Disagree	Strongly Disagree	Neutral	Disagree	Agree
iv. I think that I would need the support of a technical person to be able to use this tool.	Agree	Strongly Agree	Agree	Strongly Disagree	Strongly Agree
v. I found the various functions in this tool were well integrated.	Disagree	Disagree	Agree	Disagree	Agree
vi. I thought there was too much inconsistency in this tool.	Disagree	Disagree	Strongly Disagree	Strongly Disagree	Strongly Agree
vii. I would imagine that most people would learn to use this tool very quickly.	Neutral	Strongly Disagree	Neutral	Disagree	Agree
viii. I felt very confident using the tool.	Disagree	Agree	Neutral	Disagree	Disagree
ix. I needed to learn a lot of things before I could get going with this tool.	Agree	Disagree	Agree	Disagree	Disagree

The next set of questions gathers some background information about the participants educational experience.

Q12. How many years of schooling did you do in Canada before coming to study at York?

Options: a. 12+; b. 5-7; c. 2-4; d. less than 2

On how many years of schooling, prior to coming to York University, each participant completed here in Canada, two participants answered less than 2 years, one answered 2-4 years, one answered 5-7 years, and one answered 12+ years.

Q13. What do you think had the most effect on your grades in Highschool?

Participants were then asked what, in their opinions, had the biggest effect on their grades in high school. 2 mentioned they lacked motivation and interest in school and as a result did not pay attention as much and their overall performance was “not that good” (PC4). One participant said that their grades was mostly due to exams and homework but did not specify if they had high grades or not. And 2 participants mentioned having extra attention from their teachers or from tutors that helped explain things to them further.

Q14. Have you ever been diagnosed with a learning disability?

Options: a. Yes, With prof. opinion; b. Yes, Self-Diagnosed; c. No; d. prefer not to answer

Participants were asked if they were ever diagnosed with a learning disability, 2 said Yes and 3 said No.

Q15. Of the following Learning Styles which do you most identify with?

Options: a. Visual (spatial): You prefer using pictures, images, and spatial understanding; b. Aural (auditory-musical): You prefer using sound and music; c. Verbal (linguistic): You prefer using words, both in speech and writing; d. Physical (kinesthetic): You prefer using your body, hands and sense of touch; e. Logical (mathematical): You prefer using logic, reasoning and systems; f. Social (interpersonal): You prefer to learn in groups or with other people; g. Solitary (intrapersonal): You prefer to work alone and use self-study

Participants were given a list of Learning Styles as outlined by Learning Styles Online Website (*Overview of Learning Styles*, n.d.) to pick which they most identified with. Four out of five participants picked Solitary as one of their learning styles. Three out of five picked Visual. Three picked Kinesthetic or Physical. Some of the other learning styles picked are: Aural, Logical, Verbal, Visual, and Social.

Q16. What format of classes have you experienced here at York?

Options: a. Lectures (in person); b. Lectures (online); c. Labs; d. Tutorials; e. Studios; f. Other: (please specify)

Of the different class formats listed, participants said that they have experience all of them. A couple of students said they did not experience studios, and others mentioned courses that were field work based and hybrid or asynchronous.

Q17. Which class format(s) do you most prefer? Which do you perform better in?

When asked which formats they preferred and performed better in, participants chose the formats that had smaller class sizes, like labs, as well as formats that can be recorded and they can go back and rewatch the recordings. They also chose formats that had more hands-on learning like labs and studios.

Q18. What kind of tasks are you being asked to complete in your current courses? (choose all that apply)

Options: a. Readings; b. Quizzes; c. Discussion forums; d. Assignments; e. Midterms; f. Projects (individual); g. Projects (group); h. Labs (individual); i. Labs (group); j. Presentations; k. Lab-tests; l. Other: (please specify)

Students were asked what kinds of tasks they were asked to do in their courses, present and past during their time at York University. Of the options listed, the participants said all or most of them.

Q19. Which kinds of tasks do you most prefer? Which do you perform better in?

When asked what kinds of tasks they prefer and perform better in, participants chose again tasks that are more hands-on like projects and assignments.

This next portion of the interview explores how the participants' reflected on their understanding of the tool's purpose and the incorporation of it into courses.

Q20. Do you feel you understand the tool's purpose?

Options: a. Yes (what did you understand); b. No (why not? What information do you think was missing that could've help you understand better?)

When asked if they understood the tools purpose, most of the participants said yes and described different pieces of the intended uses of the tool. One said not fully and that they needed a more extensive tutorial.

Q21. Do you feel you understand how the tool would be implemented into a course?

Options: a. Yes (what did you understand); b. No (why not? What information do you think was missing that could've help you understand better?)

When asked if they feel that they understand how the tool can be implemented into a course participants had a positive response. Some were certain and others were somewhat hesitant about their assumptions. Participants said a mix of different things that again described the original vision of the tool: an online tool to be implemented into courses where students can do different modules with different tasks with some collaborative activities and learning challenges to be done online with other students. Most students saw the portals and different worlds as the tasks themselves rather than spaces to house the tasks, and to separate individual and group spaces. Some spoke to the logistics of how instructors would run this tool in a course.

Q22. Do you think this tool would be helpful if implemented into courses?

Options: a. Yes (how?); b. No (why?)

When asked if they think this tool would be helpful, four out of five participants said Yes, but emphasized that the tool needs to be refined and developed further before being launched in courses. Participants mentioned that this tool would make learning more fun, engaging, and interesting as it "stimulates other senses… [and will make the experience] more memorable… which should help the content being absorbed easier…" (PC1). Some mentioned that there will probably be some growing pains as instructors and students get more used to the tool. Most participants focused on this tool being more helpful for remote and online course formats rather than in-person.

Q23. Do you think this tool would make education more inclusive of different learning styles and people with learning disabilities?

Options: a. Yes (how?); b. No (why?)

The participants were asked if they thought this tool would make education more inclusive of different learning styles and people with learning disabilities. One participant said No because they don't think this tool is inclusive of people with visual disabilities and that it can be too distracting for people with ADHD. Four out of five participants said yes, because it involves different senses and engages different learning styles. They also mentioned that this is more interactive and brings a tangible or multimodal feel to virtual learning. One also notes that this environment offers a new alternative to the traditional teaching styles: "and it's sort of like you either get used to it or you don't until, and you like quit school" (PC5).

Q24. Do you think this tool would make course formats better?

Options: a. Yes (how?); b. No (why?)

For the participants' thoughts on whether this tool would make course formats better, all said yes. Some said yes because it caters to different learning styles, others said yes because it improves online/virtual learning experience, and some said it was not necessarily better, but more engaging and interesting.

Q25. Do you think this tool would make a good alternative to standard LMSs (like eClass, Moodle, blackboard, etc.…)?

Options: a. Yes (how?); b. No (why?)

On whether this tool would be a good alternative to LMSs, most participants said no because eClass offers certain functions that they don't believe can be implemented in a tool like this. The participants who said No mentioned a home screen with an overview of their courses on one page. One participant said yes because they find eClass confusing. But overall they think a revised tool like this could be used alongside more traditional LMSs.

Q26. Do you think this tool would make course assessments and tasks better?

Options: a. Yes (how?); b. No (why?)

Participants were asked if they believed this tool would make course assessments and tasks better, most participants were worried about proper use and implementation of the tool for it to make the assessments better. But most mentioned that it would make the tasks more interesting and fun.

Q27. Would having a tool like this implemented into your courses make your educational experience?

Options: a. Yes (how?); b. No (why?)

When participants were asked if they believe a tool like this being implemented into their courses would make their educational experience better, all said yes for different reasons. Some indicated that it provides a virtual physical space for online courses, some said it would make learning about games and game design more hands-on. Some said it would make their educational experience more engaging and more practical.

Q28. Was there anything that wasn't asked about, but you would like to add?

Comments participants that they were not asked about included: further implementation of visuals and further gamifying the tasks.

Q29. Do you have any questions for me now that you have completed the walk through?

All the participants had questions about the instructor view and required an explanation of what that screen is and what the use of this view is for them. Some other questions asked were: "what is the age range for this tool?"; "What happens if a student decides to run into the void, what stops them from getting lost?"; "How is this meant to turn out?"; "What is your intention with this?"; "would you want this to be like more of a spontaneous thing or like an ongoing thing throughout like a course like it's a space that builds up as the course goes on?"

Analysis

On the basis of the results of the participant testing sessions, there was a generally positive response to the tool prototype. Most participants found that the tool concept, once fully developed and the bugs fixed, to be useful and felt it would improve the educational experience. Some suggestions were made as to what is missing from the tool prototype that would make it more user friendly and better for use in classes. This demonstrates a need for more scaffolding and support for understanding the aims and purposes of the tool (clearer expectations and directives for certain performative tasks). Participants found the prototype a bit too raw, and some did not get the idea of what the tool is supposed to be. But, when asked about what they think is missing, participants mentioned some of the concepts that were implemented (not recognized) and others that are a part of the design but not implemented (implied in the prototype) in this current iteration of the design. The testing results do confirm the original assumption of this research: that using Indexical Storytelling in virtual game environments for teaching in university level STEM courses, like InViTE Collab, does provide a more interactive and hands-on experience for theoretical content. The results also show promise that providing students with such a tool might improve student engagement, understanding, and participation. The tool re-introduces elements of play and inquiry using technology that many students are familiar with outside of the educational environment. Being able to situate theoretical content of coursework in real world examples that students are familiar with also helps their learning and understanding. Even though the study participants did not seem to always recognize the educational elements that were provided, all of them seemed to understand the basics of the task presented, most of their confusion came from bugs in the implementation of the system rather than the task at hand. To avoid such confusions, the implicit functions and learning spaces need to be improved and developed to ensure different learners are not alienated or confused.

D. Assessment and Self-Reflection

This section refers back to R2, Target Criteria Table 2, and evaluates whether the different criteria were met in Prototype 2 (P2), as well as updating the table to add any new criteria that were not in the list previously.

R3. Target Criteria Table

Criteria ID	Criteria Name	Description	Priority	Met in P1?	Met in P2?
R1.1	Customizable Characters	The ability to customize how the character looks to better match with the student's sense of self and identity	2	Yes	No
R1.2	Playable 3rd-Person Characters	The ability to see the student's virtual character full (3rd person view) in the game world	1	Yes	Yes

R1.3	Individual/Solo Worlds vs. Group/Collaborative Worlds	Having a separation of Individual (private) space and Group (public) space for student interactions and learning.	1	Yes	Yes
R1.4	Cooperative Games/Tasks for Group World Activities	Group tasks must take the format of a cooperative game task where the students are forced to work together to complete the task for a more even workload distribution.	3	Yes	No
R1.5	Modular Course Build Platform	Allows for an easier interaction for instructors who are using this tool for their classes. Similar to website-builders. Users pick features and pieces from a set list	2	Yes	No
R1.6	Main Menu Screen	An initial screen/Landing page where students and instructors can see an overview status of their course(s)	1	Yes	No
R1.7	LMS Integration	The ability to link this tool with current LMSs for easier and smoother transitions from standard LMSs	4	Yes	No
R1.8	Indexical Storytelling Support	The ability to leave behind indices and interact with what is left behind by others.	1	Yes	Yes
R2.9	Humanoid Characters	Having a variation of Humanoid Characters	3	New	Yes
R3.10	Player Mechanics Integration	How a player interacts with the world. Picking up, dropping, moving items, drawing, etc.	2	-	New
R3.11	World State Preservation	Preserving the state of each world and the items the player is holding as the players go from one world to the next	1	-	New

R3.12	Cross-World Movement	How a player moves between the Worlds through portals in the game world	2	-	New
R3.13	Task Master	Having a Task Master character that provides the players with their task instructions/guidance.	2	-	New

Table 3. Target Criteria Table 3 – Updated Target Criteria after Prototype 2 (Unity)

R3. Target Criteria Rationale

10. Player Mechanics Integration

The objective for the tool to afford Player Mechanics Integration is motivated by the following:

- So that students are able to interact with the environment and the items needed to complete the tasks in the ILW and the GLW.
- Implementing all the different mechanics a student would need to complete a certain task affords a better experience with the prototype

11. World State Preservation

The objective for the tool to afford World State Preservation is motivated by the following:

- So that students are able to connect with the content and have more meaning full interaction.
- Further demonstrates Indexical Storytelling and what it can look like in the tool.

12. Cross-World Movement

The objective for the tool to afford Cross-World Movement is motivated by the following:

- Being able to use portals in the game world to move through the world affords a more immersive experience as opposed to clicking buttons on a 2D UI screen

13. Task Master

The objective for the tool to afford Task Master is motivated by the following:

- Having a Task Master provide task instructions to student in the game world in an RPG style with a dialogue box that pops up adds to the immersive-ness of the experience
- It also reduces the amount of text that users have to read: students are reading a small set of instructions, rather than a whole assignment document, and learn *through* exploring and interacting with the environment rather than through "content" delivery, explication, or direct instruction.

6. Third Iteration of the Design Concept: Prototype 3 (Future Work)

This section describes the envisioned next iteration of the Design Concept that can be carried out in the future as a next step to this prototype design. An updated concept is presented, as well as an updated Target Criteria Table. Testing steps for this iteration are presented in the Assessment and Self-Reflection subsection as a suggestion on how to evaluate this iteration. The final piece, reflection will compare this iteration of the design against the original Design Problem Statement presented in (Section 3 – Design Challenge/Opportunity).

A. Refined Design Concept

This next iteration will build off the work and prototype developed in Iteration 2 (Section 5), Prototype 2. This iteration will fix the bugs in the development of Prototype 2 as well as implement the criteria that were not met (see Section 5.D), as well as add feature that meet the new criteria outlined below (Section 6.B), such as adding in a Rewards/Badge System to further incentivise interactions with the tool; and adding in Visual Tutorials to teach users how to use new tools in an effort to cater to more learning styles. Clearing prompts and scaffolding for tasks should also be part of the redesign so users better understand the purposes and aims of their learning, even if that learning is enacted through doing, collaborating, or engaging situational challenges 'hands on'. This prototype also brings features from Prototype 1 in Iteration 1 (Section 4), such as the different main screen views for both students and instructors. However, as per the results from the testing session (Section 5.C), this iteration will explore the idea of mapping Lands to Tasks and having a cluster of Lands that make up each the Individual and Group Learning Worlds from Iteration 2.

Summary of Design Concept Elements (v.4)

Design Concept ID	Design Concept Description
DC1.1	**Digital environments that afford collaboration and support instructional and learning management in STEM courses**
DC2.1.1	Game World mapped to the Course Learning Environment
DC2.1.2	Gameplay Path(s) mapped to Course Learning Path(s)
DC2.1.3	Players in this environment are the Students
DC1.2	**Indexical Storytelling can be used in these environments**
DC2.2.1	Digital game tools that are earned up at the completion of tasks
DC2.2.2	Ability to alter the environment using the tools picked up
DC2.2.2	Ability to pick-up/drop/move items around in the world
DC4.2.3	Ability to turn on/off certain Indexical Storytelling Elements to declutter the view (ex. Footsteps tracking, drawing on a project wall, etc.…)
DC1.3	**Digital, collaborative environments that connect to LMS**

DC1.4	**Digital environments that afford individualization to learners**
DC2.4.1	Different Lands/Worlds that afford a separation of Learning, Assessment, Individual, and Group spaces.
DC2.4.1.1	~~4 Different Lands: Learning Land, Individual Assessment Land, Group Assessment Land, and Sandbox Land.~~
DC 3.4.1.1	3 Different Worlds: Individual Learning World, Group Learning World, Main Lobby.
DC 3.4.1.2	Example Tasks Across the Worlds: - Individual Learning World: Learning about Game Mechanics and Game Balance through Modifying Tic-Tac-Toe - Group Learning World: Students work in groups to design with new Mod-ed versions of Tic-Tac-Toe [see Lesson Plan in Appendix H]
DC4.4.2	Different Main Screen and Instructor Views to best suit each person's preference and needs.
DC1.5	**Individual/group game tasks that provide hands-on interaction with applied course concepts**
DC1.6	**Private digital storage/backpack**
DC2.6.1	Digital Toolbox that stores all the tools that a student earns (Digital Backpack)
DC4.7	**Badge/Rewards System**
DC4.8	**Offering Different Ways of Learning (other than text-based)**
DC4.8.1	**Providing Visual "How to Play Tutorials" for new tools to reduce text in game.**

B. Prototype Target Criteria

This section refers back to R3, Target Criteria Table 3, and updates the table to add new criteria that came out of the UX testing sessions conducted using the Prototype 2.

R4. Target Criteria Table

Criteria ID	Criteria Name	Description	Priority
R1.1	Customizable Characters	The ability to customize how the character looks to better match with the student's sense of self and identity	2
R1.2	Playable 3rd-Person Characters	The ability to see the student's virtual character full (3rd person view) in the game world	1

R1.3	Individual/Solo Worlds vs. Group/Collaborative Worlds	Having a separation of Individual (private) space and Group (public) space for student interactions and learning.	1
R1.4	Cooperative Games/Tasks for Group World Activities	Group tasks must take the format of a cooperative game task where the students are forced to work together to complete the task for a more even workload distribution.	3
R1.5	Modular Course Build Platform	Allows for an easier interaction for instructors who are using this tool for their classes. Similar to website-builders. Users pick features and pieces from a set list	2
R1.6	Main Menu Screen	An initial screen/Landing page where students and instructors can see an overview status of their course(s)	1
R1.7	LMS Integration	The ability to link this tool with current LMSs for easier and smoother transitions from standard LMSs	4
R1.8	Indexical Storytelling Support	The ability to leave behind indices and interact with what is left behind by others.	1
R2.9	Humanoid Characters	Having a variation of Humanoid Characters	3
R3.10	Player Mechanics Integration	How a player interacts with the world. Picking up, dropping, moving items, drawing, erasing, etc.	2
R3.11	World State Preservation	Preserving the state of each world and the items the player is holding as the players go from one world to the next	1
R3.12	Cross-World Movement	How a player moves between the Worlds through portals in the game world	2
R3.13	Task Master	Having a Task Master character that provides the players with their task instructions/guidance.	2
R4.14	Turning on/off Indexical Storytelling Elements	The ability for users to choose if they want to turn on/off certain Indices	3
R4.15	Different Instructor Views	Different Instructor View options to manage Student Indices and Activity information	2

R4.16	Badge/Rewards System	Having a badge/rewards system (other than new tools) to signal completion of tasks	1
R4.17	Gamification of Lesson Plans	Turning traditional Lesson Plans into more task-based and hands-on activities	1
R4.18	How to Play Visual Tutorials	Video Tutorials to demonstrate new tools and mechanics	1

Table 4. Target Criteria Table 4 – Updated Target Criteria for Prototype 3 (Future Work)

R4. Target Criteria Rationale

14. Turning on/off Indexical Storytelling Elements

The objective for the tool to afford Turning on/off Indexical Storytelling Elements is motivated by the following:

- Allows students to control the amount of Indexical Storytelling Elements that they can see to declutter their view of the environment.
- This does not apply to all elements or types of Indices; it would apply to indices like the footsteps that track others' and their own movement; as well as other's drawings on the project walls (not peer feedback).

15. Different Instructor Views

The objective for the tool to afford Different Instructor Views is motivated by the following:

- Provides instructors with different view options to be able to see the activity of their students in the most appropriate format.
- Some views that can implemented (more can be added as needed):
    - Full Class View: shows all students in the class across the timeline of the course (start to finish)
    - Student View: shows one student across the timeline of the course (start to finish)
    - Task View: shows all students in a class relative to a specific task
    - Group View: Shows students in a specific group for the duration of the group (when the group was created and all tasks they are assigned to)

16. Badge/Rewards System

The objective for the tool to afford Badge/Rewards System is motivated by the following:

- Adds a motivational incentive to completing tasks (graded or not)
- Provides students with a direct feedback and signals the completion of a task.
- Badges/points, etc., are an auxiliary feature, not a core mechanic for behavioralist forms of gamification based on extrinsic rewards or motivational transactions.

17. Gamification of Lesson Plans

The objective for the tool to afford Gamification of Lesson Plans is motivated by the following:

- So that students are able to learn their content more through tutorials, inquiry, engaging manipulable resources and challenges, and less through text-based instructions or traditional content delivery.
- For example Lesson Plan [Appendix H] should have the following modifications:
    - Have different simple modified versions of tic-tac-toe that demonstrate what Game Mechanics and Game Balance mean (similar to a game tutorial) and clear prompts for collaborative action and design goals
    - Students play the different conflict resolution games against a Bot in ILW to demo the different key words and instantiate or apply concepts.

  Students then go to GLW to work on the group project with their peers.

18. "How to Play" Visual Tutorials

The objective for the tool to afford How to Play Visual Tutorials is motivated by the following:

- Provides students with a more immersive way to learn how to use new tools through visualization and modelling.
- Reduces amount of text to further diversify the delivery methods to cater to different learning styles.

C. Assessment and Self-Reflection

This section proposes testing steps to evaluate this iteration. This section also provides a reflection that compares this iteration of the design against the original Design Challenge/Opportunity Question presented in (Section 3) to evaluate the application of this tool.

To evaluate this iteration of the tool, the next round of testing can follow a 3-step approach with a larger wider set of participants to re-evaluate the tool's usability. The 3 steps consist of:

Step 1: Initial Survey

This survey gathers information about the testers educational background, their thoughts on the current educational system, what their academic performance is like, and what changes they hope to see in the educational system in the future (if any).

Step 2: UX Testing and Interview

This portion reaches out to the respondents of the Initial Survey and invites them to participate in a larger round of UX Testing (similar to the UX Testing done in Section 5). Again this testing round would involve a larger group of students to gather information from a larger sample size that best fits the general student population.

Step 3: Follow-up Survey

Participants from Step 2 will then be sent a 2nd survey to ask about their opinions on the tool's usefulness and how successful they believe it can be to make their educational experience more engaging and practice based.

This three-step process will allow for a more detailed response and feedback on all of the different aspects of the design. The three steps draw from the UX Testing process used in Section 5C and expands it into 3 separate steps to be able to collect more detailed information and responses from the participants.

Going back to the original Design Challenge Question of this research, this project investigates the question: To what extent does the use of Indexical Storytelling in Virtual Learning Environments in Post-Secondary STEM programs afford better understanding and learnability?

The goal of the research was to design and develop a tool called InViTE Collab. This tool offers students with an interactive platform that provides a task-based, collaborative approach to learning in STEM fields, particularly where design processes and more open-ended inquiries are in play. Based on the testing results from Prototype 2 (section 5.C), the Design, Target Criteria and testing process presented in this section confirm that the Refined Design Concept does fit the Design question. This prototype aims to build further on the previous iterations, meaning that this design, updated set of Target Criteria, and testing process, should provide more insights and generate more results that can help further answer the Design Challenge question. This prototype offers users a more interactive, collaborative, and task-based educational environment that uses Indexical Storytelling as a basis for the interaction and collaboration. It also adds an element of fun and attracts students' attention and focus through real-world applications of traditionally theoretical course content.

7. Discussion

Mere memorization of decontextualized information is too often the goal of dominant forms of education and assessments (like tests and exams). Given the evidence presented from the sample of previous research studies, the main conjecture of this research is that the use of Indexical storytelling in a virtual learning environment in higher education settings should lead to better learning outcomes that transcend the memorization of such content, which also establishes a gap between knowledge as abstract 'content' and applied practical knowledge that is put into action as part of a skilled practice (e.g., engineering). Using Indexical storytelling allows the users to write parts of their journey and collaborate with each other and solve practical design challenges and problems. This affords better understanding and an (dynamic, feedback-rich, and environmentally supported) learning curve. Another takeaway from the previous research is that students learn better through more combinations of physical, visual, and textual modes of learning, as opposed to solely textual modes of learning. They also learn better when using games and virtual environments than sitting in lectures for hours and only reading or hearing about the applications of theoretical content. The current formats of teaching also seems to alienate some students as it can be confusing if the format does not match with their styles of learning and understanding, as stated by one participant of the UX Testing session in their answers to the Interview and Debrief questions. If students find a format to be confusing or if they do not recognize the purposes of learning, they will end up dis-engaging with the course and materials. This tool aims to alleviate this confusion by connecting course concepts to real world applications through immersive practice. All of these are elements of Indexical storytelling in virtual learning environments which should, in principle, make these environments a better way to deliver and actively apply course content, teach and learn in a higher education setting, and to move beyond mere content reproduction as the goal. My tool enables us to consider action, doing, making and collaborative problem solving where content, concepts, and modes of doing are interwoven, enacted, and embodied through design processes, and/or role-playing simulations with smart tools. The InViTE Collab tool addresses a current gap in learning tools for post-secondary institutions. It ensures the return to more hands-on practical learning that follows a task-based exploration of new course concepts in a virtual open-world collaborative environment that supports open-ended inquiries.

This work does have its limitations that could have influenced the results of the testing and the development of the prototype. Some of the biggest limitations can be categorized as limited resources – number of participants in the testing phase, developers, time, and educational designers – all of which could have influenced the results of this research.

The low number of participants in the study could have skewed the results because of the small sample size. Having a small sample size is considered as a limitation here due to this sample not accurately representing the whole student population. This means that our results could be because of responses from only a small group of students rather than the majority. Students were all from upper year Electrical Engineering and Computer Science (EECS) courses. A larger, more educationally diverse (from different programs and years) sample of student participants is needed to ensure that the results are more representative of our target population, which is university level STEM students.

For this tool to be properly developed and all the target criteria implemented, more developers and time is needed. Due to the limitations of team members and time, the tool prototype was not

able to reach its full potential. This resulted in many bugs in the system. It could have also compromised the participants' understanding of the tool and its purpose. With a transdisciplinary team of people and time, this tool can be implemented completely with assets (graphics, characters, models, audio, etc.…) made specifically to match the tool's vision. Using borrowed assets that don't match up with each other or the concept of the tool caused some confusion.

Working with educational designers who understand the unique learning affordances and opportunities of game environments, simulations, and micro-worlds can also help in the redesign of the course content to game tasks that can then be implemented by the developer(s). Having educational designers as part of the development team means that the learning tasks can be professionally developed to ensure that all the course learning outcomes continue to be met in this new environment. Having specialized people in each of the different roles within the team is extremely important because it allows people to work in their areas of strength.

All of these limitations can be reduced and managed with more time and people working on the tool development and research, which is a goal for future iterations.

Given the absence of pre-existing data, there are many areas for future research. One can be to take this work and do an analysis of the technology available and do a study on which mode of delivery of this design is better (phone app, game console app, web app, AR, VR, etc.). Another direction could be to take this a see the feasibility of implementing this way of teaching in universities, colleges, and public schools (within Canada or outside of it). Taking it another step forward would be designing a pilot course to be done halfway in the original way and the other half using the new tool (a more developed version of the prototype) and testing students after both modules to see if and how their performance and understanding changes. Next steps for this work after the conclusion of this MRP would be to continue the next iterations and do a study with students in an active university course to test a more advanced prototype of a virtual environment that uses Indexical Storytelling analyzing the effects it would have on students' experience and performance. The pilot course will be taught halfway in the original way and the other half using the new tool (a more developed version of the prototype) and testing students after both modules to see if and how their performance and understanding changes.

8. Conclusion

The Design Challenge Question that this research aimed to answer is: **To what extent does the use of Indexical Storytelling in Virtual Learning Environments in Post-Secondary STEM programs afford better understanding and learnability?**

As the analysis of previous research [Section 2] suggests, the use of Indexical Storytelling may provide a more immersive online environment where students can work together, collaborate, and engage with different learning activities (individual or group). This research can have a huge impact on learning and how student perception and understanding is viewed from the perspective of educational game design and other learning theories advancing inquiry-driven learning, design thinking, and interactive multimodal learning environments. It could drastically change the way we design courses, course materials and assessments, course delivery tools, as well as the applications of new and emerging technology in classroom environments. It also gives students more opportunities to have an active role in the co-authoring of their learning journey. Students placed in an environment that allows for Indexical storytelling leave an impact on the environment. But they are not the only ones affected by this impact, as their peers also feel the effects of the impact others have made by sharing knowledge, models, and techniques. The Indexical Storytelling elements include learning with and from what has been shared and "left" for others to examine and critique. This provides students a truly collaborative interaction with their peers and instructors.

The Design Challenge Question posed [Section 3] helps better situate this research within the connected fields of research, as s well as provides a rationale for the connections to each field. It also sets up the Initial Design Concept and generates the Evaluation Criteria to begin the designing of the prototype. The following iterations of the prototype and design, then, build off the Initial Design Concept and the Evaluation Criteria using user feedback.

The First Instantiation of the Design Concept [Section 4] refines the Design concept presented in the previous section and introduces a Low-Fidelity, paper and pen, prototype. This process entails building up an inspiration board and creating sketches to better visualize what the tool looks like or might look like. This section also introduces different end users through User Personae and situates their experience and how this tool can improve their learning experience through different use case scenarios. This prototype is then evaluated against the Evaluation Criteria from the previous section and introduces new criteria to help improve the next iteration.

The Second Iteration of the Design Concept [Section 5] improves on the Design Concept in the previous section and introduces Prototype 2 which is a Unity grey-box level that demonstrates the different mechanics and interactions players can have with a more complete version of the proposed tool. This prototype also introduces a more detailed description of the different Worlds, how students interact with the different Worlds and items, what they can do, examples of what Indexical Storytelling elements can be found in each world, and what different activities can look like in this environment. This section also describes the UX Testing sessions' process, what Data Collection Methodologies were used, and what process was followed. As well as the results and analysis of the Participants' comments from the walkthrough and responses to the questions posed in the Interview and Debrief portion of the session. The results of the UX testing session match the original hypothesis stated earlier in the paper. Using Indexical storytelling can provide a more engaging and fun environment for learning which will give students better learning outcomes. The participants found the grey-box prototype of the environment challenging to

understand and work with. The challenges faced by participants with the prototype environment generated information and useful points of focus for the next iterations. Some of the challenges mentioned were: items falling through the ground, the writing going through the wall, unclear instructions, not enough instruction on how to use new tools (like the pen/brush), backpack icons that did not match the items, etc.… Students may be able to better understand and retain the content, concepts, and skills they learn as they will be learning through hands-on practical applications of the theory. This iteration is then evaluated using the criteria from the previous section and updates are made to the Evaluation Criteria to set up the final iteration proposed in the next section.

The third and final Iteration of the Design Concept introduces Prototype 3 [Section 6], a future iteration and imagining of the next prototype guided by the feedback and critique of the participants from the UX Testing session [Section 5]. It shows the updated iteration of the Design Concept as well as Updated Target Criteria that are to be used to evaluate this new prototype. It also proposes a new testing process that expands on the Testing process that was used to evaluate Prototype 2 [in Section 5]. It expands the single session testing process into a 3-step process that will allow for more detailed information collection from a larger sample size of participants that better represent the target student population, post-secondary STEM students.

The Discussion [Section 7] offers general reflections on the research, outlines some of the limitations of this research, and offers possible future research opportunities that build off the work presented in this paper. The reflections look back to the original purpose of the research, as described in the Introduction [Section 1], and looks to validate whether the work completed during the course of this project is in-line with the original purpose. Then the limitations of this project are acknowledged and how to mitigate or resolve these limitations in future iterations is proposed. Finally, some opportunities for Future Work are proposed. The different suggestions can be carried out as completely independent projects or can be combine for future implementations.

References

Abrahamson, C. E. (1998). Storytelling as a pedagogical tool in higher education. *Education, 118*(3), 440–452.

Andersen, N. (2019). *Masters Thesis: Environmental Storytelling in Storyworlds* [Det Digitale Projektbibliotek, Aalborg Universitet]. https://projekter.aau.dk/projekter/da/studentthesis/masters-thesis-environmental-storytelling-in-storyworlds(9d573cf0-2068-437f-bf36-8fb0e565384f).html

Calleja, G. (2009). *Experiential narrative in game environments*. https://www.um.edu.mt/library/oar/handle/123456789/26653

Collins, F. (2006). The Use of Traditional Storytelling in Education to the Learning of Literacy Skills. *Taylor & Francis Online*, *152*(1), 77–108. https://doi.org/10.1080/0300443991520106

Egan, K. (1989). *Teaching as Story Telling: An Alternative Approach to Teaching and Curriculum in the Elementary School*. University of Chicago Press. https://press.uchicago.edu/ucp/books/book/chicago/T/bo3623439.html

Fernández-Vara, C. (2011). Game Spaces Speak Volumes: Indexical Storytelling. *Proceedings of DiGRA International Conference: Think Design Play*. http://www.digra.org/wp-content/uploads/digital-library/Game-Spaces-Speak-Volumes.pdf

Fernández-Vara, C. (2012). *Environmental Storytelling: Indices and the Art of Leaving Traces*. GDC - Game Narrative Summit, Online. https://www.gdcvault.com/play/1016566/Environmental-Storytelling-Indices-and-the

Flood, J., Heath, S. B., & Lapp, D. (2015). *Handbook of Research on Teaching Literacy Through the Communicative and Visual Arts, Volume II: A Project of the International Reading Association*. Routledge. https://doi.org/10.4324/9781315759616

Forehand, M. (2005). Bloom's Taxonomy: Original and Revised. *M. Orey (Ed.), Emerging Perspectives on Learning, Teaching, and Technology*. https://cmapspublic3.ihmc.us/rid=1FPRRBRBK-1V1PZ0J-2JPL/Blooms%20revised%20Taxonomy.pdf

Gee, J. P. (2003). What video games have to teach us about learning and literacy. *Computers in Entertainment*, *1*(1), 20. https://doi.org/10.1145/950566.950595

Grodal, T. (2009). Stories for Eyes, Ears, and Muscles: *The Evolution of Embodied Simulations*. In T. Grodal, *Embodied Visions* (1st ed., pp. 158–180). Oxford University PressNew York. https://doi.org/10.1093/acprof:oso/9780195371314.003.0008

Hannafin, M. J., & Land, S. M. (1997). The foundations and assumptions of technology-enhanced student-centered learning environments. *Instructional Science*, *25*(3), 167–202. https://doi.org/10.1023/A:1002997414652

Johansen, S. (2014). *Content Potentials in Transmedia Storytelling* [Det Digitale Projektbibliotek, Aalborg Universitet]. https://projekter.aau.dk/projekter/da/studentthesis/content-potentials-in-transmedia-storytelling(c646238f-17b9-41e3-a44b-9336be0ceec9).html

Karlsson, J., & Sääf Malm, S. (2021). *INDEXICAL STORYTELLING: A story without words*. http://urn.kb.se/resolve?urn=urn:nbn:se:his:diva-20047

Kieran Egan. (1988). *Primary Understanding: Education in Early Childhood* (1st ed.). Routledge. https://www.routledge.com/Primary-Understanding-Education-in-Early-Childhood/Egan/p/book/9781138008458

Lowdermilk, T. (2013). *User-Centered Design: A Developer's Guide to Building User-Friendly Applications*. O'Reilly Media, Inc.

Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. *Computers & Education, 70*, 29–40. https://doi.org/10.1016/j.compedu.2013.07.033

Overview of learning styles. (n.d.). Retrieved April 24, 2024, from https://www.learning-styles-online.com/overview/index.php

Pea, R. D. (1992). Augmenting the Discourse of Learning with Computer-Based Learning Environments. In E. De Corte, M. C. Linn, H. Mandl, & L. Verschaffel (Eds.), *Computer-Based Learning Environments and Problem Solving* (pp. 313–343). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-77228-3_15

Pea, R. D. (1994). Seeing What We Build Together: Distributed Multimedia Learning Environments for Transformative Communications. *Journal of the Learning Sciences*, *3*(3), 285–299. https://doi.org/10.1207/s15327809jls0303_4

Robin, B. R. (2008). The Effective Uses of Digital Storytelling as a Teaching and Learning Tool. In *Handbook of Research on Teaching Literacy Through the Communicative and Visual Arts, Volume II* (1st ed., Vol. 2, p. 12).

https://www.taylorfrancis.com/chapters/edit/10.4324/9781315759616-57/effective-uses-digital-storytelling-teaching-learning-tool-bernard-robin

Sandercock, I. (2013, March 11). How Does Active Learning Support Student Success? *Teach Online*. https://teachonline.asu.edu/2013/03/how-does-active-learning-support-student-success/

Shachter, J. (2021). *Teaching Reading Skills in "Surround Sound." 2020*, 323. https://doi.org/10.37546/JALTPCP2020-40

Tennakoon, D., Usmani, A. U., Vasileiou, A., Latchaev, S., Baljko, M., Usman, M., Khan, U., Perras, M., & Jadidi, M. (2022, August 23). *TEACHING EARTH SYSTEMS BEYOND THE CLASSROOM: DEVELOPING A MIXED REALITY (XR) SANDBOX*. 2022 ASEE Annual Conference & Exposition. https://peer.asee.org/teaching-earth-systems-beyond-the-classroom-developing-a-mixed-reality-xr-sandbox

The New London Group. (1996). A Pedagogy of Multiliteracies: Designing Social Futures. *Harvard Educational Review, 66*. https://www.sfu.ca/~decaste/newlondon.htm

Wolf, M. J. P., & Perron, B. (Eds.). (2004). *The Video Game Theory Reader* (1st ed.). Routledge. https://doi.org/10.4324/9780203700457

Younger, D., Baxter, T., & Rohde, J. (2016). *Theme park design & the art of themed entertainment* (First edition paperback). Inklingwood Press.

Zimmerman, J., & Forlizzi, J. (2014). Research Through Design in HCI. In J. S. Olson & W. A. Kellogg (Eds.), *Ways of Knowing in HCI* (pp. 167–189). Springer. https://doi.org/10.1007/978-1-4939-0378-8_8

Appendix

A. Testing: Recruitment email

Dear Students of EECS4700/4461,

A Digital Media master's student, Riggy El-Shebiny, is looking for playtesters for her prototype (a game-like interactive learning environment for STEM students).

She is looking for 3-5 playtesters who can come to the LRC104 on Monday, April 15th or Tuesday, April 16th for a one-hour in-person session.

LRC104 is easy to get to: https://piet.apps01.yorku.ca/directions-to-lassonde-research-centre-lrc-room-102/

Participants will receive a $40 gift card.

Here are the available timeslots:

Monday, April 15th: 10:00am – 3:00pm or Tuesday, April 16th: 11:00am - 6:00pm

Please email her directly at rshebiny@yorku.ca (be sure to include "Research Study Question" in the subject of your email).

First come, first serve.

Sincerely, Prof Baljko

B. Testing: Informed Consent Form

Informed Consent Form: Adult Participant

Study Name: ***INDEXICAL STORYTELLING IN COLLABORATIVE LEARNING ENVIRONMENTS IN STEM EDUCATION***

Study Researchers:

Raghad El-Shebiny (Primary Researcher)

Professor Melanie Baljko (Supervisor)

Purpose of the research:

This research is surrounding designing a better student experience for Engineering students. EECS courses are being used to help develop the tool being designed in this research. The research aims to get participant inputs on education and the prototype. The main goal of this research study is to give students a voice to make a difference in how your education is designed. This research and the tool designed aim to design and create a more useful and efficient online learning management system that supports a more interactive, collaborative, project-based design for courses and programs at the university level.

Purpose of this task in the study:

This is the UX Testing portion of the research. In this phase participants will be asked to review and test the usability of the tool being developed for this research project. This helps the research identify what aspects of the tool are helpful, which need to be redesigned or addressed in future iterations. The participants will also be asked a set of questions at the end of the usability testing session to reflect on the usability of the tool and usefulness in university level courses. The participants can comment on the design and development of the tool, the user experience with the tool, and the design and implementation of the educational material in the created environment.

Purpose of this form: The purpose of this consent form is to give you the information you will need to help you decide whether to be in the study or not. You may ask questions about the purpose of the research, what happens if you participate in the research, the possible risks and benefits, your rights as a volunteer, and anything else about the research or this form that is not clear. We will give you a copy of this form for your records.

What you will be asked to do:

Initial:

After signing this Consent form, you will be given a participant code to keep your data anonymous. The recording will be started, and you will be given a list of instructions on how this session will go. There are 2 parts to this session. The first is an unguided walkthrough of the tool using the Think-Aloud protocol for comments from the participants. The second is a Usability testing Interview and Debrief with questions about the design of the tool. Once the recording starts you will be asked to not say any identifying information about yourself or others (peers, TAs, Profs., etc.…). During the unguided walkthrough of the tool you will be asked to say any questions, comments, concerns, or thoughts you have out loud. The interviewer will not be asking or answering any questions at this time.

Follow-up:

When you are done the walkthrough of the tool and feel that you have a good understanding of the environment and the tool and the Interview and Debrief have concluded, you will have the chance to ask any questions you may have about the tool or research. When the session ends, whether you have completed all the tasks in the session or not, you will be given your $40 visa gift card for choosing to participate.

Risks and discomforts: We do not foresee any risks or discomfort from your participation in the research.

Benefits of the research and benefits to you: In the long-term, this research can be used to design a more useful and efficient online learning management system to support a different more inclusive design of courses and programs at the university level. This research and the tool designed aim to design and create a more useful and efficient online learning management system. That supports a more interactive, collaborative, project-based design for courses and programs at the university level.

Voluntary participation: Your participation is most welcome, but you do not have to participate at all. Your decision not to volunteer will not have any influence on the nature of your relationship with York University, either now, or in the future.

Withdrawal from the study: You can terminate your participation at any time during the course of the task. You have the right to stop and not submit any of your answers in this survey by simply closing the browser window. But once the answers are submitted, because the answers are anonymous and

are not identifiable, we will have no way of deleting any of the content you submitted. Should you wish to withdraw, there will be no penalty and you will still be eligible for the compensation prize attached to the task you are completing. Your withdrawal from participation or refusal to answer any questions will not jeopardize current or future relationships with the researchers, York University, nor any other group associated with this project.

Time Commitment: We require a time commitment of approximately 45-60 min for this task.

Confidentiality:

All of the information you supply during the research will be held in confidence. Your name will not appear in any report or publication of the research, nor any other sort of identifying information. At the begging of the session, you will be assigned a participant code and that will be the "name" the interviewer will use to refer to you for the duration of the session to keep the recording, notes, and session data anonymous. The results of this study will be reported in a publication, but subject to all of the restrictions listed here. Your data will be safely stored in a secured, encrypted computer and only research staff will have access. Your name and contact information will on be mentioned in the list where your participant code is assigned which will be in a locked file on a locked external hard drive (only accessible to the researchers named here. Your name and contact information will only be retained for the researchers' use in case you need to be contacted for follow-up after the session. Therefore, your name will not appear in any documentation, notes, or transcripts resulting from this session. Should your name or any potentially identifying information slip during the session on the recording, it will be scrubbed and removed when the recording is being transcribed. The data, once analyzed, will be transferred into a secured, archival electronic format. It will be re-accessed only for the purposes of verification or in the unexpected case that some follow-up analysis needs to be done.

The data files will be destroyed 3 months after the conclusion of the study.

Confidentiality will be provided to the fullest extent possible by law.

Questions About the Research?

This research has been reviewed by the Human Participants in Research Committee of the Office of Research Ethics (ORE) at York University or its official designate. This protocol conforms to the standards of the Canadian Tri-Council Research Ethics guidelines.

If you have questions about the research in general or about your role in the study, please feel free to contact either Raghad El-Shebiny by e-mail (rshebiny@yorku.ca) OR Melanie Baljko by e-mail (baljko@yorku.ca).

If you have any questions about this process, or about your rights as a participant in the study, please contact York University via the information provided below:

Ms. Alison Collins-Mrakas,

Senior Manager and Policy Adviser,

5th floor, York Research Tower,

York University

telephone 416-736-5914

e-mail acollins@yorku.ca

Legal Rights and Signatures:

I (participant name) consent to participate in the study of the UX Testing conducted by **Raghad El-Shebiny/Melanie Baljko**. I have understood the nature of this project and wish to participate. I am not waiving any of my legal rights by signing this form. My signature below indicates my consent.

Participant Signature in Online Form.

Contact Information: Study Researcher

Professor Melanie Baljko

Department of Electrical Engineering and Computer Science (EECS) (4th year)
Lassonde School of Engineering

York University

Email: baljko@yorku.ca

Office: Lassonde Research Centre (LRC) 136 (4751 Keele St)

Phone Number: x33348

C. Testing: Session Script

Consent Form: https://forms.office.com/r/UqjSH6PBTs

[[Recording ON]]

Interviewer: Hello again, my name is, [Interviewer Name], and I am with participant [participant code [XXXX]].

Welcome to the INDEXICAL STORYTELLING IN COLLABORATIVE LEARNING ENVIRONMENTS IN

STEM EDUCATION research testing session

This project aims to explore the nature of interactive collaboration between students and their instructors.

The goal of the work is to generate insights that will allow for a more project- and practice-based learning experiences in the future.

This research aims to use a student-centered approach to educational design.

I don't want to give too much information so that I can gauge later how much you can understand from the tool itself.

I can give you more information later after the interview.

The tool you are testing today is a grey-box prototype of a tool called InViTE Collab - Interactive Virtual Teaching Environment for Collaborative Learning.

It is an online sandbox open world game environment to facilitate teach and learning.

So just to reiterate, please try to refrain from mentioning any identifying information about yourself, your peers, or professors.

But if something slips, it will be removed from the transcription.

Please feel free to let me know should you feel uncomfortable answering or sharing any information.

Are you ready to start?

-wait for participant confirmation-

This session will have 2 parts:

1. Will be an unguided walkthrough of the tool and

2. Will be an interview and debrief on the usability of the tool and your thoughts on its usefulness

For the first part you will be given access to the tool prototype(s) and using the Think Aloud Protocol.

Just try to speak aloud any comments, questions, thoughts, and/or concerns you have as you do the walkthrough. I will be silent in this part and will try not to answer any questions at this point.

If you would like, I can provide you with a pen and paper for you to write any questions you want to ask on to remind yourself, but I will ask that you also speak those questions out loud.

If you would like, I can remind you to use the think aloud if you go silent. The only other time I will be speaking is if you get stuck during the play test, I will provide you with a hint on what you are meant to do next, just to keep things progressing.

-wait for participant answer-

[[give participant access to tool prototype; remind them to speak out loud if they want reminders; and take notes]]

Interviewer: Now that you have completed the walkthrough and done the think aloud protocol, we will move on to the Interview portion of this session.

The questions will on the usability of the tool and your general understanding of what the tool is intending to do as well as your thoughts on the usefulness of a tool like this in your classrooms.

Just a reminder: this portion will continue on the same recording as the walkthrough; the recording is going to be

transcribed and anonymized as explained earlier.

Please refrain from mentioning any names or identifying information. But again, if something slips it will be removed from the transcription of the audio, to keep the data collected anonymous.

In this portion of the session, I will first ask you some questions to gauge your understanding of the ***InViTE Collab*** tool and the environment you went through. Then after that you will get the chance to ask any questions you may have about the tool; the research; what happens next; etc.…

D. Testing: Interview and Debrief Questions

Pt. 1 – Participant Understanding Questions

1. What did you understand about the tool from the walk through?

2. How would you describe this tool to a friend?

3. Was there anything that stood out to you about the tool (good or bad)?

4. Have you ever heard of something called Indexical Storytelling?

5. Did you notice any elements of Indexical storytelling in the environment created? Can you name a few?

6. Do you think the scene told a story?

7. What story could you tell (make up) from the scene(s) you walked through today?

8. Did you notice any learning/educational elements in the scene? What are they/ can you name a few?

9. What information did you understand from the learning/educational elements? What do you think you were

being taught?

10. What are 3 things you liked and 3 things you would change about this tool?

Pt. 2 – Usability testing Questions

11. The System Usability Scale

**When a SUS is used, participants are asked to score the following 9 items with one of five responses that range from Strongly Agree to Strongly disagree **

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

i. I think that I would like to use this tool frequently.

ii. I found the tool unnecessarily complex.
iii. I thought the tool was easy to use.
iv. I think that I would need the support of a technical person to be able to use this tool.
v. I found the various functions in this tool were well integrated.
vi. I thought there was too much inconsistency in this tool.
vii. I would imagine that most people would learn to use this tool very quickly.
viii. I felt very confident using the tool.
ix. I needed to learn a lot of things before I could get going with this tool.

Pt. 3 – Participant Background Information and Pre-Testing Thoughts

12. How many years of schooling did you do in Canada before coming to study at York?

a. 12+

b. 5-7

c. 2-4

d. less than 2

13. What do you think had the most effect on your grades in Highschool?

14. Have you ever been diagnosed with a learning disability?

a. Yes, With prof. opinion

b. Yes, Self-Diagnosed

c. No

d. prefer not to answer

15. Of the following Learning Styles which do you most identify with?

** Categories sourced from: https://www.learning-styles-online.com/overview/index.php **

a. Visual (spatial): You prefer using pictures, images, and spatial understanding.

b. Aural (auditory-musical): You prefer using sound and music.

c. Verbal (linguistic): You prefer using words, both in speech and writing.

d. Physical (kinesthetic): You prefer using your body, hands, and sense of touch.

e. Logical (mathematical): You prefer using logic, reasoning, and systems.

f. Social (interpersonal): You prefer to learn in groups or with other people.

g. Solitary (intrapersonal): You prefer to work alone and use self-study

16. What format of classes have you experienced here at York?

a. Lectures (in person)

b. Lectures (online)

c. Labs

d. Tutorials

e. Studios

f. Other: (please specify)

17. Which class format(s) do you most prefer? Which do you perform better in?

18. What kind of tasks are you being asked to complete in your current courses? (choose all that apply)

a. Readings

b. Quizzes

c. Discussion forums

d. Assignments

e. Midterms

f. Projects (individual)

g. Projects (group)

h. Labs (individual)

i. Labs (group)

j. Presentations

k. Lab-tests

l. Other: (please specify)

19. Which kinds of tasks do you most prefer? Which do you perform better in?

Pt. 4 – Tool Usefulness Questions

20. Do you feel you understand the tool's purpose?

a. Yes (what did you understand)

b. No (why not? What information do you think was missing that could've help you understand

better?)

21. Do you feel you understand how the tool would be implemented into a course?

a. Yes (what did you understand)

b. No (why not? What information do you think was missing that could've help you understand

better?)

22. Do you think this tool would be helpful if implemented into courses?

a. Yes (how?)

b. No (why?)

23. Do you think this tool would make education more inclusive of different learning styles and people with learning disabilities?

a. Yes (how?)

b. No (why?)

24. Do you think this tool would make course formats better?

a. Yes (how?)

b. No (why?)

25. Do you think this tool would make a good alternative to standard LMSs (like eClass, Moodle, blackboard,

etc.…)?

a. Yes (how?)

b. No (why?)

26. Do you think this tool would make course assessments and tasks better?

a. Yes (how?)

b. No (why?)

27. Would having a tool like this implemented into your courses make your educational experience?

a. Yes (how?)

b. No (why?)

Pt. 5 – Participant Comments and Questions

28. Was there anything that wasn't asked about, but you would like to add?

29. Do you have any questions for me now that you have completed the walk through?

E. Testing: Participant Interview/Debrief Responses

To see full list of Questions and Answers: Participant Responses Table

Question 1	What did you understand about the tool from the walk through?
PC1 Answers	Um, it seems like a tool similar to, what's the name of it? I forgot the name. Miro, where like, I guess you can draw things and everyone can see it or else can see it and then when you add things like, everyone else would see also the things you added, something like that seems to be like that. Like gamified, so you have like a 3d space to move around and interact with objects.
PC2 Answers	I'm guessing you mean like the movement stuff. I understood how to move, how to jump, how to run. I haven't had a use for running other than to speed up the testing time. And how to open up your, oh, how to switch your inventory, I guess, with 1, 2, 3, and 4. Those keys I was familiar with, but that's partly because of my knowledge in playing video games. So I kind of know, OK, W, A, S, D, or arrow keys are to move. 1, 2, 3 is usually an inventory slider for the four items in your hand. And then shift, I guess, is to run. That was just sort of, the instructions made it very easy for me to follow through. And it made sense when I tried it out. E and Q, X and H, H, to open it up, made sense, X to open up. But I understood… what X meant is a different story. And then I wish you could push X again to close it. But either way, self -intuitive, that you just click Start or continue to exit the screen. That made sense either way. Q and E were the difficult things and Tab, mainly Q and E. It said, put item down with Q, and then I would pick up an item, the character I'm playing as, which understood the pink guy is your avatar. I get that. So he is meant to be a representation of you. You pick up an item, and then I'd start when you picked up the item, you could place it when it's in your hand, but you don't have to put in your backpack and then you telepathically move it on the field using Q. E is to pick up the item. I guess that makes sense. But then it's also to interact with the activity box. For a minute, I thought it was Tab. I don't know why. And then with literal tools, I mean, I guess you don't really want me to talk about that. But then Circle and X, the tools within the game, I thought were annoying to put the physics engine. I kind of wish it would auto place. I couldn't be honest. I didn't know how they would work. I kind of wish the dice was bigger. It was very confusing. And then the same goes for the mouse and the pointer. I had no idea how that worked even after you told me.
PC3 Answers	I mean, yeah, because since it is like a prototype, I don't really want to like, you know, to specifically say what I think this is supposed to be. But I mean, it was basically like a more interactive, basically interactive system. And then by since I played on my own, there wasn't really aspect to that. But based on the instruction, I guess it was kind of like a multi-player environment. I guess I can be some useful multiplayer environment where

	you or your and your peers can kind of all join into the environment and work on something collectively, virtually. So, I from my understanding, it is like a tool that you can use in a virtual environment without having to maybe meet them in person and work on something together and work on activity and communicate.
PC4 Answers	The walkthrough. Oh, that's the lesson four. Um, oh, the whole thing. What did I understand? Like how broadly like how it works or yeah, well, okay. So yeah. I'm, I was able to understand it's kind of like an interactive environment. You can pick up objects, store them in inventory, where you place them in different places. I think each of the levels are supposed to be a, wait, nevermind. Yeah, okay, one of levels was an example of like the tic -tac -toe game explaining, like it had a whole list of instructions, but you kind of told me it was example, so I don't know if that counts. But anyway, yeah, it's okay. That's the example of how to demonstrate how to play the game. And then it would, or demonstrate how to explain how to play a game. And, then, it had the description of game mechanics and game balance, I think. But that was kind of insignificant. It was just there. I didn't really learn much about game mechanic and mechanics and balance. I was more focused on the tic -tac -toe thing. And then it had a bunch of tic -tac -toe equipment on the ground. I thought it was supposed to be... It was there for me to win a game of Tic Tac Toe or something, but I guess it was just like extra props. So yeah, that's what I understood about that first level. I don't know why it's lesson four though. But yeah. It was kind of like an example model. And then the next one, next level was trying to get me to make a new version of that first example. So trying give me an environment where I can mod the tic -tac -toe and then I think I was supposed to write my new verison down and it would be submitted or something but that didn't work out so well. So yeah, in short, I'm guessing it's just like an environment that's designed for me to write a game. And all the objects that you pick up and stuff on the ground, I guess are just props, just to visualize what I am writing. And yeah. There's portals and stuff. I guess that is it.
PC5 Answers	So I see this as like a sort of like a collaborative 3D space where people can work on a project. It sort of reminds me of like online drawing boards where people can work together. And I think having like 3D avatars in this space can definitely give a more immersive collaboration, sharing the whiteboard and stuff. Well, mostly what I said, but like I understand it's sort of like a collaborative thing, you know, it's like people are like working together, and they use this sort of digital 3D space to sort of brainstorm and, you know, like understand the tasks of the project. So with that end, we're given a few 3D objects and a digital whiteboard to sort of solve it. And then also we're given some examples of some of the stuff that the other groups have done in previous projects.

Question 2	How would you describe this tool to a friend?
PC1 Answers	I would say it's like having a meeting for a project virtually.
PC2 Answers	It's an open world sandbox game that's in beta testing. You can move around, you can pick up items, and you can place them. And that's quite literally, oh, and you can draw. OK, I picked up on that, but I like the quill as the pen. That's cool. Yeah, you can pick up stuff, you can play stuff, and you can draw. And you can jump, but there's no parkour, so it's meaningless. Uh, two, well, there's, there's, I mean, you told me partly it was communication, and the game did as well, but like, I never got that feeling. Cause I'm only one player and I had to get, uh, I looked in the back of the board to get other people's inputs. Uh, well, there's, there's, I mean, you told me partly it was communication, and the game did as well, but like, I never got that feeling. Cause I'm only one player and I had to get, uh, I looked in the back of the board to get other people's inputs. I'm guessing those are past players, but you can communicate by drawing on the board and I'm assuming somehow, it's going to get saved and transported to the next participant, um, so you can communicate technically, you can draw either way. It's a drawing simulator. If you want it to be not very intuitive, just cause, or at least on my mouse, but it is a drawing simulator. Um, you can be a tic -tac -toe game. Yeah. You can play tic -tac -toe on your own. Um, yeah, that's it.
PC3 Answers	I think I would say something similar to what I said in the previous question, just that it was like a virtual multiplayer, like a collaboration environment. And I basically had like a play test of like the utility, which is like the purpose of this test.
PC4 Answers	Uh, I think I would describe it as a very in progress educational tool where you can pick up objects and move them around, but it doesn't really do anything. It's more just a sandbox environment.
PC5 Answers	I would describe it as like a, it's sort of, I'd say it's sort of like a 3D like Google Docs where everyone is able to, you know, come together and work on a single project wherever they are. And you know, it's a 3D space so it's like we can see what each other is doing. So it's like we can all work on it together even though we're separate.
Question 3	Was there anything that stood out to you about the tool (good or bad)?
PC1 Answers	Um, then I found the controls not very intuitive or like, it's like sometimes to pick up the objects, I don't know where to look at the object

	to pick it up or like, placing back the objects, it's like, was a little bit confusing.
PC2 Answers	I think the footprints could be a cool idea. I think you could do something with that. I don't know, obviously you probably aren't trying to make like a Super Mario video game, but the jumping. I was thinking, oh, maybe this parkour could be. Anyway.
PC3 Answers	Uh, one. I'm gonna say I think both good and bad. One thing I liked was like, I guess like, I should say, I'm not really like a game person, so it's kind of hard to describe, yeah. Like, I guess like how things are placed, I guess. Like, for example, like this environment, I don't really know much about the game, but it was still obvious that where these clouds were, I'm not supposed to go over that area, and then this wall has the instruction, and there's the objects that I can interact with. So, I did kind of like, uh, did like go back and have to go back and forth and all that, but even though I did have to do that, it was still kind of obvious what was what, so there was no confusion to that even for a person who doesn't know much about the game, so that's one thing that I really liked. Uh, one thing that I was, uh, I wouldn't say bad, something that can improve on, I think it's because of the pro, because it's the prototype, like the controlling wasn't as easy for me, so yeah. That's right.
PC4 Answers	I think I like the concept of being able to walk around an environment and pick stuff up and put them around. It's kind of like Minecraft. But I think it needs a lot more work in the programming department to be a little bit more clear on how to manipulate the objects because they're all going all over the place and I think there should be like a typing tool or something for something if I'm gonna write a like, a massive like instruction sheet like I can't draw it with this tool.
PC5 Answers	Ummm… it's a little vague about what you need to do. There's nothing really guiding me to the portals. So I was a little confused at the initial group learning world. And the instructions at first said I could draw, but only near the end, I realized I needed a special pen to draw.

Question 4	Have you ever heard of something called Indexical Storytelling?
PC1 Answers	No, heard of that term before? No, I haven't.

PC2 Answers	No.
PC3 Answers	I heard of it, but I'm not entirely sure on what it is.
PC4 Answers	No
PC5 Answers	No

Question 5	Did you notice any elements of Indexical storytelling in the environment created? Can you name a few?
PC1 Answers	Yeah, so all my footsteps will be recorded. If I left the world and go to the other portal, the things I did in that was like that and remain like that.
PC2 Answers	Uh, one, uh, um, I walk into the tic -tac -toe room and I see, well, God, no, those two things. The first one being the board with the other, I'm assuming that's what other people have posted on there. I don't know how in the world they were able to draw a perfect emoji and change the color, but just by the point you, I've seen them post stuff up there. Um, and then I could see their feedback and then I can play their game and then I can invite my own game and then I'm assuming it's going to go on the board and then the next player is going to come along and they're going to get my. Uh, environmental change. Um, and the second thing is the footprints. I mean, it doesn't really affect the game. It just, you can just see the footprints there. I'm assuming that, um, when, uh, the next player comes along, they're going to see a green trail, a blue trail, an orange trail, and then whatever color my guy is. I think pink, they're going to see a pink trail and then, uh, so who, whatever color that player is, he's going to see a pink trail. Wait a minute. Cause I'm a pink guy. Wait. Oh yeah. I'm guessing that it's going to be pink. Um, so yeah, that's the second thing, but it doesn't really do anything in terms of interactivity, but it is visually, um, changing the environment.

PC3 Answers	Oh, yeah, based on the description, like, first of all, the footprints, I'm not sure if I can also that if I'm also going to be able to see what other players did, like, their footprints, if there are, but I noticed that it leaves my footprint. And then there were some footprints that were in different color. So I am assuming that is the footprint from the perhaps like the previous players and also the drawings. Of course, there were a few drawings or text on the wall that, yeah, also look like other players left it. And about the object. Yeah. I also was the brush that I got confused on. I left it on the ground in the previous portal, and then it was like it wasn't back in the box where it initially was. It was on the floor when I left it. So that was where the yeah.
PC4 Answers	Well supposing that everything I did saves and the next player will see all this like I just drew some like weird scribbles here like I think that would be an element like they would come in and be like oh yeah some guy was like messing around with the paintbrush and like I think it also goes for all the items and stuff I changed in those other levels, I moved them around and did some stuff.
PC5 Answers	Um, a little bit, I like, I, you know, it's like, there's the tic -tac -toe board on the ground that's sort of just inviting you to at least engage with the game. Well, if I had more than one person to work with it. And then, you know, there's also the wall and obviously like the clouds that, that sort of indicate a barrier of sorts. And then obviously those towers at the edge, those, you know, those, at least invited an investigation. And I think it is interesting you like use this like around shape to sort of like, I guess, designate instruction sort of, it's a very extremely crude, crude kind of human eyed figure compared to the more of the boxy shapes, like that's sort of inanimate and I'm supposed to interact with that, but this thing's supposed to, uh, you know, instruct and inform me what to do. So I think that's sort of, although it's very crude all in all, but you know, these are some very basic sort of, uh, conveyance without any words.

Question 6	Do you think the scene told a story?
PC1 Answers	Yes
PC2 Answers	Yes

PC3 Answers	Uh, from this, uh, not really
PC4 Answers	No
PC5 Answers	I can't really say I do. It's more of a, you know, instructional, more just sort of collaborative. I don't think there's a story more as just like, we want this project to do, go experiment. I don't really think there's much of a story. It's just sort of like, most of the story is just in this backboard that does indicate there are people. So there's a little bit of a story, but not like a huge overarching narrative.

Question 7	What story could you tell (make up) from the scene(s) you walked through today?
PC1 Answers	Yeah, so I accidentally started in the Portal 2. I was a little bit confused. There was already things in there. And I went to Portal 1, and after going to that, I was like, OK, now Portal 2 makes so much sense after looking at the first Portal that I was supposed to look at. And then I connected the dots that at first, it's like they're playing a game, and then later they got the feedback and everything. Yeah.
PC2 Answers	Yeah. Uh, classroom, uh, or squid or knock off squid game. But the idea of you, cause they use the word, I think classmates in the, how do we call it the speech marks? They use the interface, the instructions when you went to the task master. Also, I like the fact that he's just stoned could have been like one of those. I forgot what they called those Easter Island statues with the faces. Um, those stone spaces. It could be funny if you made that thing look like that, where you walk up to that and it's like a teacher. And then it's telling you to go to like the playground and make talk to the other students, uh, with a tic -tac -toe and tell you to play games with others to other students, uh, and then, uh, other students have like, uh, I don't know, like sticky notes, basically, which would be equivalent to the board you had. And then, uh, the all writing notes down on what type of game this is. And then you play the game. And then the sort of story would be that you are in a, either a classroom or you're in another version of school game and you're just playing with other students. And this is a teacher's way of trying to get you to socialize.
PC3 Answers	uh like if well considering this is like a game like um if i had to come up with a story it would be perhaps like um since i think it's a bit more multiplayer based uh you have to work with your team to clear this mission to perhaps get out of this environment and then or go over to a different environment and so on

PC4 Answers	Okay, wait. For the previous question, I think it tells a story now that I did all this because they've like, that's a story of me like you know, playtesting the game and like messing around with tools and messing up the items and stuff. Like that would be a story if someone came in and, like played the game. But when I first came in, and there was nothing here, except like everything that the game came with, you're asking me to make a story about that. Okay, so yeah, um, I guess like, yeah. Um, for what I did today, I, guess it's a story about someone who wanted to explore an environment and discover everything that the environment has to offer, because I was like, I was nitpicking every single detail and stuff. And they're trying to figure out exactly how the game works. So story of someone exploring his environment and trying to discover what can be done in the environment.
PC5 Answers	like what the story should be or going off this, how would I expand on the story? I sort of like make it interesting or it's like maybe there's some like hints of some crazy dark discovery and it's like, how could a tic -tac - toe game turn into some crazy monster that I would sort of add intrigue or at least encourage people to get to the bottom of it.
Question 8	Did you notice any learning/educational elements in the scene? What are they/ can you name a few?
PC1 Answers	Yeah, I was Taskmaster the pill that, that thing. It just gave me a task that gave it to me in like, a way that make it more like a game. It had like the conversation box. See how it was nice to look at and it felt like a quest.
PC2 Answers	that a teacher would tell you probably not know, except no, no, no, that's not one. No. I was going to say, that's not a game because they tell you a strategy for how to play that would be great, but they don't do that. They tell you the rules of the game. They don't really teach. They teach, obviously, the instructions of the keyboard, but that's going to be unique to every game.
PC3 Answers	Uh, well, I think there were like, you can potentially be used for it. Definitely. So like, uh, how we can be used for learning purposes, uh, but from like this, uh, just tech, I kind of was, uh, for me, it was kind of more, I had to focus more on controlling, actually interacting cause I wasn't used to it and I'm not sure if I part, I personally felt any like actual learning or like, uh, yeah.
PC4 Answers	100% because that first level was literally called Lesson 4. It was a lesson teaching me, it taught me to, well it tried to teach me two different like descriptions of stuff, the game mechanics and the Game Balance or

	something. That wasn't very attention grabbing that part. I was more focused on the tic -tac -toe part, but yeah it also taught me how to play tic -tac -toe. But I already knew how play tic -tac -toe, I guess that's the educational part. well, they gave examples, on the back of different possibilities of mods of the game, and they said they have comments on exactly what went wrong with them, One was too hard, one was perfect, and one was, I forgot the last one. I think one skewed too much to x.
PC5 Answers	like what the story should be or going off this, how would I expand on the story? I sort of like make it interesting or it's like maybe there's some like hints of some crazy dark discovery and it's like, how could a tic -tac -toe game turn into some crazy monster that I would sort of add intrigue or at least encourage people to get to the bottom of it.
Question 9	What information did you understand from the learning/educational elements? What do you think you were being taught?
PC1 Answers	answered in previous question
PC2 Answers	answered in previous question
PC3 Answers	Yeah, I'm not really sure.
PC4 Answers	answered in previous question
PC5 Answers	I don't think it was like trying to teach us tic -tac -toe. That was just sort of the medium they wanted us to use to sort of understand. Like I think the main thing is they wanted us to learn is how to use the whiteboard and like how to collaborate on it and also understand like object manipulation in order to play tic -tac -toe.
Question 10	What are 3 things you liked and 3 things you would change about this tool?

PC1 Answers	Yeah, so three things I like. I like the concept. I think it's cool. I think I would change a little bit the spacing. Everything seemed too far. Maybe I was like running a lot or maybe because it maybe was done that way. So, there's more space to put stuff later on in case so it doesn't get too crowded. I'm not sure. I would change. I would not change by just maybe polish some of the mechanisms. such as grabbing objects. And also, I thought the sensitivity was very low, so I would need it to move the mouse a lot to turn around and everything. And maybe also have, instead of tracking every object, maybe there's shortcuts to quickly sort them to one place to the other one.
PC2 Answers	I'm just realizing when you say to limit the whole game as a whole because it's a communication. Okay. Um, things are changed. Oh God, there's a lot. Uh, I wouldn't definitely make the pen more user friendly granted. Sometimes with Q singles for the circle square, that's all one feedback, by the way, this placing stuff. Uh, what else I've said, the drawing, the placing, and I guess the, some of the interactivity instructions are a bit more intuitive. Uh, mainly just the draw the drawing, which I already mentioned, and then the print, whatever E and Q are meant to be, and then to an extent tab, uh, yeah, cause I don't like how you have an inventory where you, the character holds something, but instead of placing it down, cause your character was a human rather than placing the item in his hand down, he puts in its backpack and telepathically transports from his backpack onto the table. That makes no sense. Like realistically, I know this isn't the month to be a most realistic thing, but like it's user intuitive. It makes sense. Um, and then stuff I liked, uh, I liked that you have for prints. And I liked that you couldn't just draw on the board. I was able to pick up on that quickly. And I liked some of the, um, I guess the cute aspects of the game. Uh, I liked that those taskmasters, just a cute little stone is not just a humanoid being. I like how the dice is just a dice. I like how it's a tic tac toe game and not like a game of like, I don't know, some 3d chess or something. Uh, I liked how, um, the, uh, the RPG style of the format of the instructions, that was very immersive as well. I liked how the text actually felt like it's very video game. Like it felt like, um, you know, in some sort of fairy tale type game, um, uh, so like, I mean, probably unintentional. The border looked like a piece of toothpaste and, and like, it's some stuff. Like you could see the unity text on the portals. Um, it was a bit funny. Um, yeah, maybe more decoration to the board. Like if the board looked like a white board, like the one that's behind you, that would be cool. Um, yeah. And the way that your pen is like, uh, an old, uh, feather pen, that's cool. Uh, attention to detail. I like that.

PC3 Answers	hmm uh 3 things I like the one was the what was mentioned previously the interactive one the what I can't see like other players did I also like the footprint yeah like kind of like so basically like the interactive portion and I think I mentioned this before during the walk through but I also liked this line that basically shows what I am interacting with because it was uh it made it clear what I'm trying to pick up or talk to and all that yes and three things so uh this is I guess basically like very personal from someone who's not used to games but um for me personally I felt like um some not all but like some of the aspects it was kind of difficult to figure out what to do next so like the next step wasn't as clear for me so I think it would be and considering that this is like a like a platform like virtual platform for various people not everyone is gonna be very used to games so I think it might be it can benefit from kind of having more of a guide for people who are not used to this kind of genre or game I guess to actually like guides and kind of at least like uh let me know of what next step I should be taking
PC4 Answers	Three things I liked. I guess, again, this is part of another question I answered. I like being in a 3D environment, being able to manipulate objects. I think that's good for learning. Another thing, I've made a broad one for that first one and I think of some other stuff. I guess overall I like the idea of a educational game. I think that kind of like revolutionizes how games are treated in this world, you know, like most of the time people are just wasting their lives away playing games, but this one's actually trying to use games to help people. I think it could be very, um, it could change a lot of things if more games were educational. I don't know that counts. And that's like such a broad thing. And then, yeah. Okay, three things that would change that that one's easy. One of them is, I kind of don t want to have to scroll through all these items to figure out what they are. The icons, like they don' t, they're not exactly descriptive of what are the X in the circle. I thought that was like a fighting weapon. So like, if I can hover over it, it just says X or something like that would be nice. Another thing, of course, that typing tool would Be helpful. But number three, I think most importantly, um, I think if this is going to be used as an educational tool to like help people learn and stuff, I think the massive amount of text that we have to read, that might be get boring over time. And like games are supposed to try to make things more fun, right? But yeah, reading all that text, maybe if it was changed to like, audio and audio recordings, someone's talking or maybe just like reduce the amount of text it would be more or less boring.
PC5 Answers	It's sort of tricky because it's a prototype. So obviously, it's not the final form. I liked the moving around. I liked playing with the objects. And I liked having different worlds to explore. So you could at least have some sort of organization. I'm going to be honest, I don't like the footsteps. I think it's sort of busy. It's kind of messy. Maybe if there's a way to reset them or only have certain things on because eventually, I've only been

	here 10 minutes and it's already just messy, it doesn't really mean anything. I don't, like, the board is a bit tricky, I find, like, it's like fine drawing, like, maybe there's, I include an option to just like, you know, type words onto it, maybe pictures. Obviously, it's not super, it's a little glitchy, but I'll, I'll look it over that. And I guess I could also say I don't like the general layout of the tools. It seems like I feel like the world's a little a bit big to sort of take it on. Like, I'd rather it be smaller to sort of more focus to the room on the project. Like, I think it's just, you know, too big for what you're at least why this trying to accomplish.

Question	PC1 Answers	PC2 Answers	PC3 Answers	PC4 Answers	PC5 Answers
11. The System Usability Scale					
Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree					
i. I think that I would like to use this tool frequently.	Neutral	strongly disagree	neutral	Strongly disagree	disagree
ii. I found the tool unnecessarily complex.	Agree	strongly agree	disagree	Strongly disagree	agree
iii. I thought the tool was easy to use.	disagree	strongly disagree	neutral	disagree	agree
iv. I think that I would need the support of a technical person to be able to use this tool.	agree	strongly agree	agree	Strongly disagree	strongly agree
v. I found the various functions in this tool were well integrated.	disagree	disagree	agree	disagree	agree
vi. I thought there was too much inconsistency in this tool.	disagree	disagree	strongly disagree	Strongly disagree	strongly agree
vii. I would imagine that most people would learn to use this tool very quickly.	Neutral	strongly disagree	neutral	disagree	agree
viii. I felt very confident using the tool.	disagree	agree	neutral	disagree	disagree

ix. I needed to learn a lot of things before I could get going with this tool.	agree	disagree	agree	disagre e	disagree

Question 12	How many years of schooling did you do in Canada before coming to study at York?
PC1 Answers	less than 2 years
PC2 Answers	less than 2 years
PC3 Answers	5 - 7 years
PC4 Answers	12 + years
PC5 Answers	2 - 4 years

Question 13	What do you think had the most effect on your grades in Highschool?
PC1 Answers	most grades were due to exams and homework.
PC2 Answers	really accommodating teachers and that I could like as someone I didn't understand stuff or they'd be really good explaining things to me. Yeah, I was lucky enough to have a very lenient high school. So yeah, just very good teachers.
PC3 Answers	in high school. I guess I, I had a math and English tutor, and that definitely had like significantly helped with my grades.
PC4 Answers	Oh, okay. Most effect on my grades. My grades were not that good and I think a lot of it was due to motivation. I wasn't very motivated to do my homework and looking back now, if I had done a whole lot of homework, especially in math practice and math problems, I would have gotten much better grades. [why was there a lack of motivation?] It’s boring. I don't want to study
PC5 Answers	I would say it's usually my ability to pay attention to it. [what affected your attention?] Um, I'd say it's like the level of work and my level of interest in it. When, like if I'm asked to like write a lot of paragraphs and I'm not a very, I didn't, I'm not very good with like handwriting and stuff.

	So it's like, if it's once an essay and I'm not allowed to use a computer or anything, then I'd sort of struggle and it'd be a lot more effort to sort of get that done, but if it's sort of multiple choice, I can do that.
Question 14	Have you ever been diagnosed with a learning disability?
PC1 Answers	No
PC2 Answers	Yes, with professional opinion
PC3 Answers	No
PC4 Answers	No learning disability
PC5 Answers	Yes, with professional opinion
Question 15	Of the following Learning Styles which do you most identify with?
PC1 Answers	Solitary, Aural, Kinesthetic
PC2 Answers	Visual, Logical, and Solitary
PC3 Answers	Visual, Verbal, and Solitary
PC4 Answers	the main two, though, is definitely probably Physical and Social. Physical only because like I learn best by doing it, by having experience doing and usually physical learning is doing the other things reading and stuff, you're not really doing but..... and also Social like I feel like there's more motivation for me to do something when there is someone else like that's gonna see my work as opposed to just doing it myself is just like, they won't, it feels like am doing for nothing.
PC5 Answers	Visual, Physical, Solitary

Question 16	What format of classes have you experienced here at York?
PC1 Answers	all of the above; add in fieldwork
PC2 Answers	all except for studios (in person and online)
PC3 Answers	Everything other than studios.
PC4 Answers	I've experienced all of those. And then there's also the hybrid, and then the asynchronous one as well.
PC5 Answers	Yeah, we've done lectures online and in person, labs, and like more collaborative student things, and then also like the occasional sort of like presentation stuff. And then also just like collaborative group things where it's like everything in the class is done through the group.

Question 17	Which class format(s) do you most prefer? Which do you perform better in?
PC1 Answers	I believe labs and that's probably because I get to like have, usually they have a TA, so I get to like do questions and clarify my answers while I'm doing things.
PC2 Answers	Oh my God, it's weird to say, I prefer the in -person ones, but I did best with the online ones due to the recorded nature. Oh, also recorded online lecture, some will record, some will not. Um, so, oh, and also async within, is that count as a class? Anything that was, had some type of video, so like anything that was, I guess, I'm recorded out of a video of a professor, so online with zoom, uh, that was prerecorded because I could always go back and we look at the instructions. So I get the benefit of them. And then also get to, um, re re listened to stuff. I pay attention to that. And also it helps. I mean, it's not on here. If you have like a Q and a optional session that way I can ask questions on whatever, because in the in -person stuff, you can do that as well.
PC3 Answers	I'll say online virtual lectures.

PC4 Answers	Okay, uh, I think the format of the studio I would prefer because again, like I'm more like, I learned by doing it and studio classes allow me to do them. but I performed much better on the online portion. But I think that's because the tests and stuff, they were like, you know, open book and I was able to look up everything. So I don't know if I actually learned best in that environment. It's just, I did the best because of the format. but learn best. Yeah, that the studio.
PC5 Answers	I think online lectures work better just because my environment's a little, I think I prefer it better, my environment, because I'm able to use my computer, look up what I need to. And then also just sort of generally smaller classes where the professor is engaged and not just like going off of PowerPoint. I think that's when I learned the best.
Question 18	What kind of tasks are you being asked to complete in your current courses? (choose all that apply)
PC1 Answers	all of the above
PC2 Answers	all except for group labs, individual presentation
PC3 Answers	lab test midterm, assignment, quizzes, group project, reading, individual labs.
PC4 Answers	I've done all of those throughout my curriculum.
PC5 Answers	I think I've done all that except maybe group lab assignments.
Question 19	Which kinds of tasks do you most prefer? Which do you perform better in?
PC1 Answers	Okay, so I perform better in individual projects. I think also perform well in presentations, but usually that would be group presentations. discussion forums, too. And that's about it. The rest is like very neutral. It's not like, well, it's okay.
PC2 Answers	so I would prefer the projects. Now when it comes to group versus non individual, it's usually 50/50 bag, it's either going to be astronomically better than being alone, or it's going to be, I'm doing all the heavy lifting, and I hate it. But if you get the right group, you usually are doing your way happier than you are on alone, and you have more ideas and stuff. So I'd say group, I'll take the risk group projects are the best ones.
PC3 Answers	I guess just I think individual labs

PC4 Answers	I did, I think I preferred and I did better in the individual projects and assignments. I think they're the same thing though.
PC5 Answers	I think like individual assignments and, you know, I think, I think I'm pretty good at presentations. I'm good at not. I'm just like reading off slides, trying to, you know, add more words to it.
Question 20	Do you feel you understand the tool's purpose?
PC1 Answers	Not fully. needed a more extensive tutorial
PC2 Answers	Well, I feel like you told me that that's not fair, but alone, I probably wouldn't have as much if a communication between classmates, it's sort of like a way for people to sort of connect online for a potential class environment.
PC3 Answers	Yes. going back to the very first question, I understood it's like a virtual collaborative environment.
PC4 Answers	Yes. I understand that it's made as an environment to be used as an educational tool. And you're and they put a bunch of props and stuff for interactivity um probably for the help of or the assistance of learning um and I think this is helpful for physical learners like me probably.
PC5 Answers	I believe so. I think I understood it's like a collaborative 3D space. And it offers some 3D objects and tools to figure out. And with most of the objects sort of labeled, it was pretty easy to pick up what they wanted me to do with it.
Question 21	Do you feel you understand how the tool would be implemented into a course?
PC1 Answers	Ummm… Somewhat? I could imagine it being in a course and how it would be layout, I guess, but I'm not sure if that connects with the project or like how the tool, like the original vision of the tool, I'm not sure if that my understanding of it matches. [Original Version description:] So in the context for like being implemented in a course, there will be like several portals, and then you will go in order to like complete the task in each of them. Then by doing that, you will like learn the entire course material. [this prototype is different because of] The content, the amount of portals, there will be a lot more portals and maybe you cannot enter until you unlock the previous one, so it will be like in sequential order maybe. [Portals seen as tasks]
PC2 Answers	Yes. Okay, maybe it's because I start talking about Roblox, but in a similar sense to that video game, you would, each player would be like a video game character. One of two ways it can go and then you all go in

	and you have one player picking up an item while the other player picks up an item to play tic -tac -toe. That's just for a game like tic -tac -toe. For a mathematical example, you can draw on the board, right? We're all there as viewing participants, maybe you can disable the drawing feature for everyone except one guy, he draws equations on the board. Okay, we all see that. Or better yet, the other option is similar to how they almost exactly the way you've given it to me. Everyone's offline except one person, they draw the formula on the board, they log out, and then everyone else logs in, they see that guy's formula for a mathematical thing, for example. I mean, obviously, you're far away from VR, but like, you could have a fighting simulator in this if you wanted to for PE. Other educational formats? I mean, I've noticed that you have gravity in this, so you could do some physics experiments in this. I don't know to what extent, but I'm aware that Unity has some physics properties. Oh, I almost for a game design, obviously, because like, tic -tac -toe, you can, yeah, you can make up many games, like I can see chess.
PC3 Answers	Yes I think there's like a potential for very like a multiple way of implementation. So yeah. Um, I guess for one, I think it can be kind of using like a way of discussion forums, kind of like, uh, so just more, more than one, like multiple people can kind of join and leave their opinion on it, like perhaps by using the drawing function I saw earlier and, or the other one would be, it can be kind of used for maybe like a group project where a small group of people can join and work on an activity together. Yeah, I think there's a various use
PC4 Answers	Okay in a course um yeah maybe um So yes, I think it would be used. Okay, so that second level where everything was written down by that weird pill. I'm sure if in a course the professor, the teacher, or the instructor would be saying all those things, telling all the students, I am guessing this would a multiplayer game. It said any groups. So there would be a bunch of people inside the environment and they would be um trying to um complete the activity and then they would ask the professor some instructions but I feel like that could be done in person like quite easily especially with the stuff in the game so I'm guessing this would be like a remote alternative for people who are taking classes remotely.
PC5 Answers	Um, I, I'd like have difficulty sort of logistically, because like, you know, making sure everyone has a computer and sharing the space and like how you'd manage, you know, over a dozen students, like working with a space, I'd be, I think it'd be a bit of a challenge to make sure it doesn't just turn into noise. [anything specific you are worried about turning into noise?] Um, well, I think I pointed out the footsteps not being a helpful indicator, but like also sort of the, uh, whiteboard controls, obviously as they are now, I only know how to draw black lines to it. So obviously I think, you know, being able to erase and maybe also like save it and switch it to others would be useful.

Question 22	Do you think this tool would be helpful if implemented into courses?
PC1 Answers	Yes. I think, like, it helps you stimulate, like, other senses. So you'll be able to, like, look at it and interact with it. So I think it makes it easier, or like more memorable, the experience, which should help in for the content being absorbed easier, easily.
PC2 Answers	in it's current state now, unless it's game development, or if you want to ECS. but the idea of it Yeah, absolutely. I think if this reached its full potential, it could absolutely be used in classes. Um, a bunch of people wearing VR headsets, running around, um, well, especially if there was another pandemic, uh, trying to be in a classroom type environment, uh, with a teacher. Um, but the only difference being you can, I don't know, you're not actually there. And it would be sort of similar to how it was on zoom where you're looking at computer, except only you wearing a headset. You are looking at, and you're not actually seeing the professor's face. You can draw on the board with a virtual marker. Um, I yeah, it would be like, we were sort of like real life, but in VR, um, obviously there's some issues of glitching and stuff, but you already have that with zoom and like, I don't know, WIFI. if it was towards maximum potential, like fully fleshed out. Uh, yeah, it would just be reality right now, but in VR.
PC3 Answers	Uh, yes. Uh, well, since, uh, since after COVID, like, uh, more and more aspects of the course are getting turned into virtual. I also noticed that kind of like less people are like showing up to in -person lectures or tutorials. So having like a virtual platform where it's like, perhaps like, uh, maybe easily accessible and easy to interact. It can definitely be helpful in that sense, like to work with other people and talk to other people.
PC4 Answers	Yes, remote courses. Well, I don't, so far with what's in it so far, and I'm not sure what would be included into the future, but I don t think there's any reason to like, in person, get a bunch of people on the computer at the moment, um, and open this game to learn when they can do, especially with the tic -tac -toe, Like I can just bring a bunch of props in real life and just put them down and write. It'll probably be a lot faster. I don't see how this would be more efficient yet.
PC5 Answers	I think once you move on from the prototype and refine based on these texts, I think it could be useful. Um, I think it's like a way to get students to engage because, you know, often time, like too often I've seen like professor be like any questions and a lot, you know, it's usually dead silent. So I think this is like more of a, a less impactful way to get students to engage.

Question 23	Do you think this tool would make education more inclusive of different learning styles and people with learning disabilities?
PC1 Answers	Yeah. So maybe for like, for example, people who are like, needs hands on experience, but the class could be online. This could maybe somewhat replace that by having like the avatar do it in the virtual space, you can somewhat simulate that.
PC2 Answers	You know, at least for one group of people, blind people, because it's, it's very visual. So if you're blind and I haven't heard any audio apart from the great sound design of like the footsteps, good luck, even the VR concept, you're not going to be fully immersed, um, that, and also I don't know any blind person who knows how to use a computer. Uh, so yeah, that's, but that's always a limitation with technology that's computer - based. focusing on learning disabilities. like ADHD? might be distracting, I guess. But then that's like everything in real life. Like I'm getting distracted by the candy on the table.
PC3 Answers	uh personally I think so yes because it's more it's definitely more visual and interactive than like a simple powerpoint on the wall so
PC4 Answers	Inclusive. I think, yes, it would. I think this having it in like this digital game format, we have the opportunity to add like a whole bunch of different options on how you learn in different like areas. You can obviously add sound, you can add visuals, you you make it like physical kind of physical like you're picking up virtually stuff. And I think it offers a lot more freedom for that in the digital format.
PC5 Answers	Yes, I, I think like the traditional sort of lecture and just talking to the classes, well, like has been like tried and true and, and it's sort of like you either get used to it or you don't until, and you like quit school or, you know, get like, yeah, get used to it. So I think like, you know, being able to add different learning styles like this could be definitely very beneficial for students.
Question 24	Do you think this tool would make course formats better?
PC1 Answers	Yeah. I think it's the same with my, the learning style for different people. You're just like, it just helps. It just tailors to different learning styles that has not been explored before.

PC2 Answers	Again, in a fully fleshed out concept, I think math in particular could have some potential. Yes, you have the issue of, I can't see the screen, I need to walk forward more. But that aside, that would be very great because I've seen lectures and stuff done online for math, but we cannot interact with the whiteboard in the same way we could in person. So getting the ability to do that and just grab the marker off the teacher would be kind of helpful in the middle of a math type course, or anything that requires diagram drawing, even an art class, yeah. Oh yeah, especially an art class. I mean, I think Zoom does have that feature anyway where you can click annotate, but before we can draw over other people's drawings. Not much better.
PC3 Answers	I'm not entirely sure on better, but personally it would be more interesting and engaging.
PC4 Answers	All the online stuff, this would just make it better. because when you learn online, you kind of lose the kind of physical capabilities that you have in person. And this kind of like, squashes that it like gives you the ability to do those physical tasks, tasks virtually, not at the moment, but I think in the future, when this is improved, right now, I still feel kind of, like trying to figure out how to use all the tools and stuff
PC5 Answers	Um, if this is like the format and not just like an exercise as part of the course, I think it could be like challenging. Like I think I, or at the very least there'd be growing pains. Like when Zoom was first a thing, a lot of people maybe took advantage of the lack of security and lack of controls to like derail a lecture. And I can see the potential of this tool, uh, having similar problems.
Question 25	Do you think this tool would make a good alternative to standard LMSs (like eClass, Moodle, blackboard, etc.…)?
PC1 Answers	Yes, I actually think so. I find eClass very confusing sometimes. And I think having as a room a space that you can move around could make it easier to remember to navigate navigate through different menus. I find it easier, I think.
PC2 Answers	Okay, eClass, it's just a web, but that's just a website that's where you can go and select your activity. I don't want to say eClass is super user friendly, but it's some more generally fairly user intuitive, more so than this game, even at the end when this game is fully fleshed out. I just can't help but feel eClass will be the more intuitive thing. Like I'm trying to think, but what eClass is very different from what this is. So I'm trying to think how would you translate and the website eClass, which is just to access your homework and stuff to this game. And my only thought is the classroom idea I mentioned, you are literally walking in VR into a classroom and you, when it says something like, here's assignment one, it's just going to be a sticky note on the board. And I'm like, okay, well, you're

PC3 Answers	going to like use up more time walking up there. So just, just make eClass, I just prefer for eClass. And they're both going to be probably wifi dependent. So yeah, just, just prefer Class. I, I don't think it's a good alternative. Uh, I think... I don't think it can just entirely be an alternative for what E -Class has to, but the system has to provide us now. So now, for now, my answer would be no, but like, if it implemented perhaps more different various functions, then I can't have potentially worked [what kinds of functions are missing?] I'm kind of using eClass as an example right now, but eClass has like really a lot of functions like you can go back to your previous courses, it shows the list of the assignments that are due, the what you have to get done soon, or if you're late for anything. So yeah, that is one... like showing like the schedule like and having your basically on eClass you can interact with other people by sending them a message, but you definitely have your own individual spaces of your own courses. So those differentiation of your individual space and multi like multiplayer aspect, I think those are one.
PC4 Answers	I feel like this would, I think like no, because this feels like it would take longer to access my stuff on E class. Like I would have to go log into the game and after like walk to a wall and then like look at the stuff and walk around the wall go through portals. I don't think it'd be a alternative for eClass specifically or Moodle, but I think those are the same.
PC5 Answers	I don't think so. I think this is a very like fluid environment. And I think putting really, you know, academic information important stuff in the 3d space might make it difficult to miss important things, deadlines, etc. I don't think it's good, it would be a good substitute for eClass.

Question 26	Do you think this tool would make course assessments and tasks better?
PC1 Answers	I don’t think so. Um, I think it'll be like, it might be great for the students, but I think for like, practicality for like, the teachers may be too great might be difficult to move to every space to great students, or maybe that's what the chart was. And I was trying to understand it, but I just don't understand what it means.
PC2 Answers	Uh, it depends. Poetry, probably not. Writing's not gonna be as good. I'm trying to think of a good example, even cause like, I was going to say physics, but you could do that in real life as well. Like at least in concerns to gravity. Um, I mean, I haven't died in the game, but like, if you have a way of seeing if how humans can kill themselves, yeah. Like lethal chemicals. Sure. But I haven't seen that in this game, so I don't know how that would work. And at the same time, would you though? Cause you can't really smell some of the smells you would in an actual chemistry class, so I'm going to say not enough.

PC3 Answers	Uh, if it's used properly, yes. Uh, I mean, like, I, I don't want to talk like badly or anything, but yeah, it's not like, it's not about the tool, but I realized some, in some courses or like some instructors, they sometimes give out tools that I don't sometimes like, um, that sometimes I feel like they also don't have the full understanding of the tools they're giving up to students. So depending on the instructor or the format of the course, if they just, if the instructors just give out this tool without having a full understanding of it or properly integrating with the course material, I think it can like, uh, actually have like a bad side to it rather than a good side, so like properly connecting to the course material would be important. [can you give an example?] Um, well, I wouldn't say this was because of the instructors understanding, but for example, like turn it in, there was a few cases where I know a few of my friends were kind of like a falsely accused because the, the, what is the plagiarism percentage was high. And then the sources were kind of, um, it was highlighting the names, dates, and that's what they got the high percentage on. And yeah, there were a few technical difficulties about it that professors couldn't, um, take like handle right away. And yeah, those became problematic.
PC4 Answers	Better in the way, yes, I think it would be more fun.
PC5 Answers	I think it would be more fun and engaging, although I'm sure some would object to it being like, as like academic integrity, kind of like if it's an adequate way for like testing and exams and stuff.

Question 27	Would having a tool like this implemented into your courses make your educational experience?
PC1 Answers	Yeah. Yeah, no, same description when I used for eClass. I think just having the physicals. No, it's not physical. It's a virtual space, but it's like. Yeah, it feels physical. You can move around and it feels, you can remember, oh, this was like this place or this, the task I need to do is in, it looks like this. It looks like a blue portal or like a yellow portal. You can associate things with objects.
PC2 Answers	in the gaming sense, yes. It's good to beta test some of these games. It gives you better user experience. It gives you better idea of how games work. It makes you, it feels like a learning experience. You sort of see the pros and cons of making games and that sense, but outside of game design, art design and user interfaces. And even just the concept of how to tell people instructions. I'm not seeing how this would be useful in any sense. Oh well, useful enough anyway. That's really fun.

PC3 Answers	Well, yeah, if it was properly implemented. For what I think, it would definitely be more engaging and has more functional aspect if it was implemented for some of the group functions, like discussion forums or the group activities. I think it would be better than just simple discussion from any class. Yeah
PC4 Answers	Like this, not exactly, but if this tool was improved, I could go into like just in the broad level of just we're going into virtual 3D environments and building tasks. I think that would make it better.
PC5 Answers	Yes. I think it just like encouraged me to sort of engage with the material more instead of just, you know, being asked readings and, or just listening to what they have to say, and that's going to be in the test. And that's my motivation to pay attention to it. I think like a 3D space and, you know, the opportunity to explore in my own time and not the professor's time could be beneficial.
Question 28	Was there anything that wasn't asked about, but you would like to add?
PC1 Answers	No
PC2 Answers	are the footprint's meant to mean anything.
PC3 Answers	um no I don't think so that was yeah
PC4 Answers	I explained everything, actually. Yeah.
PC5 Answers	Are you planning to make this like less wordy as you like get better like visuals going on? I can definitely see like gaming, gamifying learning here is like a useful tool. Although I don't think I saw like much of it. It's more just, I guess it's like a 3d space I can walk around to. Isn't very novel to someone like me.
Question 29	Do you have any questions for me now that you have completed the walk through?
PC1 Answers	Yeah, what was the graph above? [Instructor View] What is the age range for this?

PC2 Answers	Um, first of all, uh, the sponges, um, sort of the portals, I like how there's a thing where it just says you must go back and do this before you proceed. Again, if you're going to go back to the educational idea with math, let's say you're doing an algebra two class, you can't go through that portal unless you do algebra one. So it, you go through and it says your teacher has, it doesn't have to say anything. A blob pops up and says, do not walk forward unless you've done algebra one already, you go back to the portal and let's say there's three portals. One is algebra one, one is algebra two, one's a lobby, different code sponges. I'm getting a guess. Um, that would be very helpful. Um, other thing. it's very good and just even in course assignments in general I mean when you learn like a language for example you need to know certain steps or stuff before you get to knowing the big writing sentences and everything. So yeah I like how you can sort of there's a system in place to help to prevent people from jumping to higher education without getting the prerequisites. What was the X button meant to be? um well okay player um I do kind of wish that the mouse was a bit more user intuitive I think I said that. What's with the running? Do you need that or is that just so you can get the class quickly? OK, I'm going to test one more thing, but what happens if I go down to the end of the world? What if someone has to be pesky and loses themselves in the void?
PC3 Answers	Um, well, it's not just, it's not really a question. I just, I'm just kind of curious on how this is going to turn out. Since you said this is like a kind of a prototype. So yeah, it's not a question, but you know, a bit more about curiosity.
PC4 Answers	What was your intention in making this game? You were kind of asking me what I believe this was about, but I didn't really know what you were trying to do.
PC5 Answers	like is this like do you would you want this to be like more of a spontaneous thing or like an ongoing thing throughout like a course like it's a space that builds up as the course goes on

F. Testing: Interviewer Session Notes

Link to Interviewer Notes

G. Testing: Prototype Walkthrough Videos

Follow the following links for the Prototype Walkthrough Videos:

[1] RES Prototype Walkthrough Video

[2] PC2 Prototype Walkthrough Video

[3] PC3 Prototype Walkthrough Video

[4] PC4 Prototype Walkthrough Video

[5] PC5 Prototype Walkthrough Video

H. Prototype Planning: Lesson Plan

<table>
<tr><td colspan="3">Lesson: Design a Riff of Tic-Tack-Toe Activity (Group Task)</td></tr>
<tr><td colspan="2">Total time: 55-75 mins</td><td>• Background information:

given tic-tac-toe as a starting point, the task is to create a hack/change the game as a group to make a new variation/make it "new" while maintaining the mechanics and game balance.</td></tr>
<tr><td colspan="3">Learning Expectations:

• Understanding Basics of Game Mechanics
• Understanding Basics of Game Balance
• Re-Designing Simple games to make new variations while maintaining mechanics and game balance
• Effectively playtesting other students' games and leaving constructive feedback</td></tr>
<tr><td colspan="2">Terminology:

Game Design

Game Mechanics

Game Balance</td><td>Tools Acquired from task (ILW):

• Drawing tools

Task Toolbox:

• Dice
• Deck of cards
• Domino pieces
• Poker chips
• Original rulebook</td></tr>
<tr><td>Time:
10
(min)</td><td colspan="2">Mental Hook/Diagnostic Assessment: Play a few rounds of original tic-tac-toe to establish a baseline for everyone in groups of 3-5.</td></tr>
<tr><td>Time:
15
(min)</td><td colspan="2">Step 1: Brainstorming variations (can be done on a white board tool in the game/graffiti wall)

In groups, students begin brainstorming different ideas on the variations and what can be added to make the game interesting using the provided toolbox.</td></tr>
</table>

	Each group is given their own whiteboard/graffiti wall (gets shared with the class with the submission)
Time 20-30 **(min)**	**Step 2: Playtesting variations** Students begin playtesting the different variations they came up with to test for correct game balance and to see how the changes affect the mechanics. Adjustments and tweaks made here until they reach a final decision.
Time: 10-15 **(min)**	**Step 3: Rewriting the original rulebook and Posting final variation** Students rewrite the original tic-tac-toe rule book with the changes in mechanics and materials for their new variation of the game. They then post their game to be play tested by others in the class. Final versions from each group will be posted up on the "Game Wall" for the class to see and test.
Time: 10-15 **(min)**	**Step 4: Playtesting and Peer Feedback** Students Playtest other groups' new variations and leave their feedback (comments, emojis, ranks) on the "Game Wall". After playtesting a group's game, students will have the option to see that group's whiteboard/graffiti wall to see their process and initial ideas.

	Indexical Storytelling elements – • Groups leaving their modified games, tutorials, tests, and instructions for the rest of the class to see and interact with; • students leaving feedback for teams on after playtesting; leaving comments, ratings in the form of words, images (memes, gifs, emojis), graffiti. • Groups' whiteboards/graffiti walls with their ideation process and initial ideas.