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Life on the Edge: Supporting Students' Learning of Cell Biology

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Abstract: The video game "Life on the Edge" is an educational game that aims to instruct and engage undergraduate biology students on the intricacies of cell biology. Developed by a collaborative team comprising researchers and students from biology, design, computer science, educational technology, and music at MacEwan and Concordia University, the game aims to provide an interactive and visually stimulating environment to help undergraduate biology students learn and understand cell biology concepts effectively. The development process is also complemented by research to evaluate the game's effectiveness in enhancing students' game-based learning experiences. In this session, participants will be afforded the opportunity to engage with the game and provide feedback to the game's creators on new game features currently under development.

Introduction

Learning cell biology can be challenging for students due to the complex and abstract nature of the subject matter, which often involves understanding intricate molecular processes and the interconnected functions of various organelles within a cell. Traditional teaching methods, such as lectures and textbooks, may not fully engage students or help them visualize these processes effectively. Our team created a game called "Life on the Edge" (LOTE) (1) that addresses these challenges. This educational tower defense video game, published on the Steam platform in June 2022, offers an interactive, game-based learning environment that allows students to explore and engage with cell biology concepts in a more immersive and visually stimulating way. By incorporating strategy and resource management elements, the game encourages critical thinking and problem-solving skills, enabling students to develop a deeper understanding of cell biology concepts. In this session, the participants will have the opportunity to play the game and give feedback to the game creators on new features currently under development.

Game overview

In the game, players take on the role of a cell and must defend against various threats that seek to damage or destroy the cell. To do this, players must utilize their knowledge of cell biology to strategically place various cell organelles and structures. Each of them has unique abilities and strengths that can be utilized to defend the cell effectively. Players can explore the cell and interact with these elements, learning about their functions and how they work together to keep the cell healthy.

One of the game's key components is its emphasis on teaching players about introductory cell biology and the interconnectedness of the elements in a cell. Throughout the game, players are presented with information about the various organelles and structures and how they work together to perform essential functions within the cell. This includes learning about the cell membrane's role, the mitochondria's function, and the importance of homeostasis, which is critical to cell survival and life itself.

In addition to its educational content, LOTE incorporates strategy and resource management elements. Players must carefully consider the placement and abilities of each component in order to effectively defend the cell against incoming threats. These threats come in the form of well-known bacteria like *Gonorrhea* and COVID-19. This requires players to think critically and use problem-solving skills to succeed.

Game development process

The game was developed over a period of four years following the Double Diamond design process (Design Council, 2015), which is divided into the Discover, Define, Develop and Deliver stages, followed by an assessment stage. During the Discover phase, the team conducted a literature review on video game design and educational video games, they also did a precedent analysis - surveying the landscape for K-12 and university-level educational games. During the Define phase, various game concepts were explored, and the team selected one. In the Develop phase, the team created animations, illustrations, and designed the game's user interface and mechanics. Music and sound effects were also created for the game (Sperano et al., 2019; 2020). Finally, in the Deliver phase, the game was published in June 2022.

The game was assessed at various stages of its development. This evaluation was carried out by potential users, including biology students and instructors (Bong et al., 2022). The feedback obtained from these evaluations led to continuous improvements being made to the game throughout its design process, which is a widely accepted approach for creating high-quality digital products (Dormans and Holopainen, 2017; Lallemand and Gronier, 2015).

The team has been collecting data on a pilot version of LOTE since the Fall of 2021. Initial findings indicated that additional support was needed to maximize students' learning (Bong et al., 2022; 2023). Based on these findings, the team revised and improved the existing LOTE game by adding new features to support learning. The goal is then to collect more data to study the effectiveness of students' game-based learning experiences.

Audience for the game

While the game is primarily geared toward first-year undergraduate students studying biology or other health sciences, it may also be suitable for high school students or anyone with a passion for learning about biology. The interactive and visually appealing interface of LOTE, coupled with its educational content, makes it an interesting game for anyone looking to learn about cell biology in an enjoyable way. Indeed, the goal of LOTE is not only to educate players about cell biology but also to enhance their engagement and motivation through a pleasurable gaming experience, thus enhancing the overall learning process.

Game development to support research in the learning sciences

This game can support research in the learning sciences in various ways. Despite the increasing use of digital games in education, there is still a need for more information on the diverse features of games and how they impact students' satisfaction and play experience (Herder & Rau, 2022; Shute et al., 2020).

Also, the ongoing collaboration between the design, the development and the research teams offers a unique opportunity to tailor the game to test specific aspects of its design and functionality. This allows the research team to make targeted changes to the game and observe the effects on students' learning experiences rather than using a pre-existing, standardized game. This approach allows for a more detailed examination of the factors that impact students' learning experiences in the game. Additionally, the ability to customize the game allows the research team to ensure it aligns with the specific research questions and hypotheses being studied.

The game will be used to develop a deeper understanding of students' digital game-based learning experiences. For example, there is a lack of research on the "relatedness need" in games, and most studies on game-based learning using Self-Determination Theory (SDT) only consider the relationship between need satisfaction and positive learning experiences (Peng et al., 2012; Proulx et al., 2019). To fully understand the design and learning experience of games, it is also important to consider frustration and negative game-based learning experiences. A dual-process model has been postulated in which there will be a sequence of positive relations between perceived need support, need satisfaction, and engagement, as well as between need thwart, need frustration, and disengagement in learning contexts (Jang et al., 2016; Li et al., 2018). It is hypothesized that engagement will be positively associated with learning outcomes and negatively with disengagement. However, no studies have tested this dual-process model in STEM-educational games. Newly added game features should support all three psychological needs (competence, autonomy, and relatedness) on both positive and negative learning experiences in *Life on the Edge*.

Additionally, our current research uses data science techniques, including analytics-based visualization tools of Unity Analytics, to overcome the limitation of self-reported data and potentially provide in-game learning support, which is another area where this game can support research in the learning sciences.

Technological setup for the interactive session

In this interactive session, the participants of the conference will have the opportunity to play the game and provide feedback to the game creators on the new features that are currently being developed. This feedback will be an important source of information, as it will allow us to better understand the perspectives of potential players, instructors, and scholars in the field of education. The anonymous feedback provided by the participants will also be valuable for the research team, as it will provide insight into a player's experiences with the game and help to inform future research on game-based learning.

This session will facilitate interactive dialogue and sharing of design decisions by the team. Additionally, this session can provide practitioners with guidelines for designing digital games that promote motivation, engagement, and learning, drawing upon the presenters' experience in the design of LOTE games as well as data collected from student surveys.

Presenters will have laptops available to participants to try the game, or they will receive guidance to install the game on their own laptop (PC/MAC) if they wish.

Endnotes

(1) The game was initially developed at MacEwan University (Edmonton, Alberta) by researchers and students in Biology, Design, Computer Science and Music. New features were added with the collaboration of the researchers at Concordia University. This project is a collaborative effort with researchers in educational technology at Concordia University.

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