Creative, Interdisciplinary Undergraduate Research: An Educational Cell Biology Video Game Designed by Students for Students

Isabelle Sperano, Ross Shaw, *MacEwan University*
Robert Andruchow, Dana Cobzas, *MacEwan University*
Cory Efird, Brian Brookwell, William Deng, *MacEwan University*

Abstract

In a three-year, practice-based, creative research project, the team designed a video game for undergraduate biology students that aimed to find the right balance between educational content and entertainment. The project involved 7 faculty members and 14 undergraduate students from biological science, design, computer science, and music. This nontraditional approach to research was attractive to students. Working on an interdisciplinary practice-based research project required strategies related to timeline, recruitment, funding, team management, and mentoring. Although this project was time-consuming and full of challenges, it created meaningful learning experiences not only for students but also for faculty members.

Keywords: *biology, interdisciplinarity, practice-based research, video game design, undergraduate research*

doi: 10.18833/spur/4/2/7

The video game industry is immense, with more than $137 billion in revenue. Each year, many new games are developed for entertainment or education purposes (Takahashi 2018). The game environment in K–12 is well developed and used alongside traditional instruction methods such as lectures (Cortez 2017; Whitmer and Asher-Schapiro 2017).

Although there are serious games developed for the post-secondary level, most of these have been implemented historically at the graduate or professional level, with a recent move into serious games developed and tested on undergraduates (Vlachopolous and Makri 2017). The academic field of serious games has been calling for more development of these games that are actually fun to play (Buday, Baranowski, and Thompson 2012; van Roy and Zaman 2017; Sanford et al. 2015). This is what led the authors to create a game for undergraduate biology students with the aim of making it both educational and entertaining.

Developing a video game requires specialized and diverse skill sets, so an interdisciplinary team composed of 7 faculty members and 14 undergraduate students from the biological science, design, computer science, and music programs at MacEwan University was assembled. The faculty members set various goals for the students: to take part in a practice-based creative research project, join an interdisciplinary team that connected students and faculty, discuss their work with colleagues outside their field of expertise using nontechnical vocabulary, and apply their newly acquired disciplinary skills in a concrete project.

Working on this project also brought critical questions to the fore regarding project-based undergraduate research. What unique learning experiences can they acquire? What are the benefits and challenges for students taking part in interdisciplinary practice-based research? What quality of product can undergraduate students create? Through presentation of the project, this article explores and reflects on these questions.

A Practice-Based Research Approach

Engaging students in research can take many forms. In creative disciplines, one common approach is practice-based research (Chapman and Sawchuk 2012; Muratovski 2015). Practice-based research can be defined as "research that takes the nature of practice as its central focus" (Candy 2006, 2).

Practice-based research projects usually begin with open questions and relatively broad goals (Coulton and Hook 2017). The main distinction between this type of research and conventional research resides in the fact that the creative process and the generated artifacts are at the core of the researcher's results (Candy 2006, 2). Practice-based research also is different from professional practice. Projects conducted by practitioners are usually "directed towards the individual's particular goals of the time rather than seeking to add to our shared store of knowledge in a more general sense" (Candy 2006, 2). Practice-based research results from a formalized academic process, and the research outcomes are intended to be shared and disseminated.

As Coulton and Hook (2017, 99) elaborate, practice-based research is particularly well suited for video games:

> As games are predominantly designed to be played in the real world, in complex social situations, it seems appropriate therefore that some approaches to game design research are able to embrace the mess of non-laboratory-based research, and practice-based design research is arguably well equipped to meet this aim.

This seemed like the right contextual approach for the present study. First, since all students working on this project were undergraduates studying in applied disciplines, they were well-suited for a practice-based research project. Also, as most students in these programs seek to gain professional experiences, a practice-based project was an effective way to interest them in research and develop practical skills in their individual fields.

A Tower Defense Game to Teach Cellular Biology

Although complex video games can take years and millions of dollars to develop ("Why Video Games" 2014), the faculty members planned to produce a simpler video game (five levels and two hours of game play) that required minimal financial and human resources. The main goal of the game, called Life on the Edge (LOTE), was to teach key learning outcomes of introductory molecular and cellular biology to undergraduate students.

Life on the Edge is a tower defense game in which players protect a cell to keep it alive. Tower defense games are strategy video games in which players protect territories or possessions from attackers by setting up defensive structures (Reece 2015). This type of game lent itself nicely to the biologic functions of a cell. Indeed, cells constantly have to battle to stay healthy within the context of the surrounding environment. The first level orients the player to the game interface and outlines the objectives of the game. The focus is set on maintaining homeostasis—the balance established and maintained by a cell with its external environment (using primarily water and nutrients). Bacteria and viruses then attack the cell, and the players must fight off their enemies by building various structures in the cell membrane (see Figure 1C).

When the game development began, MacEwan's Biological Sciences Department updated their program and course learning outcomes. The game is primarily intended for first-year biology students taking cellular biology or general biology courses. Key cellular biology learning outcomes covered by the game design include how the structure of cell components relates to their function and how the flow of energy underlies all cellular processes. In playing the game, students also learn how cellular functions are critical to life. The biological concept of homeostasis forms the basis of LOTE, and maintaining homeostasis is

FIGURE 1. Evolution of the Game Interface for Life on the Edge

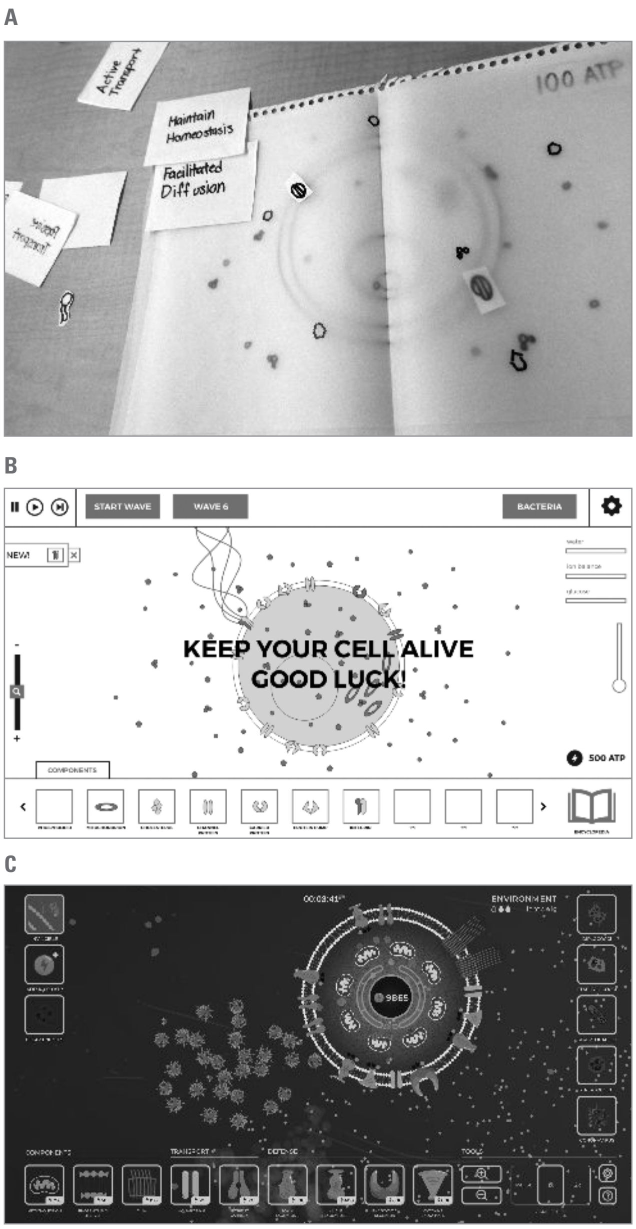
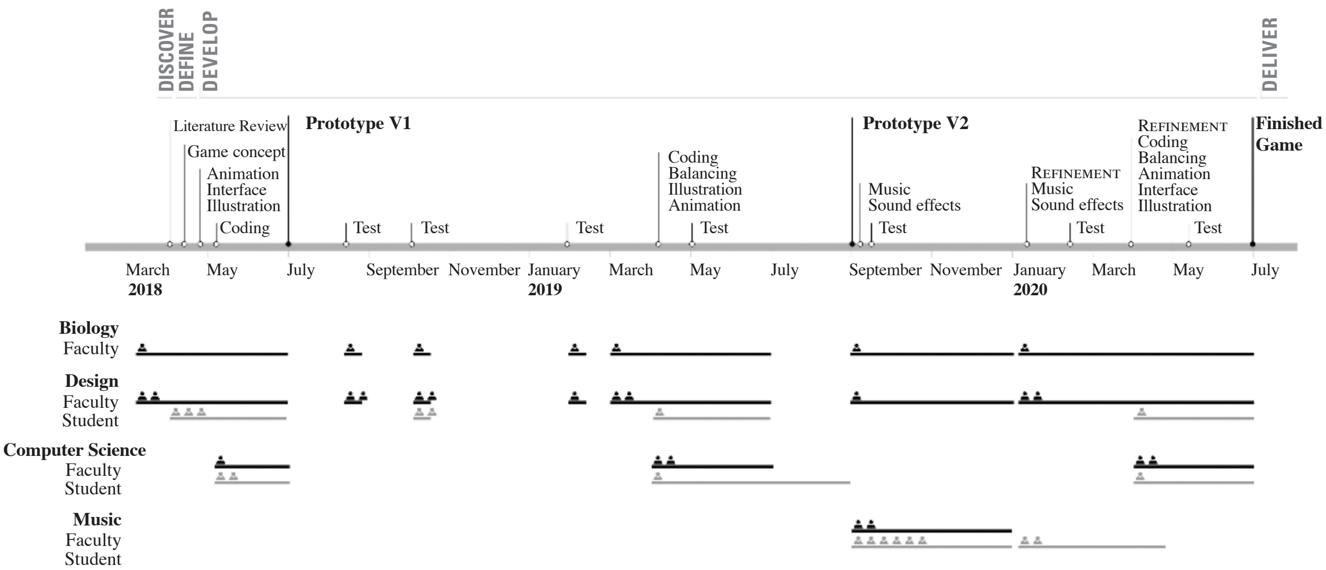


FIGURE 2. Development Timeline, Life on the Edge



Note: Each symbol represents one participant from a specific discipline at a particular stage of the project.

key to the player's success in winning the game. The main benefit to students playing the game lies in exploring the life of a cell in a complex environment, the interconnectedness of its components, and the difficulty of managing the health of a cell. In developing LOTE, some cellular biology learning outcomes were not addressed: applying the scientific method, performing lab skills, citing and referencing sources, and producing effective written communication. However, it is notable that the game does have an experimental (sandbox) mode in which the player can mimic the experimental stage of the scientific method.

Research Development and Management

Working on an interdisciplinary practice-based research project required particular development and management strategies, notably concerning process and timeline, recruitment, funding, team management, and mentoring.

Timeline and Process

The game was built on a three-year timeline (see Figure 2). Initially, the faculty members expected the game to be completed in two years but realized that more time was crucial to building a quality product. The top of the timeline shows the main tasks (literature review, game concept, animation, etc.). Figure 2 displays the number of team members involved in each part of the project and their respective disciplines.

Figure 2 indicates that most of the work was completed during the spring and summer months (April to July). These were the best periods to work on the game because the faculty members on the team did not have to teach, and most students were not taking classes.

To create the game, the Double Diamond design process (Design Council 2015) was followed. This process was selected because it is renowned in the design field and used throughout the MacEwan design degree program. It also was presented to the nondesigners of the team. This process divides the creation process into the discover, define, develop, and deliver stages (see Figure 2), followed by an assessment stage.

Discover. The discover phase began with a literature review on video game design and educational video games. Nonbiology faculty members and students also read key chapters of a cellular biology textbook for an understanding of the fundamental concepts of the biology classes (Sperano, Andruchow, and Shaw 2019).

Define. During the define phase, various game concepts were explored, and the team chose one. Design students then developed scenarios, game mechanics, and draft user interfaces by producing paper and digital prototypes.

Develop. As shown in Figure 2, the develop phase was the longest. During this phase, design students started illustrating the different game components, creating animations, and designing the user interface (see Figure 1). The computer science team (two students and one faculty member) coded the game and built the prototype's first version. At that stage, the goal was to build a playable prototype. For the second version of the prototype that was completed a year later, new animations and illustrations were included, the game mechanics and the balance of the game were refined, and new levels were added. For the final version of the game, music and sound effects were created, and animations, user interface, and game balance were finalized. (See Life on the Edge n.d. for more about the game).

Deliver. Once the game is fully developed, it will be used in a classroom environment for beta testing and then distributed widely by summer 2021.

Assess. To create a high-quality digital product, the game had to be assessed (Dormans and Holopainen 2017). The game was tested by potential users (biology students and instructors) at various points in the project (see Figure 2), leading to iterative changes throughout the design process. This is a common approach to designing a digital product (Lallemand and Gronier 2015).

Time Commitment

This project required considerable time commitment from students and faculty members. The overall numbers of hours invested in the project were estimated and are presented in Table 1. The table shows that faculty member hours equaled 1,250, and student hours totaled 3,445. Computer science students used 58.05 percent of the student hours (2,000 hours). This information is relevant for anyone starting a similar project, especially when planning annual research workloads and writing grants to hire research assistants (students).

Student Involvement Strategies

Various administrative strategies were adopted to include students in the project. First, MacEwan grants were obtained from the Faculty of Arts and Sciences, the Faculty of Fine Arts and Communications, and the Office of Research Services. Almost all the grant funds were used for student salaries. Second, an independent study course was used to involve music students. Since their role was well defined and the work could be completed in one semester, this was an appropriate strategy. Third, one student undertook this project as a non-credit activity that appeared on the student's cocurricular record.

To recruit and select students, two approaches were adopted. In most cases, faculty members directly contacted students they knew had the necessary skills. For music students, a general call was sent to students enrolled in the music program at MacEwan. The faculty members could have adopted a more inclusive approach with a call to design and computer science students instead of reaching out directly to specific students; this will be done in future projects.

Team Management

Managing the team was a key challenge in this project. Dealing with the hectic schedules, dissemination activities, and other research projects of faculty members as well as the constraints, such as external professional commitments, of students required a flexible yet rigorous approach.

At the beginning of the project, a charter (project-management.com 2020) was created; it became a valuable tool to ensuring all team members understood and complied with the project goals and creation process. The charter included components such as the project description and goals, roles and responsibilities, and the communication process.

TABLE 1. Team Composition and Time Invested in Life on the Edge by Discipline

Discipline	Number of team members	Faculty/student	Number of hours
Biology	1	Faculty	550 hours
Design	2	Faculty	555 hours
	5	Students	1,065 hours
Computer science	2	Faculty	95 hours
	3	Students	2,000 hours
Music	2	Faculty	50 hours
	6 (4 composition, 1 sound effect, 1 audio director)	Students	380 hours
Total faculty	7	Faculty	1,250 hours
Total students	14	Students	3,445 hours
Grand total	**21**	**All team members**	**4,695 hours**

Decisions for the most part were made during team meetings (in-person and online). Two types of meetings were conducted: discipline-specific meetings (e.g., design, computer science), where discipline-related matters were discussed in greater detail, and whole-team meetings, where disciplinary work was validated and general matters were discussed (e.g., game concept, balance, game mechanics). During all meetings, detailed notes were taken that included clear action items. All documents were hosted on Google Drive so team members unable to attend a meeting could access the latest updates and decisions. Outside of meetings, online communication to keep all members aware of the game evolution was maintained mainly through Slack software. This approach was efficient and led to concrete results while proving flexible enough for everyone on the team to indirectly follow discussions through meeting notes and on the Slack channel if they missed a meeting.

Student Mentoring Network

Students were supervised by at least one faculty member from their discipline; they also received feedback from faculty members and students in other disciplines, which created a unique mentoring and supervision experience (Sorcinelli and Yun 2007). This mentoring network allowed the students to learn how to explain their process and argue their proposals to experts from related fields.

Disciplinary Context, Learning Experience, and Challenges

In an interdisciplinary project, every discipline plays specific roles and encounters unique challenges. This section presents disciplinary perspectives on the project. The main context for each discipline is described, as is each student's point of view of the experience. Students' comments collected during their exit interviews (completed after their work on the project) were used to identify the latter. Data were used from 100 percent of the design students ($n = 5$), 66 percent of the computer science students ($n = 2$) and 50 percent of the music students ($n = 3$).

Biological Science

Context. Biology, or the study of life, is a subject that naturally attracts students. The core curriculum at MacEwan University is designed around learning outcomes that require students to develop strong critical thinking skills and apply these in scientific settings. Biology students enroll in both lecture and laboratory components in most biology courses. They can access a variety of materials that include readings, videos, animations, podcasts, and activities in both digital and hands-on formats. A serious video game is another way for students not only to visualize cellular systems but also to experiment with them.

Because the biology concepts taught at an undergraduate level are quite complex, having a biology expert on the team was crucial. The ultimate decision about which biological concepts to include in the game was a key challenge, as it was possible to include endless biological details in a game, similar to what happens when teaching a course. Returning to the goal of finding a balance between learning and fun helped guide which biology concepts to include.

Design

Context. Design is a problem-solving discipline with a particular focus on the interactions between humans and technology (Norman 2013, 5). Here, technology is defined broadly to mean anything built by humans: spaces, buildings, tools, and so forth. There are multiple designer roles involved in creating a video game: game designer, level designer, user interface (UI) and user experience (UX) designers, as well as art-based roles such as character designer, concept artists, animators, and environment artists (Shylenok 2019). Each designer must balance form, function, and ease of use.

The MacEwan University design degree does not specifically offer game design courses but does have a digital experience design pathway, with nine courses dedicated to digital products. The program also includes a range of general design thinking courses (Brown 2008) that teach students problem solving, strategy, and group facilitation skills. Lastly, there are many visual communication design courses such as drawing, typography, illustration, motion graphics, and visual storytelling, informing many of the skill sets required to take on a designer role in a video game project. All design students involved in this project were enrolled in design-thinking courses as well as a digital experience design course and visual communication design courses.

Learning Experiences and Challenges. Design students identified various disciplinary skills learned during the project. First, they learned about the subject matter they were designing for (cellular biology). They also learned about designing game mechanics and about UX and UI conventions for game design. Finally, they learned how to prepare deliverables usable by the computer science team (developers). Other skills identified were related to working in a group and on an interdisciplinary team.

Students were challenged by the new experience of speaking up and communicating with a large interdisciplinary team. However, as they realized the team was providing constructive feedback rather than criticism, communication improved.

Computer Science

Context. The development of video games involves some of the most exciting and challenging areas of computer science, including graphics, artificial intelligence, human-computer interaction, and distributed systems. Moreover, beyond connecting these computer science subfields, a unique aspect of game development lies in the process itself and the interdisciplinary collaborative environment it offers. The opportunity to communicate effectively with others in different disciplines is essential to becoming a competent game programmer.

MacEwan University's program offers a particular topic stream that focuses on game development. The computer science involvement with LOTE was well aligned with this stream and offered participating students and their mentors the unique hands-on experience of working closely with students and faculty members from other disciplines. The role of the computer scientists was to confer with the other members of the team and create the program scripts to implement the game as designed. In addition, students followed industry-standard methods for project control (the frameworks Scrum and Agile) on a real project with real deadlines.

Learning Experiences and Challenges. One important disciplinary skill acquired by the computer science students was how to use deliverables created by designers. This was interesting because one of the disciplinary skills identified by the design students also was related to this transitional moment between the designers' and the computer scientists' work. Similar to the design students, the computer science students also learned how to work as a team, in a group environment.

One main challenge identified by computer science students was related to the collaboration and communication between team members. It was challenging for them to find the right balance between the roles of the computer scientists and the designers. For example, the design propositions sometimes involved more programming time than the timeline allowed. Computer science students then had to express their concerns and suggest other solutions. This was sometimes difficult for the computer scientists to communicate and the designers to accept.

These communication issues may be related to a lack of understanding of the role of the other discipline (and sometimes of the student's own role), and its strengths and limitations. They also may lie in differences in the work culture of designers and computer scientists. For example, computer science students were not accustomed to presenting their work using a critique model (meetings in which team members discuss what is working and what is not), which is very common in design.

The faculty members have realized that computer science students should have been included in the define phase, so that they had the same buy-in as the design students earlier in the process. It would have been a good opportunity for the team to gain an understanding of each other's roles, build the game concept together, and potentially foster collaboration and facilitate communication for the remainder of the project.

Music

Context. Developing sound and musical scores for video games resembles film scoring, as it involves creating mood, time, and character and foreshadows impending actions (Wardrobe 2016). Only two music courses are available at MacEwan to increase students' breadth and depth of knowledge of film musical production.

The students started by reviewing the game play and deciding on the specific sound elements that needed to exist between each of their compositions. A list of sound cues for in-game actions also was made for the sound effects producer. After the overall atmosphere of the music was determined, each composer pitched their musical ideas. The students then used the team's feedback to ensure that the compositions were appropriate in the game context.

Learning Experiences and Challenges. Video game scoring for music and sound represented a unique "real world" work experience and opportunity. The ability to interpret the language used in feedback to improve compositions was identified as a new skill developed during the project.

One significant challenge was to have the composers express individual creativity while keeping the feeling that all the music belonged in the same game. Although this was identified as a challenge, it was noted by students that this complex endeavor was successful.

Discussion

Generally, the communication between disciplines was good due to the implementation of a project charter that outlined roles, responsibilities, and communication channels. However, even with this document, students sometimes still struggled to adjust to each other's disciplinary work and communication expectations. Overall, students recruited to the project were highly skilled academically within their disciplines but required significant mentoring by faculty members, especially about communicating their ideas at large team meetings. Faculty members realized that selecting team members who possess effective communication skills may in some cases be more important than having strong disciplinary skills.

This project presented learning experiences for students that would be difficult to replicate in a classroom context. The large size and scope of the project required students to be more detail-oriented than in a class project. Also, working with an interdisciplinary team of students and faculty was a unique experience.

TABLE 2. User Experience Assessment of the Game during Development

User experience adjective pairs	Fall 2018 (*n* = 4)	Spring 2020 (*n* = 7)
	1 to 5 scale	1 to 5 scale
1. Is the game complicated or simple?	2.75	4.14
2. Is the game ugly or attractive?	4.75	4.71
3. Is the game impractical or practical?	3.50	4.29
4. Is the game tacky or stylish?	4.00	4.43
5. Is the game unpredictable or predictable?	2.50	3.71
6. Is the game cheap or premium?	3.75	3.43
7. Is the game unimaginative or creative?	4.50	4.57
8. Is the game bad or good?	4.00	4.86
9. Is the game confusing or clearly structured?	3.25	4.43
10. Is the game dull or captivating?	3.75	4.29
Average user experience	**3.68**	**4.29**

Note: Five-step scale for adjective pairs (1 = very negative, 2 = negative, 3 = neutral, 4 = positive, 5 = very positive).

Research Outcome

A Game to Teach Cellular Biology

The main outcome of the project was the game itself, the artifact created. As stated earlier, the game was tested on multiple occasions during the process to improve the game. Some of these tests were informal, and others were formal (Interaction Design Foundation 2016; Lallemand and Gronier 2015). The formal tests not only were an opportunity to improve the game but also a way to gather data to assess the overall user experience of the game and to start understanding the learning experiences of biology students playing the game.

In fall 2018 (*n* = 4) and spring 2020 (*n* = 7), formal tests were conducted by undergraduate biology students. Participants were invited to play the game for approximately 30 minutes and simultaneously comment on their experience, whereas observers noted the main problems encountered (Lallemand and Gronier 2015). After the test, participants were asked to complete a questionnaire.

Quality of User Experience. An adapted version of the AttrakDiff Short scale (Hassenzahl, Burmester, and Koller 2003) was used in the questionnaire to assess the game's overall user experience. This instrument uses a semantic differentials technique. It consists of 10 pairs of bipolar adjectives. The adjectives were rated on a 5-step scale (1 = very negative, 2 = negative, 3 = neutral, 4 = positive, 5 = very positive). Table 2 compares the results of the two testing sessions using the average ratings for all the biology student participants.

Table 2 indicates that the user experience improved between fall 2018 and spring 2020 in every aspect except for two (cheap or premium, and ugly or attractive). According to the results, the game appeared more "simple" to use in fall 2018 (2.75) than in spring 2020 (4.14). In spring 2020, the game was described as "good" according to the results (4.86). Overall, participants experienced a quality "user experience" playing the game during the last testing session (4.29). These results reflect that students and faculty members on the team were able to create a high-quality game experience for the students.

Assessment of Learning Experience. On the spring 2020 questionnaire, participants (*n* = 7) also were asked to discuss their learning experiences. Since one goal was to create an educational and entertaining game, students were asked to rate a statement related to that goal on a scale of 1 to 5. According to the participants, the game balanced fun and learning successfully (4.57).

They also were asked if the game helped them understand cellular biology concepts better. All the students (*n* = 7) answered "yes." Students were then asked to explain how the game helped them better understand cellular biology (see Table 3). As shown in Table 3, participants identified different ways the game helped them learn cellular biology concepts, which can be summarized in four main points:

TABLE 3. Understanding Cellular Biology with Life on the Edge

Participants	How did the game help you understand cellular biology better?
Participant 1	"I did not know that too many nutrients could slow down ATP production."
Participant 2	"I had completely forgotten that mitochondria generated ATP even though 'Mitochondria is the powerhouse of the cell' is a phrase ingrained in my brain. It helped create a eureka moment when I remembered that as I was struggling with generating ATP for my cell. It also helps make more abstract structures like the aquaporins feel more 'real.'"
Participant 3	"Because I had to remember what hypo/hyper/isotonic environments are and how a cell responds/how to protect the cell. I think it would be an especially useful tool when I was learning these topics in class so I could apply and solidify my knowledge of cells and cell structures."
Participant 4	"It gave me a visual and interactive way to understand how a cell is composed and how it functions with different organelles and how the cell overall fights bacteria."
Participant 5	"It was a very good interactive visual showing how components of the cell function."
Participant 6	"It provided information about each cell structure."
Participant 7	"I haven't played any educational games prior to this (and I've played many games) and I felt that it was a really great recap of what I'd learnt in BIOL 107. I think it would have been beneficial to have played this prior to even starting class as it allowed me to attach game functions of various elements to 'meaning' in my mind, rather than memorization of words as the visual cue. Considering I've only played it for an hour, the analogy of tower defense to cell biology is spot-on for my learning style."

- Learn new content (participant 1).
- Recall content presented in a class (participant 2, participant 7)
- Apply the knowledge presented in class (participant 3)
- Show the content in a visual and interactive way (participants 4 and 5)

These are preliminary results only. After the game is implemented, the faculty members plan to study the impact of the game more deeply. The field of game-based learning is well-established, and various studies have already examined the effects of postsecondary serious games on learning (Zhonggen 2019). However, more studies with a primary focus on biological sciences games for the postsecondary level are still needed.

Dissemination

Beyond the development of the game itself, this project created opportunities for students working on the project to disseminate their work at several conferences and events and in articles. For example, students presented their work at the MacEwan Celebration of Teaching and Learning Conference and at the Dark Matters: Game On! event in Edmonton.

Conclusion

This research was conceived as a project built by students and faculty members for students and faculty members. This nontraditional approach to research was attractive to students and offered them an exciting opportunity. Developing a video game was a new, challenging, and gratifying process for the students involved. The project dynamics nurtured a unique connection among the design, biological science, computer science, and music programs, fostering student-driven research and innovation. The faculty members represented multiple disciplines, creating a unique mentoring opportunity within and between fields of expertise. This project has generated meaningful learning experiences not only for students but also for the faculty members involved.

Acknowledgments

The authors thank the design team (Stephanie Lumayno, Chanelle Paradis, Kia Valdez Bettcher, Erika Amper, Cam Zimmel, Matthew Satchwill, John Montague, Kelly Veillette, and Isabela Lopez), the computer science team (David Cao and Kevin Ho), the music team (Emilie Lebel, John McMillan, Matthew O'Connor, Fabio Henao, Kate Ashton, Shea Iles, and Colin Deneka), and Samuel Mugo in MacEwan's Physical Sciences for their involvement in this project. The project was funded by the MacEwan Arts and Science Department, Faculty of Fine Arts and Communications, and Office of Research Services.

References

Brown, Tim. 2008. "Design Thinking." *Harvard Business Review* 86(6): 84–92.

Buday, Richard, Tom Baranowski, and Debbe Thompson. 2012. "Fun and Games and Boredom." *Games for Health Journal* 1: 257–261. doi: 10.1089/g4h.2012.0026

Candy, Linda. 2006. "Practice-Based Research: A Guide." CCS Report 2006–V1.0 November. Sydney: Creativity and Cognition Studios, University of Technology.

Chapman, Owen B., and Kim Sawchuk. 2012. "Research-Creation: Intervention, Analysis and 'Family Resemblances.'"

Canadian Journal of Communication 37: 5–26. doi: 10.22230/cjc.2012v37n1a2489

Cortez, Meghan. 2017. "Q&A: Vadim Polikov's Startup Brings Game-Based Learning to Science Class." *EdTech*. Accessed April 23, 2020. https://edtechmagazine.com/k12/article/2017/04/qa-vadim-polikovs-startup-brings-game-based-learning-science-class

Coulton, Paul, and Alan Hook. 2017. "Games Design Research through Game Design Practice." In Lankoski and Holopainen 2017, 97–115.

Design Council. 2015. "What Is the Framework for Innovation? Design Council's Evolved Double Diamond." Accessed April 10, 2020. https://www.designcouncil.org.uk/news-opinion/what-framework-innovation-design-councils-evolved-double-diamond

Dormans, Joris, and Jussi Holopainen. 2017. "Investigating Game Design Methods and Models." In Lankoski and Holopainen 2017, 75–95.

Hassenzahl, Marc, Michael Burmester, and Franz Koller. 2003. "AttrakDiff: Ein Fragebogen zur Messung wahrgenommener hedonischer und pragmatischer Qualität." In *Mensch & Computer 2003*, ed. Gerd Szwillu and Jürgen Ziegler, 187–196. Berichte des German Chapter of the ACM, vol. 57. Wiesbaden: Vieweg+Teubner Verlag. doi: 10.1007/978-3-322-80058-9_19

Interaction Design Foundation. 2016. "UX Research Communication: Informal Usability Tests." Accessed October 15, 2020. https://www.interaction-design.org/literature/article/ux-research-communication-informal-usability-tests

Lallemand, Carine, and Guillaume Gronier. 2015. *Méthodes de design UX: 30 Méthodes fondamentales pour concevoir et évaluer les systèmes interactifs*. Paris: Eyrolles.

Lankoski, Petri, and Jussi Holopainen (Eds.). 2017. *Game Design Research: An Introduction to Theory and Practice*. Pittsburgh: ETC Press.

Life on the Edge. n.d. "Life on the Edge." Accessed December 18, 2020. https://lifeontheedgegame.com

Muratovski, Gjoko. 2015. *Research for Designers*. London: SAGE.

Norman, Donald. 2013. *The Design of Everyday Things: Revised and Expanded Edition*. New York: Basic Books.

project-management.com. 2020. "What Is a Project Charter?" Accessed April 25, 2020. https://project-management.com/what-is-a-project-charter

Reece, Damon. 2015. "Best Tower Defense Games of All Time." Gameranx.com. Accessed April 23, 2020. https://gameranx.com/features/id/13529/article/best-tower-defense-games

Sanford, Kathy, Lisa J. Starr, Liz Merkel, and Sarah Bonsor Kurki. 2015. "Serious Games: Video Games for Good?" *E-Learning and Digital Media* 12: 90–106. doi: 10.1177/2042753014558380

Shylenok, Pavel. 2019. "Understanding the Roles of Game Dev Professionals." Gamasutra.com. Accessed December 18, 2020. https://www.gamasutra.com/blogs/PavelShylenok/20190115/334322/Understanding_the_Roles_of_Game_Dev_Professionals.php

Sorcinelli, Mary Deane, and Jung Yun. 2007. "From Mentor to Mentoring Networks: Mentoring in the New Academy." *Change: The Magazine of Higher Learning* 39(6): 58–61. doi: 10.3200/CHNG.39.6.58-C4

Sperano, Isabelle, Robert Andruchow, and Ross Shaw. 2019. "Interaction Design and Educational Video Game: Motivating Undergraduate Students to Explore New Territories." Presented at the Interaction Design Education Summit, Seattle, February 3–4, 2019. Accessed April 15, 2020. https://medium.com/ixda/interaction-design-and-educational-video-games-motivating-undergraduatestudents-to-explore-new-ac82dca444db

Takahashi, Dean. 2018. "Newzoo: Games Market Expected to Hit $180.1 Billion in Revenues in 2021." VentureBeat.com. Accessed April 8, 2020. https://venturebeat.com/2018/04/30/newzoo-global-games-expected-to-hit-180-1-billion-in-revenues-2021

Van Roy, Rob, and Bieke Zaman. 2017. "Why Gamification Fails in Education and How to Make It Successful: Introducing Nine Gamification Heuristics Based on Self-Determination Theory." In *Serious Games and Edutainment Applications*, ed. Minhua Ma and Andreas Oikonomou, 485–509. Switzerland: Springer Cham. doi: 10.1007/978-3-319-51645-5_22

Vlachopoulos, Dimitrios, and Agoritsa Makri. 2017. "The Effect of Games and Simulations on Higher Education: A Systematic Literature Review." *International Journal of Educational Technology in Higher Education* 14: art. 22. doi: 10.1186/s41239-017-0062-1

Wardrobe, Damon. 2016. "The Guide to Composing Music for Video Games." Midnight Music. Accessed April 23, 2020. https://midnightmusic.com.au/2016/06/the-guide-to-composing-music-for-video-games/

Whitmer, Regina, and Avi Asher-Schapiro. 2017. "Game On: Game-Based Learning Pinpoints Special Ed as well as Core Subjects and Uses Fictionalized Worlds to Derive Real-World Insight." Questia.com. Accessed April 20, 2020. https://www.questia.com/read/1G1-497506241/game-on-game-based-learning-pinpoints-special-ed

"Why Video Games Are So Expensive to Develop." 2014. *Economist*. Accessed December 18, 2020. https://www.economist.com/the-economist-explains/2014/09/24/why-video-games-are-so-expensive-to-develop

Zhonggen, Yu. 2019. "A Meta-Analysis of Use of Serious Games in Education Over a Decade." *International Journal of Computer Games Technology* 2019: art. 4797032. doi: 10.1155/2019/4797032

Isabelle Sperano
MacEwan University, speranoi@macewan.ca

Isabelle Sperano is an assistant professor in digital experience design (DXD) at MacEwan University. She embraces a systemic and user-centered view of DXD. This approach reveals itself in her teaching, notably by raising student awareness about the importance of taking user needs into *account and developing a deep understanding of information behaviors to elaborate relevant and useful digital solutions. She focuses on finding common avenues of reflection for scientific research, teaching, and practice in DXD.*

Ross Shaw is an assistant professor in biological sciences. Specializing in marine biology and, most recently, captive coral research, he has pursued a passion for teaching. This path led him to explore the scholarship of teaching and learning, and ultimately to begin development of serious video games for postsecondary students. He received MacEwan's Distinguished Teaching Award in 2016.

Robert Andruchow is currently chair of the Department of Art and Design with a teaching and research focus in DXD. He recently led the creation of an innovative design degree at MacEwan, which places social science theory and methods at the core of the designer's education in addition to traditional art training. Andruchow also plays a leadership role in the local digital industry as a member of the board of Digital Alberta.

Dana Cobzas is an assistant professor in computer science. Her expertise is computer vision and imaging, with an emphasis on mathematical models in medical image analysis. She is teaching a computer graphics course as part of the game stream at MacEwan.

Cory Efird is a fourth-year student majoring in computer science and math. His primary interests are computer graphics, machine learning, and physics simulations.

Brian Brookwell is an assistant professor in computer science. His primary academic interests focus on game design and instruction.

William Deng is a fourth-year student majoring in music recording and production. He has engineered and produced music for a number of local musicians in a wide range of genres.