Beyond Motivation and Engagement: Students' Voices on the Use of Game-based Learning in a Bachelor Computer Science Online Degree

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Figure 1: Gameplay of three game-based learning activities in the BSc Computer Science online degree.

ABSTRACT

Video games have many potential uses beyond pure entertainment, including their use in educational contexts. Yet, it remains really challenging to put together guidelines to design effective game-like interventions in educational contexts. This study examines existing work relating to gamification, game-based learning, and serious games, and finds there is still limited qualitative work concerning the student perspective and limited work developing pedagogical guidelines for developers wishing to develop effective game-based learning experiences. The study focuses on the perception of students in regard to game-based learning activities in the context of a BSc Computer Science online degree. Students enrolled in the online degree were invited to fill in an online survey after their experience with a selection of game-based learning activities in the online degree. Reflexive Thematic Analysis was used to evaluate the open-ended responses from 55 participants. First, quantitative and qualitative results revealed insightful information along with four overarching themes ("Complementary to lectures on topics that are usually hard or too abstract to teach", "Allow students to take on identities and learn from different angles and perspectives", "Balanced challenge and context relevance to minimise students wasting their time", and "Reward players for their effort with meaningful rewards and provide a safe space for failure"), suggesting that game-based learning interventions offer more than just motivation and engagement. Second, technical and pedagogical principles emerged from the data analysis, proposing guidelines for future designers of game-based learning activities in similar educational contexts. Finally, the study provides a selection of twelve open-source and browser-based game-based learning activities, the ones students encountered in the BSc Computer Science online degree.

CCS CONCEPTS

• **Applied computing** → **Interactive learning environments**; **Computer games**.

KEYWORDS

Serious games, game-based-learning, gamification, and distance learning.

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1 INTRODUCTION

Nowadays, video games are a much broader medium than just entertainment and their influence and use have become intergenerational [9]. The beneficial aspects of video games have aroused interest in academics and instructors to integrate, especially in the cognitive and motivational domains, video games with traditional educational activities. In 2019, we were asked to collaborate with academic colleagues at Goldsmiths, University of London, to develop a series of short educational games that we would embed in our new online BSc Computer Science degree, and these games are the subject of this paper. Upon researching best practices in educational video game design, we found that there were numerous terms adopted to describe and design such games (e.g. Serious games, Game-based learning, and Gamification). The relatively new context in which they had to be deployed (the world-first undergraduate degree on Coursera) made the preliminary design decisions rather challenging. With a limited time frame, we chose to take a game-based learning approach, where the game itself contains educational material, as opposed to gamification (using game elements to motivate/engage students), on an intuition that it provided for better alignment with the other educational material. Upon release, the BSc Computer Science online degree featured twelve game-based learning activities designed with what we believed were valuable principles of both entertaining and educational games. Our ambition was to develop the games using best practices from the research on game-based learning, but we found there were problematic gaps in this research: the lack of clear guidelines to design such activities, the relatively new context in which they had to be designed, and the fragmented and not exhaustive qualitative research on the field. The work presented in this paper addresses those gaps with the adoption of a contextual qualitative research approach. Students were given the opportunity to provide feedback on their experience with the game-based learning activities in the online degree via an online survey. The survey was designed to collect quantitative demographic data as well as open-ended responses to the following five questions:

(1) What are the prevailing reasons for students to undertake the BSc CS online degree?
(2) What is the overall students' perception of the proposed game-based learning activities?
(3) Do students expect the proposed game-based learning activities to have similarities with entertaining video games? What is their goal when playing educational games? What are the features they would like to see?
(4) What would be the one thing that students really wanted to see on the BSc Computer Science online course game activities?
(5) How would students compare the BSc course game activities to other more traditional in-course activities such as readings, discussion forums, quizzes, and video lectures?

With the use of Reflexive Thematic Analysis as a method to evaluate students' game-based learning experiences and a deeper understanding of the context and demographics in which they were developed, this paper provides the following contributions:

(1) Reflexive thematic analysis of students' experiences using game-based learning, suggesting key themes such as "Complementary to lectures on topics that are usually hard or too abstract to teach", "Allow students to take on identities and learn from different angles and perspectives", "Balanced challenge and context relevance to minimise students wasting their time", and "Reward players for their effort with meaningful rewards and provide a safe space for failure".
(2) Insightful information and pedagogical guidelines for designers wishing to create game-based learning experiences such as constructivism, spacing effect, and constructive alignment; and;
(3) A selection of open source and browser-based game-based learning activities.

1.1 Games beyond entertainment

In the early history of video games, "Tennis for Two" made its public appearance at the Brookhaven National Laboratory in the United States in 1958 [1]. The developer, William Higinbotham, took advantage of the research institution's Donner Model 30 analog computer to overcome the static and non-interactive characteristics of most science exhibits at the time. The great success of the Brookhaven National Laboratory's experiment in 1958 laid the foundation of a merely entertaining original medium set to influence the following years.

Nowadays, video games are a much broader medium than just entertainment and their influence and use have become intergenerational. A contemporary study conducted by Isabela Granic, Adam Lobel, and Rutger C. M. E. Engels highlights the benefits of video games other than purely whimsical experiences. The analysis summarises the research on the positive characteristics of playing video games in the cognitive, motivational, emotional, and social domains, recognising enhancement in attention allocation, spatial resolution in visual processing, mental rotation abilities, acceptance of failures with excitement, improvement of player's moods and increase of prosocial behaviors [12]. A 2013 study from Susan Krauss Whitbourne, Stacy Ellenberg, and Kyoko Akimoto [22] analysed the reasons for playing casual video games and the perceived benefits among 18-80 years old adults. The study compared the online survey responses of 10,308 adults to questions regarding Bejeweled Blitz, a very popular Facebook casual puzzle video game. All respondents aroused interest in social and competitive reasons for playing such a game. However, there were differences in older adults who reported playing the game for stress relief and felt increased cognitive function such as response time and visuospatial skills. Younger adults experienced improved memory and felt sharper as a result of playing the game. According to Ian Bogost, "videogames are not a subcultural form meant for adolescents but just another medium woven into everyday life," suggesting that video games should be imagined as a medium with valid uses across a spectrum, from art to tools and everything in between [2].

The idea that video games serve additional purposes other than entertainment is certainly not new and game designers were already making games for diverse purposes in the early 80s and 90s. While arcade developers were working hard to keep up with the

demand and continuous growth of young players' skills, independent developers like Ryan Best took advantage of the popularity of role-playing games to produce their own digital title. The primary purpose of Ryan's digital game, named *GayBlade* and released in 1992, was to support the gay and lesbian community in San Francisco during the AIDS crisis encountered in the late 80s [7]. Another early example of video games that served purposes other than entertainment could be seen in the Super Nintendo title "Packy and Marlon" released in 1995. In a controlled study designed to improve self-care among children and adolescents with diabetes using the game, 8-16 years old participants showed that in addition to more communication with parents and improved self-care, they demonstrated a significant decrease in urgent medical visits [3].

The use of video games outside their primary aim of entertainment, despite the elusive characteristics of what exactly makes such games, is often referred to as the umbrella term *Serious games*. The general tendency of serious games, seen as the use of technology for the purposes of training, informing, and promoting behavioral change [5, 8, 15], has encouraged education to open its door to such media as a source to enhance students' learning experiences. Video games, in fact, possess strong instructional and motivational principles. In his book *What Video Games Have to Teach Us About Learning and Literacy*, James Paul Gee highlights the instructional benefits of well-designed entertaining video games and criticises individuals who classify these games as non-instructional and a waste of time [11]. He emphasises that digital games encourage active and critical thinking, games allow players to take risks in a space where real-world consequences are lowered, games allow dynamic and not boring repetitive practice, and games operate on the "regime of competence", that is the perception of tasks to feel challenging but not impossible. Gee supports the idea that the theory of learning in good video games is close to what he believes are the best theories of learning in cognitive science. With the apparent agreement on the purpose of serious games, that is the use of games to train, inform, and promote behavioral change, academics and instructors have started to use more specific terms to define this collaboration between education and video games such as *Gamification* and *Game-based learning*.

Gamification, defined by Sebastian Deterding as "the use of game design elements in non-game context" [18], has generated numerous theories in the attempt to provide empirical evidence on its benefits in the context of formal education. In the latter context, gamification is usually integrated as a motivational, engaging, and progress-tracking system [10, 13, 14] where elements such as points, badges, and leaderboards are employed as part of the learning experience.

While gamification can be employed as a powerful tool for increasing motivation and improving engagement, game-based learning refers to the design of learning environments that builds on the educational properties of games [23]. These environments highlight systems that use more comprehensive video game elements in an attempt to enhance engagement and motivation in a similar manner to gamification but with the advantage of delivering direct learning. An example of a game-based learning system designed to enhance students' learning can be seen in a paper from Sahar Shabanah et al. [17] The authors highlight the challenging task that faces Computer Science instructors when teaching topics such as algorithms and data structures. As a result, the study introduces a new learning strategy that benefits from computer games' popularity and engagement to help university students understand algorithms better by designing computer games that not only visualise algorithms but that allow learners to interact with their structure.

Gamification and game-based learning have indeed the potential to successfully improve different aspects of students' learning experiences. The rationale behind the adoption of game-based learning was dictated by its advantages to deliver direct learning, as well as motivation and engagement that other methods like gamification can also offer. Successful uses of game-based learning in education are evident in the literature. Whether it is employed to engage students and extend their motivation to read and do their homework [19], deployed as a way to actively teach algorithms in Computer Science [17], or designed to promote content knowledge and critical thinking in social study classrooms [6], the use of game-based learning in education seems to be a really promising tool to enhance students' learning experiences.

The problem though lies in the fact that despite the evidence of successful application of game-based learning in formal education, it is really challenging to understand how to design effective game-like activities. There is a tendency to blindly steal concepts from entertaining video games (e.g. points, badges, leaderboards, role-playing) in the hope that those work also in the context of education. Most papers evaluate their interventions with quantitative findings. That approach may inform readers on whether a certain intervention for a particular problem works, but it does not provide insightful information on how to actually design effective game-based learning activities. In short, we do have knowledge that game-based learning is effective but we lack effective guidelines to design such systems. There is limited qualitative research that tries to give students a voice regarding their opinion about the integration of games in formal education. Asking the direct users might contribute to the design of better-fitting game activities, work towards a more systematic use of methods such as gamification and game-based learning, and reduce the guessing science of adapting entertaining video game beliefs in the context of education. With this in mind, this study evaluates several game-based learning activities while qualitatively assessing students' opinions on the overall design, beliefs, and suggestions on the use of video games in online formal education.

2 METHOD

This section starts by describing examples of the game-based learning activities deployed in the online degree. Then, the survey and data gathering method is described. Following that, the adopted qualitative data analysis method, Reflexive Thematic Analysis, is described.

2.1 Designing the game-based learning activities

The initial design of the game-based learning activities was informed by Gee's [11] theories and principles which positively correlate video games and cognitive development: encouraging active and critical thinking via compelling environments, allowing players to take risks in a space where real-world consequences are lowered,

operating on the "regime of competence" (balanced challenge), and implementing dynamism of boring and repetitive practice.

The BSc Computer Science online distance learning programme featured twelve game-based learning activities at launch [1]. The activities were developed with vanilla HTML, CSS, and JavaScript and they were deployed on Coursera via dockerised virtual environments (static web pages that students could access with a simple "Start" button). The activities were spread across various modules in the degree, covering topics such as algorithms, version control, data structures, and machine learning. Most of the game-like activities share similar mechanics and design patterns. They are quick formative activities where students can spend as much time as they want and make mistakes without compromising their marks in the various modules taken in the degree. There are no competitive elements such as badges or leaderboards, and players cannot keep track of their progress due to the short length of the game-like activities. Some of them feature an interactive tutorial, others a scrolling text with information on how to play. Some are only exploratory activities, others instead are more goal-oriented with elements of linear narrative. Figure 1 illustrates, from left to right, three examples of the game-based learning activities:

(1) **GitTogether:** This interactive storytelling game explores the basics of Git version control in both single and collaborative work and attempts to provide a visual explanation of the steps required to perform the basic operations. The environment puts the players in the shoes of an external helper of a startup company that is asked to use Git version control for the very first time. Players progressively learn the Git pipeline and basic commands as the story progresses and are actively participating in the story through a quiz-based mechanic. By the end of the journey, players should have a clear mental model of both single and collaborative Git version control and understand the basic operations;
(2) **Sorting Algorithms:** The "Sorting Algorithms" is an interactive learning environment aimed at better understanding the nature, steps, and performance of both the Bubble and Insertion Sort algorithms. Players compete against the computer to correctly sort a list of integer numbers in an attempt to match both the number of passes and swaps according to the nature of the algorithm. Players can then compare their results to the computer attempt and verify the correct use of the Bubble or Insertion Sort algorithm. The game offers a vast number of different exercises where players can choose to sort a list of integer numbers or alphabetical letters; and
(3) **Palindrome Stack:** The "Palindrome Stack" is an interactive learning environment aimed at better understanding the nature of the "stack" data structure and its operations. Players are required to correctly execute stack valid operations to verify whether words are palindrome, meaning that the words are exactly identical if read backward. Players can finally verify their answers against the computer and also receive feedback on the correctness of the stack operations executed.

[1] https://www.doc.gold.ac.uk/goldplugins/

2.2 Population and data collection

A cohort of approximately 5000 students enrolled in the BSc CS online degree was invited to fill in an online survey via a public announcement on the virtual learning environment. It is worth mentioning that the study obtained ethical approval from the academic board at Goldsmiths, University of London before any data collection took place. The survey [2], hosted on Microsoft Forms, contained a mix of quantitative (multiple choices and Linkert scale) and qualitative (open-ended) questions. The questions were organised into four sections: demographics, the experience with the game-based learning activities, a general comparison between educational and entertaining video games, and a comparison between the game-based learning activities and other learning activities in the online degree. Students were not forced to fill in the survey and no incentives such as cash prizes or vouchers were used to convince them to fill in the survey. Students were also reassured that the process was anonymous. Purposing sampling was employed to filter the sample by students who tried at least one of the game-based learning activities. The game-based learning activities, in fact, were not compulsory and not every student would have engaged with them during their studies. A total of 55 responses were considered valid for the analysis process.

2.3 Choosing the appropriate method

In light of the characteristics of the collected data, as well as our emphasis on *sense making*, *understanding*, and *giving someone a voice*, we selected the use of qualitative analysis to evaluate the open-ended online survey responses.

At first glance, Grounded Theory seemed an appropriate qualitative methodology path to capture students' voices on their experience with the game-based learning activities. In essence, Grounded Theory is both the process of category identification and integration (as a method) and its product (as a theory), concerned with identifying and constructing theory from data [4]. Unfortunately, the primary concern was with the nature and scale of the qualitative study. Grounded Theory operates with theoretical sensitivity, where the researcher interacts with the data in an iterative manner. Such a type of interaction, which usually requires the researcher to analyse data as it is collected, was not compatible with the nature of this qualitative study as the data collection process ended prior to beginning the analysis.

IPA (Interpretative Phenomenological Analyses) was also reviewed as a possible methodological approach but it was soon ruled out due to incompatibility with the nature of the study and the data collection analysis.IPA's concern is with exploring people's lived experiences and the meaning people attach to those experiences. At the heart of this perspective lies a clearly declared phenomenological emphasis on the experiential claims and concerns of the people taking part in the study as discussed by Larkin, Watts, and Clifton [16]. IPA's aim is to produce rich personal experience narratives, suggesting the collection of data via interviews rather than surveys. Furthermore, IPA operates with relatively small sample sizes (8-12 participants) which was way above the sample size obtained from the online degree survey responses.

[2] https://forms.office.com/r/AUA5BLWNEn

The need to give students a voice and the data collection process suggested the use of Thematic Analysis to carry out the qualitative evaluation. More precisely, Braun and Clarke's emended Thematic Analysis method, which they now refer to as Reflexive Thematic Analysis [21]. The authors' amended TA method is best described as theoretically flexible only as a generic method; specific iterations of TA encode particular paradigmatic and epistemological assumptions about meaningful knowledge production and thus their theoretical flexibility is more or less constrained compared to the TA approach described in 2006 [20]. The Reflexive Thematic Analysis was carefully executed using an inductive approach. "Inductive" in the sense that we let the data speak without trying to fit the data into pre-existing theory or framework. Themes were generated at a semantic level, that is they were identified within the explicit or surface meanings of the data and not beyond what participants have said. We used the following six steps of analysis:

(1) **Familiarising yourself with your data:** This phase involved noting down on paper the initial ideas and concepts of individual participants' responses. The survey responses were printed and noted using post-it notes.
(2) **Generating initial codes:** This phase involved the generation of initial codes. Coding was executed systematically through the entire dataset on paper with the use of coloured pencils, giving full and equal attention to each data item. The obtained codes and respective text extracts were then grouped together using Taguette [3].
(3) **Generating initial themes:** Here, the focus was again on the analysis at the broader level of themes, rather than codes, and involved considering how different codes would combine under a single overarching title/theme. It was really helpful at this stage to use visual representations (mind maps) to help sort the different codes.
(4) **Reviewing the themes:** The refinement procedure consisted in analysing the themes and code extracts in depth. Some themes collapsed into each other while others needed to be broken down into separate themes or sub-themes. The approach to this phase consisted of two levels of review. In the first level, Taguette was used to read once more all the collated extracts for each theme and considered whether they appeared to form a coherent pattern. In the second level, Taguette was used to analyse the themes in relation to the entire data set.
(5) **Defining and naming themes** At this point, it was time to define and further refine the themes to identify their *essence*. The process required going back to the collated data extracts one more time to refine the mind map so that it reflected as accurately as possible the main point of interest for each of the generated themes.
(6) **Producing the report:** This phase involved the final analysis and write-up of the narrative.

3 RESULTS

This section highlights the results of quantitative and qualitative data obtained from a sample of 55 responses. Both quantitative and qualitative results are then discussed in the next section of the paper.

Quantitative data were collected from the demographic section of the survey and via Linkert scales for the questions related to the game-based learning activities. Results from the demographic section of the paper indicate an imbalanced gender ratio, with 76% male. In terms of age groups, 44% falls within the 35-44 age range, followed closely by 18-24 and 25-34 with a percentage of 22%. When it comes to provenience, the study showcases a diverse representation, with the largest percentage belonging to Europe at 42%, followed by Asia, North America, and Africa with relative percentages of 20%, 16%, and 13%. The majority of students prefer to access the Coursera platform via laptops 78% and mobile devices 49%. Only 5% of the students have no previous programming experience. Finally, 73% of the students play video games. Their preferred platform to play is PC 58%, with action, adventure, and role-playing being among the favorite genres.

Figures 2 and 3 show the results for the questions related to the experience of students with the game-based learning activities in the form of a 5-point Linkert scale.

Qualitative data were analysed using the six steps of Reflexive Thematic Analysis on the responses to the following five open-ended questions:

(1) What are the prevailing reasons for students to undertake the BSc CS online degree?
(2) What is the overall students' perception of the proposed game-based learning activities?
(3) Do students expect the proposed game-based learning activities to have similarities with entertaining video games? What is their goal when playing educational games? What are the features they would like to see?
(4) What would be the one thing that students really wanted to see on the BSc Computer Science online course game activities?
(5) How would students compare the BSc course game activities to other more traditional in-course activities such as readings, discussion forums, quizzes, and video lectures?

Figure 4 shows the final themes and sub-themes obtained by overlooking all individual reflexive thematic analysis results of the five open-ended questions. Obtained themes and sub-themes for the individual open-ended questions are then discussed in the next section of the paper.

4 ANALYSIS

This section starts by describing in detail the quantitative data and the final themes obtained from the use of Reflexive Thematic Analysis. Following that, the section suggests game-based learning technical and pedagogical design guidelines informed by the above descriptive results.

4.1 Final themes

From the demographic data in the previous section, it was possible to capture preliminary information that might help with the design of the game-like activities. The fact that students mainly accessed the online degree on Coursera with a laptop and preferred to play games on PCs suggests the focus on designing for larger screens

[3] https://www.taguette.org/

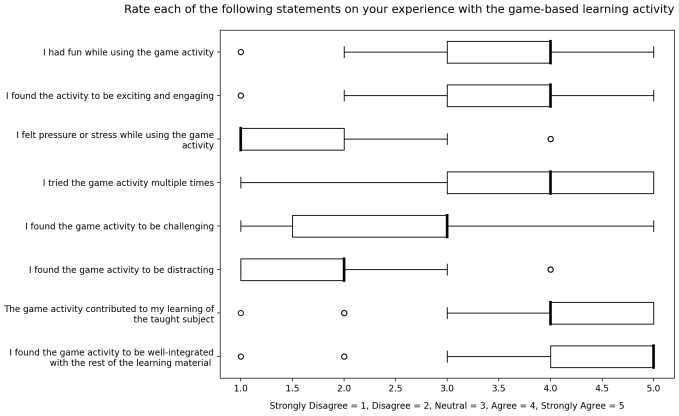

Figure 2: Five-point Linkert scale results from the question "Rate each of the following statements on your experience with the game-based learning activity".

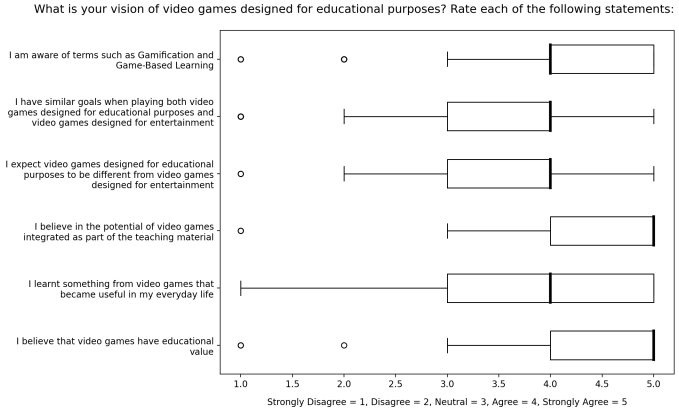

Figure 3: Five-point Linkert scale results from the question "What is your vision of video games designed for educational purposes?".

as a priority within the online degree. The age range was slightly higher than the one on a traditional on-campus experience and many students entered the online degree with little programming skills. This, and the fact that most students only played games occasionally, recommend that early on game-like activities in the online degree should accommodate non-experienced users. Furthermore, the qualitative analysis results on the question "What are the prevailing reasons for students to undertake the BSc CS online degree?" identified three major themes: flexibility, accessibility, and recognition of a certified degree. Most students were in fact working or parenting and they needed a flexible study environment to accommodate their busy schedules. They had different accessibility needs for wanting to study online: economical, the lack of on-campus institutions around their area, events of force majeure such as medical conditions, and certain personalities finding online

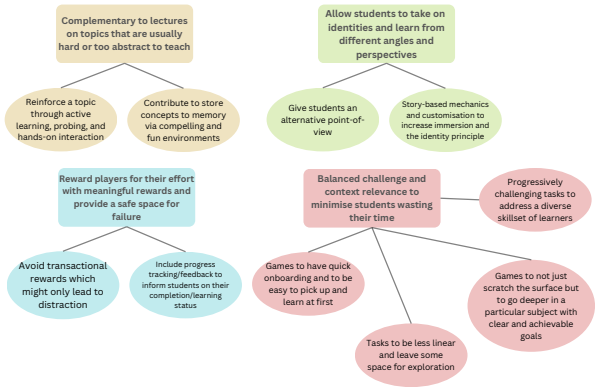

Figure 4: Final themes and sub-themes obtained from the overall qualitative analysis.

education a safer and more adaptive space to their needs. Linking back to the design of the game-like activities, this informs that such activities should not waste the learners' already limited time and be designed as safe and inclusive environments.

Moving on to the questions related to the game-based learning activities, "What is the overall students' perception of the proposed game-based learning activities?" and "Do students expect the proposed game-based learning activities to have similarities with entertaining video games?", quantitative and qualitative results show that students had a positive experience with the systems. Figures 2 and 3 suggest that students found the game-based learning activities appropriate to the online degree and helpful in their learning process. Students did not perceive the activities as stressful, distracting, or challenging. Students believe in the educational value of video games and hint that they should not be that different from games designed for entertainment, except for their goals. The obtained themes and sub-themes from the Reflexive Thematic Analysis reveal that the activities, even if not fully perceived as games, provided ways for students to facilitate awareness of facts and helped them to store concepts in memory. More specifically, the game-like activities helped with the understanding of intangible and hard topics thanks to compelling visuals, their ability to abstract complex scenarios, and the idea to tackle the subject to learn from a different perspective. Students expect the game-based learning activities to teach without wasting their time. Finally, the perception of the difference between entertaining and educational games is not massive. Active and critical learning, as well as the idea of a safe environment where failure is allowed, are elements that students really want to retain from entertaining video games. Students do not demand complex graphics, as long as the activities implement progressively challenging tasks, meaningful rewards to avoid distraction, and immersion via tackling the learning subject from different perspectives. Goal-wise, students search for activities where they can quickly learn in a way that is not possible with other teaching interventions.

The analysis of the last two open-ended questions, "What would be the one thing that students really wanted to see on the BSc

Computer Science online course game activities?" and "How would you compare the BSc course game activities to other in-course activities such as readings, discussion forums, quizzes, and video lectures?", reveal that students want to see more similar games in the online degree and that they find them complementary to traditional methods, especially lectures, to reinforce a particular subject. Students are also keen on the game-based learning activities to provide a balanced-challenge experience that goes beyond simple tasks, as well as rewarding players for their effort with meaningful prizes.

The individual analysis for each of the questions was really useful to identify key themes but not quite enough to suggest a pipeline to design effective game-based learning activities. It was necessary to zoom out on all the individual question analyses to also identify the most important features across all the open-ended questions.

Figure 4 shows the overarching final four themes along with sub-themes. Here are those themes: "Complementary to lectures on topics that are usually hard or too abstract to teach", "Allow students to take on identities and learn from different angles and perspectives", "Balanced challenge and context relevance to minimise students wasting their time", and "Reward players for their effort with meaningful rewards and provide a safe space for failure".

4.1.1 Complementary to lectures on topics that are usually hard or too abstract to teach. This theme presents two sub-themes: "Reinforce a topic through active learning, probing, and hands-on interaction" and "Contribute to store concepts to memory via compelling and fun environments". Overall, students found the game-based learning activities to be a great contribution to their learning ("I'm lucky to say that I tried multiple games and my rating reflects on all of them, I think they are built in a way to be engaging and I can totally assure that It did contribute to my learning,","I found all plugins very useful and instructive, even though I am not a fan of gamification"). Students found the game-based learning activities complementary to the rest of the learning material in the online degree. More specifically, students found them complementary to lectures as they offered a more active and hands-on approach to learning compared to just watching instructors ("I think it complements the lecture material well, and it is akin to watching a lecture, but learning instead via a hands-on approach"). This was true, especially for subjects that students found too abstract or too difficult to understand ("Overall I do believe interactive, and visual, experiences are the best way to learn something, especially more complex topics. The whole process of designing these tools requires that the complex processes or topics they represent to be simplified and abstracted"). The game-based learning activities also helped students store concepts in memory more efficiently than other learning activities. According to students, it was easier for them to commit certain information to memory by recalling the experience they had with the game-like activities especially if these were fun and with compelling visuals ("The games are pretty engaging and more fun, makes me better when it comes to remembering some stuff", "I found the activity useful to help remember the concepts. Just reading things in a book makes them hard to remember. Actually doing them makes it easier").

4.1.2 Allow students to take on identities and learn from different angles and perspectives. This theme presents two sub-themes: "Give students an alternative point-of-view" and "Story-based mechanics and customisation to increase immersion and the identity principle". Students found the game-based learning activities to be an interesting approach that can teach them in a way that other activities in the online degree could not. Students emphasised the fact that they could take on identities and learn a particular subject from a unique perspective: the perspective of the system they were trying to learn ("Your game surely is an amazing idea. Where we understand CPU by.... being a CPU. This is genius", "It helped visualize the process of sorting, and by doing so allows a different perspective on the learning material"). Students felt immersed in the game-based learning experiences and suggested both story-based mechanics and customisation to maintain immersion and engagement ("For education, I think the emphasis is not on adrenaline, or tension, but more based on simulation or being able to immerse oneself into the experience, for example, the character can be turning the gates on a logic circuit", "Educational games ought to have more interactivity, every single aspect of the game ought to be customizable, so that experiments with whatever you're learning with becomes possible").

4.1.3 Balanced challenge and context relevance to minimise students wasting their time. This theme presents four sub-themes: "Games to have quick onboarding and to be easy to pick up and learn at first", "Progressively challenging tasks to address a diverse skillset of learners", "Tasks to be less linear and leave some space for exploration" and "Games to not just scratch the surface but to go deeper in a particular subject with clear and achievable goals". The biggest outcome of this theme is the fact that students required the game-like activities to have a balanced challenge. First, linking back to the idea of not wasting the learners' time, the activities should offer a quick on-boarding experience and be easy to understand at first ("The games are too complicated. The cognitive lift needed to understand how to interact with the game takes too much time"). Second, students found the game-based learning activities way too easy ("It wasn't hard to work out what to do, and I only did it once. Maybe if it had been more difficult somehow I would have come back to it"). They should instead offer progressively challenging tasks and leave some space for exploration by reducing linearity and promoting correct spacing out of objectives ("I didn't find it to be challenging as the instructions provided in the guide made the game rather linear in a sense that there was only 1 possible outcome to achieve", "Perhaps things like objectives/tasks could be implemented, rather than a step-by-step check to see if the user is correct, then only providing the user with a task after that condition has been met"). Finally, students would like to see game-based learning activities not to just scratch the surface of a particular subject but to unleash their full potential and go deeper into the teaching ("In general I would like to see them go a bit deeper into subjects being taught").

4.1.4 Reward players for their effort with meaningful rewards and provide a safe space for failure. This theme presents two sub-themes: "Avoid transactional rewards which might only lead to distraction" and "Include progress tracking/feedback to inform students on their completion/learning status". Students reported some interesting aspects about rewarding players. First, most of the game-based learning activities did not implement explicit rewards (e.g. points,

score) and this was not a concern for students. They were happy as long as they felt the activities were valuable to their learning ("I'm lucky to say that I tried multiple games and my rating reflects on all of them, I think they are built in a way to be engaging and I can totally assure that It did contribute to my learning"). Second, students who mentioned about the possibility to include rewards preferred not to have them if they led to distraction ("As long as rewards didn't affect the students negatively; like made some students feel self-conscious or left out if they don't succeed, or other students obsessively play to remain on the leader board and ignore their studies.") and suggested instead to consider adding features like progress tracking ("It would be cool to see continuity across the game activities and tracked progress").

4.2 Game-based learning technical and pedagogical design guidelines

With the results from the quantitative and qualitative analysis shown in the previous section, this paper suggests potential technical and pedagogical guidelines for game-based learning in contexts similar to the online BSc Computer Science degree. First of all, it is important to understand the audience and define the context in an attempt to gather preliminary information to best adapt game-based learning to students' needs. It is then important to define the type of intervention and design game-based learning activities with precise goals in mind. This is the equivalent of constructive alignment in pedagogy. Also, consider the use of game-based learning as hands-on complementary material to passive activities such as lectures or readings, especially for topics that are usually hard or abstract to teach. This is the equivalent of constructivism in pedagogy. Avoid wasting the learners' time by designing activities that are easy to use/learn at first. Then, make use of progressively challenging tasks with spaced-out objectives and reduced linearity. This is the equivalent of scaffolding and the spacing effect in pedagogy. When possible, add elements of narrative and identity takeover to increase the level of immersion and tackle the learning material from different perspectives. Remember to reward your learners with meaningful prices and safely punish them for mistakes to maintain a low-consequence experience. Finally, there is nothing wrong if students have fun with game-based learning as long as it does not distract and it is a consequence of learning rather than the primary objective.

5 CONCLUSIONS AND FUTURE WORK

In the introduction, the paper enumerated three intended contributions. First, in carrying out a qualitative approach using Reflexive Thematic Analysis, the obtained results highlighted four themes that go beyond motivation and engagement and may inform future designers of game-based learning in a similar learning environment: *Complementary to lectures on topics that are usually hard or too abstract to teach. Allow students to take on identities and learn from different angles and perspectives. Balanced challenge and context relevance to minimise students wasting their time. Reward players for their effort with meaningful rewards and provide a safe space for failure.* Second, it suggested the following game-based learning and pedagogical guidelines for designers and educators who wish to incorporate game-based learning in a similar context: *Define the context and understand your audience. Define precise goals/interventions (constructive alignment) and avoid just exploration. Consider game-based learning as hands-on complementary material to lectures for hard topics (constructivism). Do not waste the learners' time: design with the right context and easy-to-use/learn games at first. Make use of progressively challenging tasks with spaced-out objectives and reduced linearity (scaffolding and spacing effect). Include elements of narrative and identity to tackle topics from different angles and improve immersion. Rewarding for effort with meaningful prices/progress tracking and safely punishing for failure. Fun is ok as long as it is not distracting and a consequence of learning rather than the primary objective.* Third, the paper offered a selection of open-source and browser-based game-based learning activities. With the study limitations in mind, the fact that students were asked to fill in the online survey several months after they tried the activities or the fact that the qualitative analysis was not further validated with methods like "member checking", this paper invites future educators and designers to consider a similar design/evaluation approach and perhaps expand on this work. In future work, we are planning to incorporate these insightful findings into the existing game-based learning activities in the online BSc Computer Science degree.

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