Improving serious games by crowdsourcing feedback from the STEAM online gaming community

Moro, Christian; Phelps, Charlotte; Birt, James R.

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Improving Serious Games by Crowdsourcing Feedback from the Steam Online Gaming Community

Abstract

The inclusion of game-based learning in tertiary institutions is increasing as educators seek ways to enhance student engagement and motivation. Through the development process of gaming resources, educators need feedback to ensure a quality learning experience. In many cases, however, this feedback is generally received from students at the end of the subject or course and is often regulated centrally. Another way of garnering feedback and capturing player analytics could be to capitalize on the millions of global gamers. A game developed for use in a Health Science and Medicine program, *The King's Request: Physiology and Anatomy Revision Game*, was made freely available on the Steam platform. Over 16,000 Steam users engaged with the game over 12 months, with 150 providing written reviews. In contrast, a cohort of 100 first-year health science and medical students were requested to review the game after playing in class, with only 17 providing written feedback. In reviewing the feedback, similarities were found between the groups, such as where both Steam community players and in-class students requested more questions and a longer game. However, the Steam community highlighted several unique aspects which could be used to improve the game for learning, such as a refined implementation of the incentive system. As the online gaming community is far larger than students enrolled in any tertiary subject, its expansive feedback can be used to accelerate the design and refinement of serious games. This wealth of feedback could provide unique insights for educators wishing to improve the provision of games in education and the overall learning experience.

Keywords: Learning games; Educational Games; Gamification; Video Games; Medical Education; Health.

1. Introduction

There is growing interest in game-based approaches to enhance student learning (Subhash & Cudney, 2018). Generally, games are provided largely for fun and entertainment, but games can also be used for learning. This use of serious games (Blumberg et al., 2013), where the primary purpose is pedagogical (Arnab et al., 2015), has provided educators with innovative ways to engage students in their subject or course (Krath et al., 2021). When used purposefully, serious games can improve knowledge acquisition, content mastery, and student motivation, providing clear incentives for educators to embed them in the curriculum (Moro, Stromberga, et al., 2020). It is not surprising then that in health sciences and medical education, there has been a steady increase in the design, development, and implementation of serious games (Maheu-Cadotte et al., 2021).

After the initial inclusion of a game in a course or subject, educators generally require feedback to refine and enhance the game for future cohorts (Keogh et al., 2021; Van Gaalen et al., 2022). This information can then be used to assess and evaluate the user experience and inform improvements for future game iterations (Moizer et al., 2019). Feedback from students enrolled in the subject generally comes from subject or course evaluations, which may be of variable quality and often have a poor response rate (Steinmetz et al., 2020). Opportunities exist to canvas a wider audience, such as the international gaming community, to provide feedback during beta testing and early game development.

Globally, there are over three billion gamers, with an annual ± 5.4% player growth (Newzoo, 2021). It therefore makes sense to 'test' a design using this wider gaming community. A platform that could be used for testing prototypes is Steam (Valve Incorporated, Bellevue, Washington, US), which is a video game digital distribution service and storefront. Steam has

over 120 million monthly active gamers, and provides features that allow users to rate, review and provide feedback regarding games to developers and other players. The annual player growth is likely to continue as gaming becomes more accessible through mobile devices and portable platforms such as Steam Deck, translating into an ever-increasing number of potential global gamers to provide feedback.

There is, however, a downside to soliciting open and anonymous feedback. The online gaming community can be 'toxic', 'without diversity', and 'misogynous', with members hiding behind their anonymous usernames and avatars (Paul, 2018). For educators seeking feedback during the design phase of their serious games, the value of this wider global gaming community is not known. We decided to 'test the waters' by making a game developed for students in a Health Sciences and Medicine program (*The King's Request: Physiology and Anatomy Revision Game*, Figure 1) freely available on the Steam platform, enabling community players to rate the game and provide written reviews.

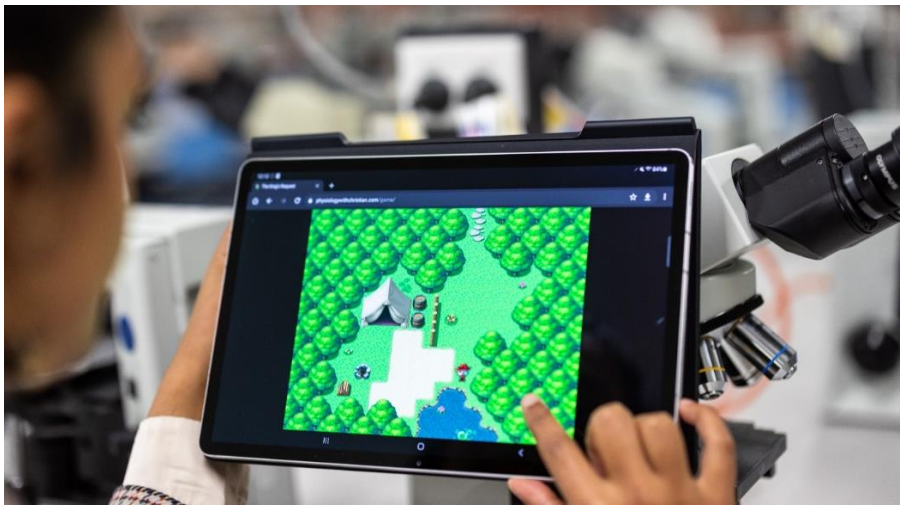

Figure 1: A student plays *The King's Request: Physiology and Anatomy Revision Game* in a Health Sciences and Medicine laboratory session.

1.1. Evaluating serious games

Educational game use is growing across many disciplines, with science, technology, engineering, and mathematics being the most popular subjects for implementation (Boyle et al., 2016). Not all serious games or educational games are, however, effective for supporting engagement and improving learning outcomes, especially in the field of health education (Maheu-Cadotte et al., 2021). Serious game development should be progressed carefully, with educators considering whether they wish to implement components to induce affective outcomes, motivational outcomes, or both (Krath et al., 2021). In addition, the development can be guided by literature, such as the identification of core elements of well-designed games, which include enabling ongoing interactions between the player and the game, setting specific goals, providing ongoing feedback, and increasing player engagement through uncertainty (Shute & Ke, 2012).

To evaluate the developmental choices taken within a game, a variety of structured approaches can be taken. Of particular interest is the Hunicke et al. (2004) Mechanics, Dynamics, and Aesthetics (MDA) framework. This framework provides a formal approach to understanding and presenting game design in the literature. Specifically, the *Mechanics* describes the game rules; the *Dynamics* describes the behavior of the mechanics acting on players' inputs and outputs over time; and the *Aesthetics* (such as Sensation, Fantasy, Challenge, Expression and Discovery) outlines elements that can induce emotional responses by players as they interact with the game (Hunicke et al., 2004). By understanding this framework, an educational designer can map the educational experience to the mechanics, dynamics, and aesthetics, leading to enhanced emotional responses as the learner interacts over time (Kusuma et al., 2018). This is important when evaluating and designing serious games as effectively implementing aspects stimulating emotion, learning, and play can

enhance the overall effectiveness (Caserman et al., 2020). Although there is criticism of MDA for its mechanics-centric approach, it still remains a successful method for analyzing game design (Argasinski & Wegrzyn, 2019).

1.2. Crowdsourcing feedback

Games, like any software, should go through multiple iterations of design following a user-centered design process (Moizer, et al., 2019). User experience (UX) is essential when designing digital games and determines user acceptability. Given the increased application of games for educational purposes, sound UX can be considered a determinant of user learning (Fromm et al., 2021). When designing games, or gamified elements for teaching, educators are often limited to receiving feedback solely from students directly enrolled within their courses (Moro, Phelps, et al., 2020). This restricts the number of players who can genuinely provide feedback or assist in the development of future iterations and enhancements to the game itself.

Crowdsourcing is the practice of obtaining needed services, ideas, or content by soliciting contributions from a large group of people, especially from the online community rather than from traditional employees or suppliers (Merriam-Webster, 2021). In health science and medical education, crowdsourcing has been emphasized as having the potential to enhance teaching across disciplines such as radiography (St John-Matthews et al., 2019). From this review, the literature highlighted the potential for crowdsourcing to facilitate the development of a national bank of teaching materials, or to enhance the quality and number of examination questions. Crowdsourcing has also been an effective way for students to create a variety of study materials, such as shareable flashcards, with some evidence to suggest that this process can benefit exam performance (Bow et al., 2013). Furthermore, crowdsourcing has assisted to

engage clinicians in the creation and curation of medical education resources across a broader range of fields, rather than solely in their specialty (Chan et al., 2015). As a result, crowdsourcing is increasingly being adopted in science and health professional education courses, with its incorporation well-received by students and faculty (St John-Matthews et al., 2019).

1.3. Theoretical rationale and conceptual framework underlying this study

It is important for educators to reflect upon their practice and consider evaluation feedback from learners to enhance and improve teaching practices. For educators incorporating games, hearing from players regarding their perceptions of this resource can provide insights and stimulate improvements for future iterations and updates (Huang et al., 2013). The use of students as informants for redesigning learning materials is becoming more commonplace worldwide (Reed, 2005). Educators can individually request written feedback from their students, although this often results in low response rates (Steinmetz et al., 2020), or is restricted to those solely enrolled in their classes, which may provide very low sample sizes in smaller subjects, as well as introduce bias. One additional avenue of feedback, formal instructor evaluations provided by the university, tend to assess semester-wide considerations (Khoza, 2018). As such, these subject-wide evaluations can help to provide overall feedback and stimulate instructor self-reflection (Khoza, 2018), but may not provide a suitable resource to relay a learner's perception towards a discrete learning intervention, such as the introduction of a specific educational game.

The concept of reflection, anchored in the works of Dewey (1986) and Schon (1983), remains a central focus within educator professional development programs. When attempting to enhance the learning experience of a developed resource, educators can benefit from

reflecting upon advice and suggestions for improvement received from both students and faculty (Hadad et al., 2020; Moro et al., 2021; Singh et al., 2019). As formal university evaluations assess content over an entire semester, and in-class students may not be prompted or willing to provide written opinions for individual resources, crowdsourcing may present a suitable method for the receipt of feedback (Hilton & Azzam, 2019). Reviews from the Steam community certainly assist when games undergo open development during the alpha and beta testing phases (Gandolfi, 2018). However, there is no evidence to assess whether feedback from an online cohort of gamers would be as valuable or helpful as individual responses received directly from in-class students within a subject.

This study aimed to identify the effectiveness of crowdsourcing feedback from the Steam gaming community, selected due to its scale, accessibility, and game-hosting options. Review text provided on the Steam platform was compared to feedback received from an in-class cohort of students regarding a game developed to enhance the revision of introductory physiology and anatomy content within a health sciences and medicine program. The study was guided by the research question, *"due to the limited number of responses received from enrolled students, which aspects of crowdsourced reviews from the online gaming community provide constructive feedback for educators when designing and implementing serious games?"*.

2. Materials and method

2.1. Narrative description

The King's Request: Physiology and Anatomy Revision Game is set within the "role-playing game (RPG)" genre (Figure 2). Its intent was to quiz and consolidate students' knowledge acquisition in general first-year physiology and anatomy discipline themes (for example,

muscle contraction, electrolytes, organ systems, brain structure, and function). The storyline followed the hero (player) who, upon waking from sleep, was greeted by an adventurer seeking their help. The adventurer directed the hero toward the King's castle to take on a quest.

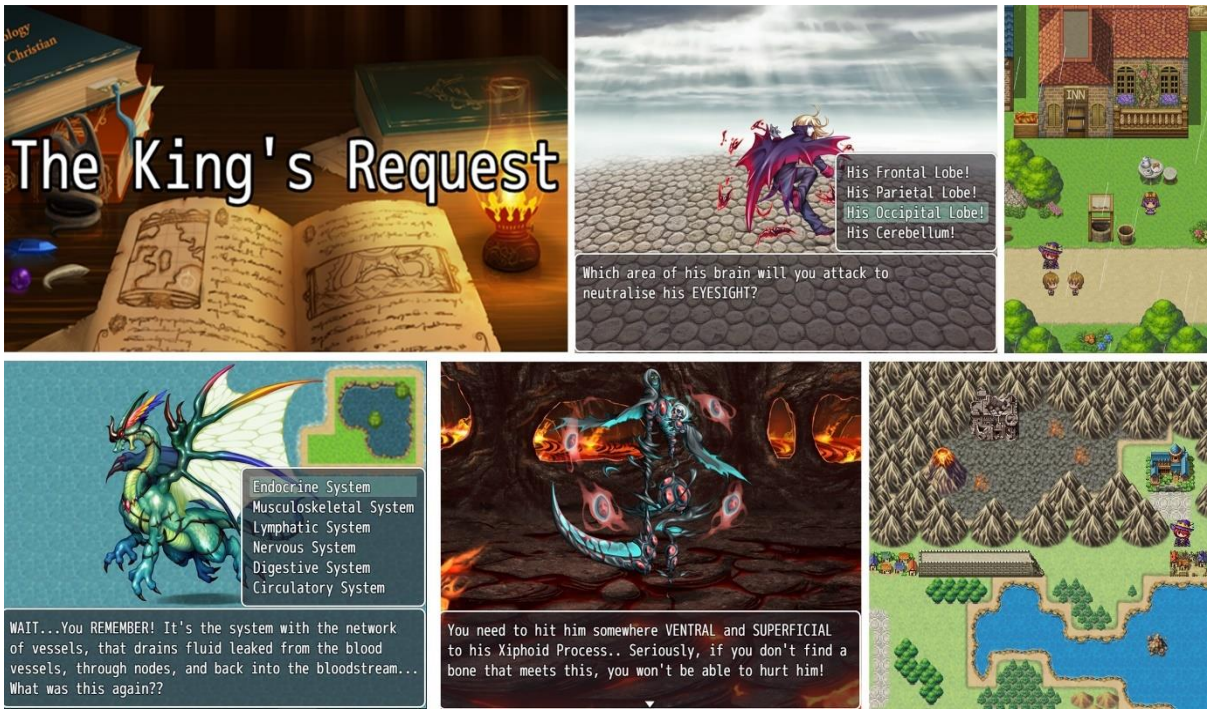

Figure 2: Screenshots from *The King's Request: Physiology and Anatomy Revision Game*. Each region of the map contains a variety of enemies, different questions to answer, and areas to explore.

Nearly every peripheral object in the game (for example, people, trees, and houses) was interactable by mouse-clicking the object or pressing enter on the keyboard. Interactions could spawn a secret boss, provide additional gold for the player, or teleport the user to a secret area. However, most interactions simply contained a witty comment or anecdote (i.e., *the stone emits a light hum, so you move closer and listen more carefully. It appears to be playing 'rock music'*). This encouraged exploration and provided an incentive beyond the

goal of progressing and answering formal questions. In nearly all cases, successful interactions were also coupled with music, animations, or sound cues.

After meeting with the King and Queen, the player was tasked with clearing enemies around the castle. While walking across the map, at certain points the player encountered enemies, which were full-screen battles. Each enemy had a weak point and could only be conquered when a physiology or anatomy-related question was answered. For example, the vampire could be defeated by damaging its eyesight, so the associated question was "*Which area of his brain will you attack to neutralize his eyesight*?". The player was then directed to impact the region of the brain responsible for vision (the occipital lobe). When this occurred, after a cutscene animation played with some additional information on the content underlying the question, the screen returned to the top-down map and the player could continue their journey. After a wrong answer, the player was told why that was incorrect, and the game reset to offer the multiple-choice options again. In this way, there were no penalties for incorrect answers.

At the conclusion of the game, the King and Queen rewarded the hero during a short animation while closing music played and the screen faded to black. The timing of the game aimed to have players reach the end by around 20-30 minutes so it could be played in-class during practical workshops if desired. There were 20 core questions included in the main questline, with an additional 10 questions that could be found if the user explored off-the-path, clicked on hidden objects, or solved small puzzles throughout. Hints of where to find secret enemies and hidden areas were provided by speaking to the King, Queen, Princess, and Palace Guards at the very end of the game, encouraging players to pursue subsequent playthroughs after their first completion.

2.2. Study setting and design

The King's Request: Physiology and Anatomy Revision Game, was created and developed by the primary author (CM) and made available on Steam (store.steampowered.com, Bellevue, WA, US). Through the Steam platform, the gaming community were able to provide feedback in the form of written reviews. Over Steam, versions of the game were available for community users on Windows, Mac, and Linux systems, with most users playing on the Microsoft Windows 10 64-bit platform. The game was also provided in-class to a cohort of first-year students enrolled in a Health Science and Medicine subject at an Australian university. A total of 100 in-class student participants from the university cohort played the game using a laptop and provided feedback in the form of written reviews using an anonymous online Qualtrics (Qualtrics XM, Provo, UT) survey. For enrolled students, after the session had been completed and the survey conducted, a link to the full game was emailed out for students to play at home as many times as they wished during their course revision. Ethics was approved by the University's Human Ethics Committee and approval to use review text from the Steam platform for this research purpose was granted by Valve L.L.C. (Bellevue, Washington, US).

2.3. Development of the application

The development of the game involved the integration of the online software platforms RPG Maker, Unity3D, and GameMaker Studio. The asset packs (backgrounds, houses, characters, music and sound effects) were procured directly from publishers (i.e., within RPG Maker Pro, or via the YoYo Games Marketplace) and combined into an interactive world for players to explore. Care was taken to use mechanics in a way that encouraged the player to progress through provided questions. For example, only after answering the question correctly could

the player continue to the next area or enemy. The resource of ‘gold’ was incorporated as an attractive ‘collectible’ incentive and could be found by interaction with various objects around each map. This aimed to encourage exploration and could be spent in the in-game store (the tavern) for fun novelty items such as hats, as well as to purchase drinks or snacks (to spawn small drinking or eating animations). The dynamics were kept relatively simple, where the user would use the keyboard’s arrow keys and mouse to move around and interact with objects. For aesthetic considerations, to allow the user to feel like they were progressing through the game, the maps help tell the story and set the scene for the upcoming enemy types. The maps included grassy plains, forests, campgrounds, villages, the university, a fortress, the beachside, the ocean, islands, and an underground cavern. The game ended by returning to the King’s castle. The graphics and sound depicted classic RPGs in keeping with the design of the game.

2.4. Development and validation of the questions within the game

A process was undertaken to develop and validate the physiology and anatomy questions implemented throughout the serious game. An expert committee of five Health Science and Medicine qualified academics was established to evaluate the validity of the questions. This committee assessed each question based on its relevance, clarity, format, simplicity, comprehensibility, and grammatical construction. During development, the game was piloted by 20 health science and medical students before its final updated version was compiled and released over the Steam platform or dispersed to the in-class students.

2.5. Data collection

Data collected from reviewers on the Steam platform were collated from the *Customer Reviews* section and included length of playtime, recommendation status, and written

comments. All data remained anonymous and was imported from Steam into nVivo v12 (qsrinternational.com, Vic, Aus) for analysis. The data collection process for the in-class university students included responding to open-ended questions on the online survey tool Qualtrics, provided immediately after completing the game. All data collected was anonymous and imported into Excel v16 (Microsoft Corporation, Washington, US) for thematic processing and analysis. A committee of six academics with experience teaching first-year university students was established to evaluate the face value of the survey questions. This committee assessed each survey item, with five randomly selected participants undergoing a pilot study on the proposed questions. The final survey questions included:

- *Do you think this was a beneficial revision tool for your personal learning?;*
- *Please describe any features that you found useful while using the learning tool?;*
- *How would you like us to improve the game to make it a more effective learning tool in the future?;* and
- *Please provide any other comments that you would like to make*.

2.6. Data analysis

The Braun and Clarke (2006) six-phase qualitative analysis framework was applied to identify emerging themes from participants' written responses. Thematic inductive content analysis was undertaken based on the recommended stages, which followed: 1) familiarization with data; 2) initial codes generated; 3) themes identified; 4) themes reviewed; 5) themes defined; and 6) analysis written. Thematic analysis was completed manually, as per this framework. Specifically, in this study, the first stage involved two researchers (CM, CP) who thoroughly read through the community and student responses. In the second stage, initial codes were generated from the responses from 150 Steam community players and 17

in-class students by writing a 1-2-word summary code, based on the overall point made. The second author initially coded the data, which were then evaluated by the first and third authors. In the third stage, tentative themes were created by a more thorough analysis of participant responses and collation of codes. The potential themes were then reviewed and refined into a final set of themes with clearly defined names. In the final stage, the most representative examples for each theme were included in the final qualitative analysis for the write-up.

3. Results

3.1. Participants

A total of 31,302 Steam users added the game to their library, with 16,394 downloading, launching, and playing it. From these users, 150 players contributed written reviews over Steam, with an average playtime of 36 ± 20 minutes (mean ± standard deviation). Overall, 93% of the reviews were positive, with players stating "recommended" on the Steam platform. Most players were from North America (38.1%), Western Europe (20.0%) and Latin America (9.8%), with the remaining users downloading and playing the game from over 150 countries. Of the total 100 in-class health science and medical students enrolled in the study, 17 provided written reviews for data analysis. The average playtime for in-class students was 20 minutes. Percentages described within the results section of this study relate to the number of participants commenting (n = 150 for community players, n = 17 for in-class students). It was not recorded how far each of the participants progressed in the game, or whether they repeated a playthrough multiple times, as ethical approvals were not sought for the collection of individual in-game analytics. This was due to the regulations of the distribution platform and data retention requirements.

3.2. Feedback Analytics

The response rates were relatively low for both cohorts, with 1% of players from the Steam community and 11% from the in-class group providing written feedback. Of these, the Steam community provided an average of 47 words per participant reviewer, and the in-class group provided comments with an average of 10 words per written review.

3.3. Thematic analysis

Three overarching themes were identified in relation to community and student user perceptions of playing the adventure game *The King's Request: Physiology and Anatomy Revision Game*. The themes that emerged from the data recorded by participants (P) in this study included: (1) game design, (2) learning, and (3) user experience. A summary of the themes and the corresponding codes which emerged from the thematic analysis of written responses is displayed in Table 1 and the frequency of relevant comments and reviews associated with each theme summarized in Figure 3.

Table 1: Summary of codes and corresponding themes that emerged from thematic analysis of the participant reviews.

Theme	**Code**
Game design	Mechanics/dynamics/aesthetics
	Length of game
	Accessibility
Learning	Knowledge acquisition
	Knowledge consolidation
	Complexity of questions
User experience	Entertainment
	Consequences

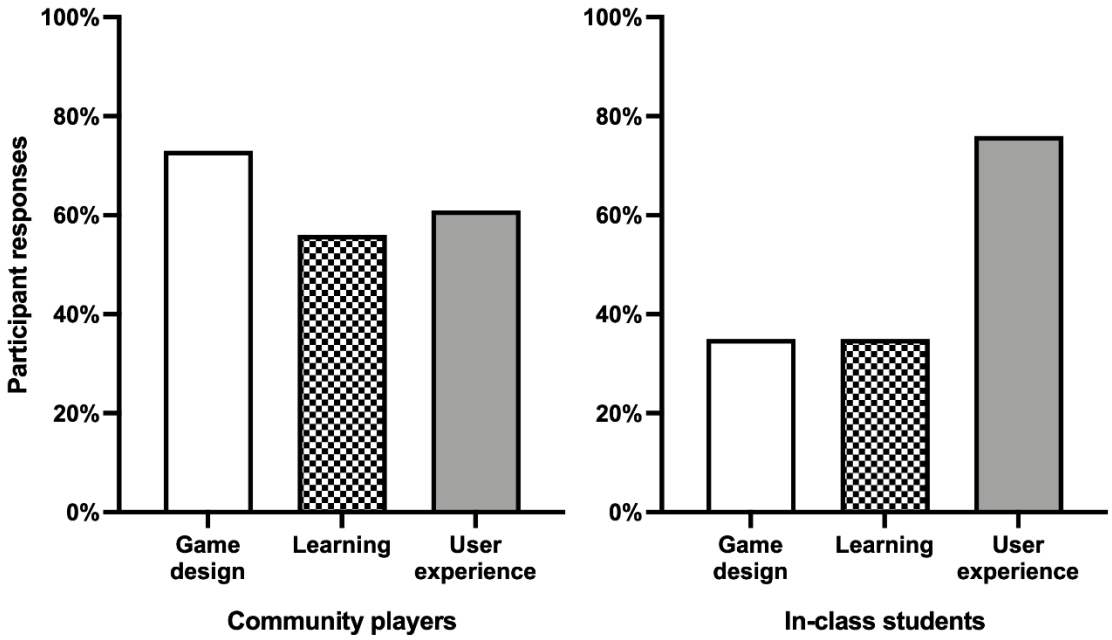

Figure 3: Comparison of the percentage frequency that themes appeared from reviews of the serious game by the community player and in-class student cohorts.

3.3.1. Game design

The Steam community highly valued the game design: 'mechanics, dynamics, and aesthetics' (44%), short length of the game (44%), and accessibility (10%). The Steam community players also correctly identified the game as a role-playing game (RPG) and were aware that it incorporated physiology and anatomy quizzes.

Several components of the game were specifically recognized, including discovery, challenge, and fantasy. One user, although recommending the game, suggested a greater emphasis on a unique narrative: "*the game doesn't have much story in it – it's the regular "become a hero and save the princess" story"* (P7). The game required the user to navigate their way through the town, interact with characters and different environments, and answer physiology and anatomy related questions to progress. There was limited text allocated to the

story development, outside of the main quest to save the kingdom and report back to the king and queen.

The Steam community players made frequent comments related to the interactivity of objects and characters in the town (21%). There was emphasis on the dialogue encountered throughout, described as "*simultaneously clever and silly*" (P18). The RPG game format allowed users to explore different environments and objects as they progressed, although 11% of Steam reviewers commented on a degree of uncertainty as to whether they had interacted with everything available or experienced the game in its entirety. There was also a common confusion as to the purpose of the gold collected. Some users mentioned they used gold to buy food or cosmetic items (e.g., hats, colored shirts), while others did not use their gold at all. In seven cases, community players commented on a perceived lack of purpose for the gold system (5%), and the feeling that this did not provide any additional reward. Although the in-class students did not comment on the interactivity with objects and characters, one participant did highlight that the quizzes throughout made the game "*interactive since you have to answer questions"* (P6).

In terms of the mechanics of the game, no errors were experienced throughout. The Steam community users valued the aesthetically pleasing environments, quality graphics, and the music. One point of feedback on the mechanics was made:

> *"…some dialogue sections have no sleep encoding, which means it loads the dialogue and then only shows for a millisecond. Before loading the next dialogue screen"* (P102).

The length of the game was a focus point for a number of Steam community players (44%). All comments of this nature provided feedback that the game was too short, did not contain enough content, and was more of a demonstration rather than a full-length game. Although most users "*had fun playing it while it lasted"* (P48), one player commented "*it's short, so if you decide you don't like it, it isn't too long enough to be considered a waste of time"* (P9). Though based on this, recurrent feedback that was provided revealed that community users thoroughly enjoyed the game and in the future were "*happy to pay for a lengthier, more complete, and possible sequel"* (P38) to the game. Whilst the in-class health science and medicine student users did not mention the length of gameplay, they emphasized the game could incorporate more questions as the main point of feedback (18%).

The accessibility of the game was highly commended by several community players (10%), as it was easy to access and free to play. This meant that those who were not satisfied with the game (7%) were not financially impacted. However, for some community players, English was not their primary language, thus reducing the accessibility of the game for these players as it is not accessible in another language. Although on a positive note, some of the non-English speaking users used a dictionary and commented they "*took the opportunity to learn more words"* (P121). The accessibility of the game was a feature also valued by the in-class student users, who commented on the convenience of accessing the game at home as an additional study tool.

3.3.2. Learning

Learning was a key theme identified by both the Steam community players and in-class health science medicine student users in their feedback. Under this theme, the codes of knowledge acquisition, knowledge consolidation, and complexity of questions arose.

Although difficult to measure actual learning, as data was not available on the number of game completions or errors made when answering questions, insights can still be gained from player feedback. In particular, the Steam community perceived the game to be educational and to provide interesting information for learning anatomy and physiology (23%). The game was reported to be a "*great educational resource"* (P32) and a "*cool concept for teaching anatomy"* (P42). One feature of the game mentioned to be useful for learning was the explanation provided upon answering a question incorrectly:

> "*…the explanation when you get the answer wrong is good enough for someone like me who has no knowledge on the field to understand"* (P7).

The consolidation of knowledge was also a recurring statement that appeared in community reviews (22%), which detailed the game as a suitable way to review knowledge, refresh memory of anatomy/physiology topics, and a useful tool to use during study. Some community players revealed they found the game particularly useful as it aligned with their professional field, such as a nurse, doctor, medical student, and teacher (6%):

> *"As a medical student I've been looking forward to this for so long!"* (P10).

Some of the community players also remarked that the game was not useful for learning if they did not have prior physiology or anatomy knowledge (19%), and this required them to research the answers or "*guess [their] way through"* (P78). Based on this, six (4%) of the community players recommended that it would have been beneficial to have information taught throughout the progression of the game prior to answering questions.

The in-class health science and medical student users particularly valued the game as a revision tool (35%), with some highlighting that they "*did find it beneficial by putting information into play"* (P24) and that "*by answering questions along the way it makes it easier to cement my learning"* (P22).

Under the emerging theme of learning, the nature of the questions in the game received varied responses from the community players. This appeared to be highly dependent on the users' prior knowledge of physiology and anatomy content. A trend that appeared was that those who mentioned they had a health science or medical background (8%) found the questions were relatively basic and easy to answer:

> *"For me this game was easy, but I'm a nurse"* (P15).

However, for those community players lacking prior physiology and anatomy knowledge, the questions were perceived to be challenging on a more frequent basis (15%). One reviewer commented:

> *"…you need to know a lot of medical terms to understand and answer the questions"* (P7).

The difficult nature of the questions provided a mental challenge that was appreciated on rare occasion by the community players (3%). However, for others, the questions were *too specific* (P47), advanced, or reported to be "*too intellectual for some players"* (P26). This led to some of the users having to "*click all those 'answer options' until [they] got to the last one"* (P73). One recommendation was to include a feature where the user could choose their level of physiology and anatomy knowledge to cater the difficulty of the questions and personalize the experience:

"It would be nice if there was an option to input your level of knowledge (for scaling question difficulty to you)" (P66).

3.3.3. User experiences

Analysis of the community player and in-class student written comments after playing *The King's Request: Physiology and Anatomy Revision Game* provided insight into what concepts underlying the user's experience were valued. Overall, the majority of community players (93%) perceived the game to be an entertaining and fun experience and would recommend it to others.

The community players highlighted that part of the fun experience stemmed from the game being *cute* and *adorable* based on the graphics, dialogue, and interactions throughout (51%). One user also mentioned the game to be "*really novel and a great concept"* (P65) of incorporating an RPG with quizzing. This was further corroborated by another comment that emphasized "*education can be turned into something fun"* (P86). The in-class health science and medical student users also highly valued the entertaining nature of the game (76%), describing it as a "*funny, upbeat way to learn"* (P22) and reporting that the "*game was brilliant"* (P12).

Within the game, when users answered a question incorrectly, they were not penalized and were provided with unlimited attempts to answer correctly. The community players made particular emphasis on this feature and presented it as a downfall to the overall user experience. The majority of community users were noticeably disappointed that there were no consequences for answering incorrectly (8%). One user commented:

"…the fact that you do not lose or risk anything by answering wrong diminishes the reward of answering correctly" (P42).

A player from the community also suggested that if the game incorporated negative consequences for answering incorrectly and positive consequences for answering correctly, this would "*discourage randomly guessing and enhance the use of the game as a study tool"* (P118). One community player also commented they would have favored a score at the end of the game.

4. Discussion

4.1. General findings

Overall, the limitation of solely seeking feedback from an in-class face-to-face cohort of students was highlighted, with the receipt of only 17 written forms submitted (17% of the player cohort). Alternatively, although most of the community players did not provide written responses, the international cohort was so large that in the end, the receipt of 150 individual comments (1% of the player cohort), alongside overall recommendations, was highly beneficial. This demonstrates that regardless of the community, it may be a challenge to receive written feedback from players of serious games, making the size of the player-base a key factor. In this way, the online player community, through platforms such as Steam, has presented an excellent avenue for educators seeking to improve their games and educational interventions.

A key finding from this study was that community reviews consistently requested an increased complexity for the questions provided. This is commensurate with the literature, where there is increased enjoyment from games that present considerable challenges to

overcome (Gee, 2003), or when a game is developed to adapt and balance difficulty levels to match players' abilities (Shute & Ke, 2012). One surprise regularly featured within the Steam community reviews was the request to incorporate consequences for incorrect answers. In the current game, there was feedback provided as to why an answer was wrong, but no actual penalty other than the user having to answer it again. There is some evidence that penalties may decrease learning and interest (Easterday & Jo, 2013), and so although this appears to be a valid request, more care should be taken before implementing such a design element into the game.

Gold was provided as an incentive system that could be spent at the in-game store for novelty and vanity items. There are a range of benefits for incentive systems of this nature, such as enhancing the player's sense of autonomy, and allowing a break from the gameplay experience (Rahimi et al., 2021). In *The King's Request*, there was no mention of a store until halfway through the game, which may have been the catalyst for feedback received from the Steam community when players highlighted a broad confusion surrounding the point of finding gold. Perhaps a more formal introduction of this incentive system, and the associated purchases (such as having an opportunity to visit the store earlier in the game), would result in players 'seeking out' gold as a potentially exciting pursuit and enhancing its role as an in-game incentive. As such, this provides an additional example of where the feedback from the crowdsourced gaming community would become quite useful towards identifying game design elements for improvement in future iterations of the game.

Although the title of the game was *The King's Request: Physiology and Anatomy Revision Game*, many players from the community appeared to be unaware of the game's focus on revision and knowledge consolidation. Instead, they expected a tool that could help them

acquire new knowledge in this field. The game's questions were designed for students who had already completed the course content, assessing their knowledge through formative quizzing. As the provision of the game can be scheduled in-class at a suitable time of the semester, the practice of embedding helpful formative assessments within would likely be well-received by enrolled students (Shute et al., 2009). However, the Steam community engaging with the game held a wide variety of educational backgrounds, and many would not have learnt the content prior. As such, it was not surprising to read several community reviews commenting that it was not conducive to their knowledge acquisition. As in-class students were currently learning the content, the direct relevance of the questions and content within the game may have provided an enhanced experience compared to the Steam community players (Malau-Aduli et al., 2013). As a reflection game, based on taught course content, it is feasible that an in-class cohort would provide better feedback on the learning aspects, while the online gamers would provide better feedback on the game design and user experience. The implication is that before acting on feedback received, and throughout its evaluation, educators should consider the source of the feedback and the nature of the community that provided it.

4.2. Improving serious games with player feedback

The percentage of responders to players remained relatively low across both the in-class and Steam community groups. This was commensurate with literature, demonstrating that low student response rates are common across the tertiary sector (Dey, 1997; Luo, 2020). However, the sheer size of the gaming community through the Steam platform means that far more responses can be received than the limited student numbers which would be currently enrolled within an educator's subject. In addition, the average feedback was at a length of 47 words per reviewer from the Steam community, but only 10 words from each of the in-class

members. This could be potentially due to the Steam community being well-versed and more experienced in games and thus potentially more motivated to improve the outcome of the game.

As educators, the receipt of feedback from both the Steam community and in-class students was highly valuable for the consideration of future updates and additions to the game. When delivering information, there is often concern that the volume of content presented (Jordan et al., 2020), and the length students are requested to engage with specific content (Bradbury, 2016), needs to be balanced for effective learning to occur. There was no mention of the game's length from in-class players, however, 44% of Steam reviewers requested a longer game. This may have been due to the fact that Steam players could be used to playing longer games and thus expect more. Potentially, the interactive delivery and self-paced progression of games of this nature might make them less likely to overwhelm students. As such, extending revisions of the game to go for longer (currently around 25 minutes), could present some benefit and allow for more interactions. The consideration of developing the game to be longer was not an idea that would have arisen out of the current literature, nor from reviewing the in-class student feedback, presenting it as a beneficial insight provided from the Steam community.

From the Steam community reviewer feedback, the focus on a 'revision' game was not necessarily appreciated. To address this, future iterations of this game could provide links to external sites or embed additional text within the game so knowledge acquisition can occur (Bedwell et al., 2012; Sailer & Homner, 2020). However, before acting on the provided recommendation, some considerations should be made. As the purpose of the serious game was to engage enrolled students in relevant revision activities, this might be an area where the

Steam community comments are less relevant than those from in-class participants. When crowdsourcing feedback, and before acting on the Steam community's recommendations, it is prudent to keep the intent and targeted population of the serious game in mind.

An additional consideration arose from feedback requesting varying levels of difficulty. Well-designed serious games do provide a feature of adaptive difficulty sliders, where students can be introduced to more challenging or simpler questions based on their ability (Shute & Ke, 2012). As such, it is likely that an adaptive difficulty feature could present some benefits to engagement (Hendrix et al., 2019). However, to properly include this would require a range of considerations (Andrade et al., 2005; Hunicke, 2005), as poor implementation of dynamic difficulty adjustments may result in negative player experiences (Zohaib, 2018). The current game was a one-size-fits-all approach (Orji et al., 2014), meaning that both novices and players well-versed in the content received the same experience. Nonetheless, as 15% of responders requested easier questions, and 3% requested greater difficulty, highlights the variety of background knowledge and experiences from players. Based on this helpful feedback, incorporating 'levels' of difficulty throughout, with the aim to enhance learning performance (Nebel et al., 2020), will certainly be a consideration for future updates of the game.

Although this study assessed self-reported user experiences through an inductive thematic analysis of the written feedback (Braun & Clarke, 2006), it was not clear if any measurable learning occurred (Baki et al., 2018). Learning technologies are designed to facilitate meaningful interaction (Kaptelinin & Nardi, 2018), and in the absence of embedded learning analytics it is difficult to quantify the learning outcome. While grouping one of the themes under the MDA framework provided insights into participant perceptions of game design, the

themes for learning (knowledge acquisition, knowledge consolidation, and complexity of questions) were relatively stand-alone. For an assessment of the game's effectiveness for learning, further considerations would need to be evaluated. This could be in the form of pre-post testing, within groups experimental design, embedded data analytics, or through using a framework to evaluate the game itself. For example, assessing aspects of the User Experience Design for Learning framework (Troop et al., 2020) can assist in evaluating and directing design in a way that engages and motivates students to learn, and the model of Learning Experience Design can support the development of interactive elements within the game (Tawfik et al., 2022). As such, future assessments of serious games could accompany feedback received from players with monitored interactions and an overall analysis of how users engage with the medium while playing. Attempting to link feedback received in this study to this literature does highlight one restriction from the Steam community's feedback. The fact that the Steam review platform is solely an open box for comments means that educational developers are not able to provide specific questions, or targeted queries to the players, as can be done when requesting feedback from in-class students. To achieve this, specific survey instruments would be required within the game, however, consideration would be required to avoid violating platform data privacy and acquisition rules.

In response to the research question, crowdsourced reviews from the Steam community can provide a large volume of written responses, extending the potential for the receipt of feedback beyond the limited number of students enrolled in an educator's subject. In particular, the online community provided particularly useful insights on the game design, while enrolled students were more focused on evaluating the specific benefits for learning. Although the Steam community can provide an additional avenue for the receipt of written feedback, it is recommended that educators consider both sources, and the nature of the

participants within, when evaluating what to change in future updates and iterations of their serious games.

4.3. Limitations and future directions

All reviews incorporated in this article were opt-in, with the provision of voluntary reviews. This means that there may have been bias in which types of gamers not only downloaded and played the game, but also provided written feedback. In addition, although relying on crowdsourcing can reduce the bias of those electing to participate in a study, there still remains the chance for bias of those choosing to leave a public comment regarding the game (Li et al., 2022). In particular, the Steam community would most likely be experienced gamers, making their enjoyment of games in general an underlying bias towards the highly positive overall feedback (93% positive approval ratings), with disregard to the actual learning obtained. An additional limitation to this study was the independent methods of obtaining feedback from the two cohorts. The Steam community provided a voluntary open-ended review, whereas the in-class users were prompted with open-ended survey questions, which could result in different outcomes. Lastly, the focus of the serious game was on health sciences and medicine content, and future cohorts could assess the effectiveness of seeking feedback from the Steam community in other fields. Future research could work to 'close the loop' and see if revisions of serious games, based on the Steam community's feedback, were more effective for both knowledge acquisition and knowledge consolidation.

5. Conclusions

With the ability for games to reach millions of users through online platforms such as Steam, it is increasingly accessible for educators to obtain crowdsourced feedback from hundreds, or even thousands of users. Although the Steam community reviews were varied in their

comments, the feedback was largely commensurate with many of the aspects that make a quality game, and can certainly be used to develop updates, enhancements, and refinements to game elements and pedagogical outcomes in serious games. With low rates of in-class feedback, and the limitations of receiving feedback from students enrolled in a single subject, crowdsourcing reviews from the Steam community opens a valuable opportunity for educators wishing to receive insightful feedback on individual learning resources, above and beyond what is received in the commonly provisioned university-wide evaluations. Also, as the feedback provided was targeted directly at the resource in question, the insights received extended far beyond would be available from reviewing the published literature. As such, this study presents the gaming community as a unique and valuable avenue for feedback and helpful suggestions when improving serious games.

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Author contributions

The authors confirm contribution to the paper as follows: study conception, planning and design: CM. Data collection: CM. Analysis and interpretation of results: CM, CP, JB. Draft manuscript preparation: CM, CP, JB. All authors (CM, CP, JB) provided substantial contributions to the work, were involved in drafting, the final reporting and approvals, and agree to be accountable for all aspects of the work.

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Data availability statement

All data relevant to the study are included in the article or uploaded as supplementary information. Any additional data or processes are available upon reasonable request by emailing the corresponding author.

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Figure legends

Figure 1: A student plays *The King's Request: Physiology and Anatomy Revision Game* in a health sciences and medical class.

Figure 2: Screenshots from *The King's Request: Physiology and Anatomy Revision Game*. Each region of the map contains a variety of enemies, different questions to answer, and areas to explore.

Figure 3: Comparison of the percentage frequency that themes appeared from reviews of the serious game by the community player and in-class student cohorts.

Table captions

Table 1: Summary of codes and corresponding themes that emerged from thematic analysis of the reviews.