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RESEARCH REPORT

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Development of a framework for implementing digital serious games in anatomy education: A single-centre qualitative study

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Abstract

Serious games are emerging as innovative tools in medical education, yet their adoption in anatomy teaching remains limited due to educator hesitancy, institutional constraints, and design challenges. This qualitative study explores the perspectives of anatomy educators on digital serious games and proposes a framework for their implementation. Semi-structured interviews were conducted with ten anatomy educators from the University of Leeds and Leeds Teaching Hospital. Reflexive thematic analysis revealed four overarching themes: conceptual understanding of serious games, perceived utility in teaching and learning, factors influencing adoption, and design of serious games. While participants recognized serious games as potentially effective and engaging learning tools, they expressed concerns regarding stigma, time constraints, and a lack of evidence on efficacy. A novel finding was the ethical recommendation to exclude cadaveric specimens from game content to preserve donor dignity. Participants also emphasized the importance of inclusive design to accommodate diverse student needs and ensure equitable learning. Based on the themes generated, a framework for implementing serious games was proposed, integrating components of curriculum alignment, educator support, and student-centered design. The framework highlights the importance of stakeholder involvement, including student buy-in, institutional support, and gradual familiarization to overcome adoption barriers. This study contributes to the growing discourse on educational innovation in anatomy by offering practical guidance for ethically and pedagogically sound integration of serious games into curricula. It also calls for broader institutional support and evidence-driven design to support meaningful implementation.

KEYWORDS

anatomical sciences/medical education, anatomy and medical education, anatomy education, anatomy educators, game-based learning, qualitative research, serious games, thematic analysis

INTRODUCTION

Anatomy education remains one of the main cornerstones of undergraduate medical education.[1] However, it is often perceived as one of the least engaging subjects.[2] To address this, educators have explored other creative means of teaching, in addition to conventional teaching methods, which include comic book superheroes,[3] escape rooms,[4] or game-based learning.[5] Game-based learning can be defined as the use of a game to facilitate the achievement of the learning outcomes.[6] The game can be in the form of serious games or entertainment games. Serious games can be defined as games that can be in the form of digital or non-digital, also termed as analog or table-top games, with the primary purpose of training, education, or healthcare, and entertainment being made secondary but not completely excluded.[7] Conversely, entertainment games can be defined as games in which the primary purpose is for entertainment, while the educational aspect may be optional.[8] On the efficacy of serious games, review studies have shown mixed findings. Review studies by Gentry et al.[9] and Maheu-Cadotte et al.[10] on the efficacy of serious games for healthcare professionals found no statistically significant difference in knowledge and skills gain when compared with digital learning tools, but demonstrated higher knowledge gain when compared with traditional learning methods. Conversely, a study examining the efficacy of serious games in anatomy education found improved learning outcomes and engagement.[11] These mixed findings underscore the potential of serious games in anatomy teaching, yet their successful integration may hinge on educators' attitudes and implementation strategies.

Despite recognizing the pedagogical potential of serious games, educators frequently report barriers that limit their adoption. However, a barrier to implementation is the traditional attitude of educators.[12] Another challenge is the congested curriculum, resulting in a lack of time to learn.[13] Educators have also described the limited availability of serious games to meet their needs.[14] Similar findings are also seen in medical educators. The use of serious games for problem-solving, the allowance of making mistakes in a safe environment without causing real harm, and learning from feedback.[15] Further, the congested medical curriculum remains a challenge.[16] Medical educators who lack awareness of serious games view them as risky learning tools[15] or as lacking feasibility for large-group teaching.[17] Also, medical educators with a traditional attitude view games as frivolous.[17] Collectively, these findings suggest that perceived barriers are not solely pedagogical but also cultural and structural, necessitating a deeper exploration of educators' perspectives.

The variability in efficacy findings and educator perspectives may stem from the abstract and heterogeneous nature of serious games, which influences their design and deployment.[11] To optimize educational impact, several design and implementation principles have been proposed. Meaningful learning through games requires consideration of key elements such as repeated completion and structured debriefing.[18] Additionally, the learning mechanic–game mechanic–self-determination theory (LM-GM-SDT) model emphasizes alignment between learning mechanics, game mechanics, and motivational theory to ensure design coherence and foster intrinsic motivation through play.[19]

However, the views of anatomy educators toward serious games are scarce in the literature, and it is valuable to explore their understanding of them. A motivation to explore their views is that, although a serious game can be a potentially effective tool for teaching and learning, another factor that can influence its efficacy is how it is implemented in the curriculum. Further, educators play a significant role in choosing, implementing, and assessing whether games are helpful tools.[20] This qualitative study aims to explore the perspective of anatomy educators toward digital serious games and to propose a framework for implementation. By understanding educators' awareness, understanding, potential challenges, and concerns, a framework for implementation can be proposed, which can assist in designing and deploying digital serious games in anatomy education. The research question is "*What is the perspective of anatomy educators toward digital serious games?*"

MATERIALS AND METHODS

The method section is outlined in accordance with the Standards for Reporting Qualitative Research (SRQR).[21]

Ethical consideration

Ethical approval was obtained for this study by the University of Leeds' Medicine and Health University Ethics Review Theme (MREC-20-093).

Research paradigm

Research paradigms are philosophical assumptions that direct researchers' approach to understanding and inquiry.[22] As this study focuses on exploring the perspective of anatomy educators, an interpretivist paradigm is adopted. Perspectives can be subjective and differ between participants, resulting in multiple realities that are socially constructed rather than a single external reality viewed through a positivist's lens.[23]

Characteristics of researchers and reflexivity

During the study period, the primary author, a PhD candidate and anatomy demonstrator, had experience with digital entertainment games. To reduce the risk of bias, reflexivity was practiced through reflexive journaling, thereby preserving the rigor of the study by making the researchers' experiences, beliefs, and values transparent and explicit.[24] Subjectivity is considered a strength

rather than a weakness in qualitative studies because it can help researchers generate latent themes.[25] Conversely, subjectivity should be kept in check to prevent data interpretation from being skewed.[26]

Sample size, sampling, and recruitment

Anatomy educators who have been actively teaching human and clinical anatomy at the University of Leeds were recruited via purposive sampling on a voluntary basis. Although there is no consensus on the sample size for qualitative research, it is suggested that the focus should be on the information power, which is dependent on factors such as the aim of the study, specificity of the sample, the quality of the interview, or the diversity of the participants' experience.[27]

Data collection

Semi-structured interviews were employed because they offer a structured yet flexible approach to exploring perspectives, using an interview guide that was pilot-tested.[28] To facilitate conservation, participants were provided with a freely accessible serious game as an example before the interview. Due to the COVID-19 pandemic and social restrictions, the interviews were conducted via Zoom (Zoom Video Communications, Inc., San Jose, CA, USA). The interview data were audio-recorded, manually transcribed, anonymized, and pseudonymized by the first author to preserve participants' anonymity and were stored in an encrypted institutional data repository for security and confidentiality.[29]

Data analysis

The data were also analyzed using reflexive thematic analysis by Braun and Clarke[30] which encompasses six phases:

1. Familiarization: Transcribed data were reviewed repeatedly to gain familiarity.
2. Initial coding: Transcribed data were systematically coded across the dataset.
3. Generating themes: Related codes were grouped to form potential themes.
4. Reviewing themes: Themes were checked for coherence and relevance to the data.
5. Refining themes: Each theme was clearly defined and labeled.
6. Write-up: Themes were written up with supporting data extracts.

In reflexive thematic analysis, researcher subjectivity is treated not as a threat but as a strength for generating richer, more contextually nuanced interpretations.[31] It embraces inductive latent coding, which seeks to uncover deeper insights into anatomy educators' perspectives on serious games, resisting the imposition of artificial constraints that might flatten the interpretive depth of qualitative inquiry.[32] The software used for data analysis was NVivo.[33]

Techniques to enhance trustworthiness

Given the interpretivist paradigm adopted in this study, which recognizes multiple perspectives and inherent researcher subjectivity, no single truth exists regarding anatomy educators' views on serious games.[22] To support credibility amid varying realities, strategies such as reflexivity, iterative theme development, transferability measures, pilot interviews, and the deliberate exclusion of positivist-aligned methods were used to enhance the trustworthiness of the qualitative data.

Reflexivity

Reflexivity was integrated to acknowledge and mitigate the researcher's influence through reflexive journaling as described earlier.

Multiple iterations in theme development

Data analysis involved repeated reviews across the six phases of reflexive thematic analysis (RTA), with ongoing discussions among peers and supervisors. This iterative process enhanced the credibility of the results by incorporating diverse interpretations and refining themes through multiple perspectives.

Transferability

While random sampling aligns with positivist paradigms for statistical generalizability, this study used purposive sampling to select relevant anatomy educators, enabling theoretical generalizability.[25] This approach allows findings to be transferable to similar educator cohorts.[34]

Pilot interviews

Interview questions were piloted with academic peers and supervisors to refine clarity, avoid leading prompts, and ensure feasibility within a 45-min timeframe. Key revisions included adding introductory questions, replacing closed-ended queries with open-ended ones, removing jargon, and linking interview questions to participants' teaching experiences.

Exclusion of positivist and post-positivist methods

In this study, methods such as inter-coder reliability (ICR) and member checking were excluded because they are grounded in positivist and post-positivist traditions that prioritize objectivity, replicability, and minimizing researcher bias.[35,36] These approaches assume the existence of a single external truth accessible through standardized procedures, a stance fundamentally at odds with the interpretivist paradigm, which recognizes knowledge as multiple, co-constructed, and inseparable from the subjectivities of researchers and participants.[22,37]

In keeping with reflexive thematic analysis, procedures grounded in positivist paradigms, such as ICR and member checking, were not employed, as they assume a fixed external reality. ICR relies on consensus-building and agreement metrics, which risk oversimplifying the interpretive nature of coding, privileging explicit semantic codes over deeper latent meanings while failing to eliminate subjectivity.[38] Similarly, member checking assumes that participants can validate a fixed "truth" of their experiences, undermining the researcher's role in synthesizing patterns across the dataset and introducing ethical and practical challenges, such as disempowerment, re-traumatization, and low response rates.[39]

With this, while ICR and member checking are often promoted as safeguards of rigor, they may be incompatible with interpretivist research.[36,37] By excluding positivist procedures and privileging reflexivity, subjectivity, and context, this study strengthens trustworthiness and dependability in line with interpretivist principles, yielding authentic, nuanced, and transferable insights into educators' attitudes toward digital serious games.

RESULTS

Participant characteristics

Ten participants were recruited from the University of Leeds Faculty of Medicine and Health, the Faculty of Biological Sciences, and the Leeds Teaching Hospital. There were 5 females and 5 males. All participants have been actively teaching human anatomy to undergraduate students. Table 1 lists the participants, their academic positions, years of teaching experience, gender, and affiliations.

As shown in Table 2 and the following sections, themes are arranged in a three-level system,[40] which includes the overarching theme, themes (**bold** and *italic*), and sub-themes (*italic*).

Overarching theme 1: Conceptual understanding of serious games

The first theme is ***varying awareness of serious games among anatomy educators***. Participants indicated a different level of awareness of serious games, with some having only heard about them for the first time during recruitment or previous experience of hearing or using serious games. Three participants stated that they learned about serious games at conferences or had previously used them in their teaching.

> I actually went through an entire seminar about that. Um…it was specific educational pedagogical seminar. And how this lecturer, or this researcher actually, created all these different games to deliver content which I found very fascinating.
>
> Participant 3

> Probably because the (serious) games that they're out there (commercial market) might not be well established, so that educators aren't familiar with them and they are not using them.
>
> Participant 4

Participants also highlighted **difficulty in imagining serious games due to the dissonance between "serious" and "games**," which is the second theme. Participants articulated that the terms "serious" and "games" carry two different meanings, which are paradoxical to each other. "Serious" can indicate severity, while "games" sound fun or frivolous.

TABLE 1 Study participant recruited.

#	Position	Years of teaching experience	Gender	Affiliations
1	Teaching Fellow	7 years	F	Faculty of Medicine & Health
2	Senior Teaching Fellow	21 years	F	Faculty of Medicine & Health
3	Teaching Fellow	7 years	M	Faculty of Medicine & Health
4	Teaching Fellow	4 years	F	Faculty of Medicine & Health
5	Teaching Fellow	4 years	F	Faculty of Medicine & Health
6	Lecturer	2 years	F	Faculty of Biological Sciences
7	Associate Professor	14 years	M	Faculty of Biological Sciences
8	Assistant Professor	10 years	M	Faculty of Biological Sciences
9	Clinical Radiologist	18 years	M	Leeds Teaching Hospital
10	Clinical Radiologist	2 years	M	Leeds Teaching Hospital

TABLE 2 Thematic tree showing the overall overarching themes, themes, and sub-themes.

#	Overarching theme	Themes	Sub-themes
1	Conceptual understanding of serious games	Varying awareness of serious games among anatomy educator	
		Difficulty in imagining serious games due to the dissonance between "serious" and "games"	
		Serious games as games for learning more than fun	
		Hesitancy among anatomy educators toward the use of serious games	Traditional attitude of educators
			Stigma toward games
2	Utilities of serious games	Fun way of learning by gamifying teaching	
		Complementary to conventional teaching methods	
		Safe environment to learn from mistakes	
3	Factors influencing adoption of serious games	Fostering of interaction	
		Needs of educators	
		Evidence of efficacy	
		Provision of time for familiarity	
		Cost of serious games	
4	Design of serious games	Complete design team	
		Serious game design led by learning outcomes	
		Flexible learning content in a serious game	
		Excluding cadaveric specimens	
		Designed for inclusivity	

> Serious…sounds like a severe, serious, doesn't sound fun. And…a game is, well, there's a dissonance, isn't there? Serious and game. Game is associate with enjoyment and fun and pleasure, and serious is the…erm…may need a little an ease around that terminology.
>
> Participant 8

> I think it's the term game, in my mind has a different meaning. Serious in game kind of seems paradoxical to me, which I think is maybe a personal stigma that's in my head. So…even I think of game, I think of a PlayStation or a board game. I struggled…before I looked at those resources you gave me, I struggled to envisage what a serious game would look like.
>
> Participant 1

Despite participants indicating it was difficult to picture what a serious game is, they viewed **serious games as games for learning more than fun**, which is the third theme. Participants shared that serious games are inherently still games, but learning is prioritized over entertainment.

> But I suppose…serious games mean it's not a game just for fun and enjoyment. There is a point behind it. So…context it's for educational purposes. It's a game with some clear objectives at the end of it.
>
> Participant 8

Conversely, there was **hesitancy among anatomy educators toward the use of serious games**, which is the fourth theme. An attribute of the hesitancy is the *traditional attitude of educators*, which is a sub-theme. Senior educators can be conservative in their views toward innovative technologies, such as the digital transformation initiatives in higher education institutions.[41]

> And this digital transformation is like a four-letter word, like…I don't want to hear about that, I do my lectures, I'm a professor, they are lucky to be sitting here listening to me (chuckle), right? So there's this type of resistance and there are younger and newer academics with great new innovative ideas…you know, it can be very helpful but there are also dinosaurs that don't want to change.
>
> Participant 3

Another attribute is the *stigma toward games*, which is another sub-theme. Participants elaborated that the word "game" can be associated with entertainment. Thus, serious games are seen as jovial, frivolous, or childish, which can potentially distract students from learning.

> That (serious games) seems quite childish to me…especially when I teach other groups of students…I think if I said to them…we're going to play a game. They probably look at me…and think, 'This is a bit silly'.
>
> Participant 7

Overarching theme 2: Utilities of Serious Games

Participants have shared that serious games can offer a **fun way to learn by gamifying teaching**, which is the first theme. The use of serious games can provide fun or a less serious tone as a pleasant pause from the monotony of traditional teaching.

> I think it's (a serious game) something...different something students would enjoy and engage and a nice possible break from traditional resources.
>
> Participant 1

Participants added that serious games can also be **complementary to conventional teaching methods**, which is the second theme. Participants elaborated that a serious game can be introduced after a didactic teaching session to reinforce learning.

> So the game...it's a reinforcement of your learning... you learned it before you play the game, and the game is this fun way of consolidating it and checking that you've learned something or not.
>
> Participant 3

Serious games can also provide a **safe environment to learn from mistakes**, which is the third theme. As playing a serious game requires an action by the player, mistakes are allowed to happen, which can facilitate learning without the concerns of causing any real harm.

> So if you have a serious game where someone can learn and make mistakes but no person comes to harm.
>
> Participant 10

The fourth theme is ***fostering of interaction*** as the fourth theme. This is because the nature of games requires students to make a move when playing.

> So if you have a lecture...people (students) sometimes they don't want to speak or feel uncomfortable speaking, whereas this medium (serious game) by its nature encourages interaction because you'll have to interact with it.
>
> Participant 10

Overarching theme 3: Factors influencing adoption of serious games

Participants indicated factors that may influence the adoption of serious games into curricula. The first theme is the ***needs of educators***. Participants highlighted that, although emerging tools and technologies, such as serious games, have the potential to enhance teaching, their selection and use should be guided by their effectiveness in addressing specific problems, which ultimately determines their relevance to educators' needs.

> ...we've got this technology. Let's see what we can do, as opposed to we've got a problem." Let's see how we can solve it....we'll make everything a game because we can, but then it may not achieve its educational goals...
>
> Participant 8

The second theme is ***evidence of efficacy***. Participants argued that traditional teaching methods are substantiated by strong evidence of their efficacy while for serious games, the evidence may not be sufficiently convincing.

> I think with traditional methods. One of the reasons why they're quite difficult to change or resistant to change is because they're perceived as tried and tested numerous, kind of literature has been written about different ways to teach anatomy, dissection, prosection models and things like that.
>
> Participant 1

The third theme is the ***provision of time for familiarity*** with serious games. Participants indicated that the congested, hectic medical curriculum can leave little time to learn about or become familiar with serious games. Thus, participants mentioned preserving traditional teaching practices, as there is insufficient time. Furthermore, educators must use efficient approaches due to limited teaching time.

> A lot of people, I don't know. You just get used to doing things in a certain way. A lot of people think if there's nothing wrong with it, then why would you change it? So...yeah, I don't necessarily think it's an active thing of avoiding change. I just think it's a, you get used to doing what you're doing and if there's nothing wrong with it, then people think that why should they change? Not necessarily that's the right way of thinking, but just, it happens.
>
> Participant 5

The fourth theme is also the ***cost of the serious game***. Participants highlighted that higher education institutions tend to select teaching methods that are cost-effective. Universities are essentially businesses, and the use of any teaching methods incurs operational costs. With that, the adoption of serious games depends on the cost required to use them and the target goal of student learning that is supposed to be achieved.

> And I think another barrier is also depending on what resources you need for the game, it could be costs.
>
> Participant 7

Overarching theme 4: Design of serious games

Participants indicated the importance of having a ***complete design team*** for the serious game, which is the first theme. This should include the content expert, the technical expert, and the target audience. Each stakeholder can contribute meaningfully to the design of the serious game.

> Software engineer…talk to the facilitators, but they never really talk to the students to find out what the students need…If we are to design something suitably, we do need the students' input, the students of a very nature. Otherwise, it's very hard to establish a sort of a system which works for the end user…And the part of it is that…experience suggests that it's hard right now to get development of something (technology) which is really taking into account all parties.
>
> Participant 6

The second theme is the ***serious game design led by learning outcomes***. The participants argued that educators tend to tailor their teaching sessions around the learning outcomes of the game, but this should be the reverse.

> We (educators) should be designing teaching around what the (learning) objectives are rather than the game.
>
> Participant 8

However, it is recognized that commercially available serious games may be rigid and inflexible. Participants suggested that ***flexible learning content in a serious game***, which is the third theme, allows the game to be adapted to educators' teaching needs.

> Having something (serious games) that would fit with your teaching…having that flexibility, because I think curriculum changes quite a bit. So…I guess that'd be seen as another barrier. You don't want to put a lot of effort and kind of time into creating something… which is then going to be no use in like two, three years' time.
>
> Participant 9

Participants also suggested ***excluding cadaveric specimens*** from the contents of serious games, which is the fourth theme. It was argued about the ethical nature of having cadaveric specimens in serious games, which may risk disrespecting those who have donated their bodies for education.

> I'm not…sure…how respectful it would be to donors if…we were using their parts of their body in games… as they understand that they're donating their body to students to investigate and look at in an anatomical sensible sense. And I think if it was a game, it would trivialise that a little bit.
>
> Participant 7

The fifth theme is ensuring that the serious games are ***designed for inclusivity***. Participants suggested the design should account for students with learning disabilities, be user-friendly, accessible to all students regardless of cost or type of digital platforms, and ensure the learning experiences remain similar, as some students may be avid gamers.

> In terms of students, I think the barriers (of using serious games) would be…disabilities if you ignore those. So, for example, a simple one is colour blindness. That immediately introduces all kinds of issues.
>
> Participant 6

> Having something that's cross platform…something that everyone can be easily and readily available to people…you don't want people to feel disadvantaged.
>
> Participant 10

> Again, the potential of discrimination really against those who can and cannot afford this. I mean, if it's something that the university provided to all students and then that would make it fairer.
>
> Participant 2

> If some students are…better with the technology or the games…in terms of just better at the game then they may get more from the experience than others.
>
> Participant 1

DISCUSSION

This study qualitatively explores the perspectives of anatomy educators on the potential use of digital serious games as a teaching and learning tool. The findings show that participants viewed serious games as an emerging technology with the potential to serve as a tool for teaching and learning. However, due to limited awareness, participants showed caution or hesitancy about using serious games. Participants attributed their hesitancy to barriers such as stigma toward the concept of games being frivolous and the traditional attitudes of educational stakeholders. Finally, measures to mitigate barriers were mentioned, such as fostering familiarity, providing evidence of efficacy and ensuring the availability of serious games in terms of time and access within a congested curriculum for educators and students.

The findings in this qualitative inquiry demonstrate similarities with those in the literature, yet they also reveal nuances and potential gaps that warrant further scrutiny. An instance of this is the varying awareness of serious games, as evidenced by

a survey study exploring the perspectives of clinical educators, which revealed that nearly half of the participants were unaware of serious games.[15] A possible reason for the varying awareness is the engagement in educational scholarship, where participants mentioned initial exposure to serious games as an emerging intervention in one of the seminars.

Findings on the utility of serious games, such as fostering interaction or reinforcing learning, are also described in the literature. Studies have shown increased interaction between educators and students,[42] the reinforcement of learning through play after class,[43] or educators taking on a supervisory role as students engage in games during class.[14] Such advantages are attributed to the nature of serious games, which require players to act, observe, and reflect in cycles, thereby supporting learning through formative assessment and retrieval practice.[44,45] Furthermore, regarding the factors that influence adoption, such as evidence of efficacy, fostering familiarity, or traditional attitudes. This is similarly highlighted in review studies, which described challenges associated with these factors.[12,43] Conversely, a high acceptance rate of serious games as a teaching method has been observed, which is linked to medical educators' regular gaming habits.[16]

Potentially, if educators are allowed gradual exposure to serious games, it can facilitate familiarity and help calm stigmatization and the traditional mindset. One reason for the stigma is the association of games with entertainment, which can contribute to dissonance since the term "serious games" is an oxymoron in itself.[46] With initial exposure and opportunities to play serious games, educators may gain a better understanding of how they can contribute to learning. Yet, this proposed mitigation strategy assumes uniform access to resources, which our findings critique as overly optimistic, especially in resource-constrained environments. On the other hand, the findings indicated a scarcity of serious games available to them, a finding similarly mentioned in a mixed-methods study exploring educators' beliefs about digital games.[13] Critically, this scarcity points to a market or development gap that the literature has not adequately addressed, raising concerns about the feasibility of widespread adoption without targeted investments in open-access game repositories.

Further, the observed hesitancy and attribution of barriers to stigma and traditional attitudes can be critically reframed not merely as individual failures of mindset, but as possible systemic challenges to pedagogical innovation. The recurrent themes of limited awareness and the need for evidence of efficacy are mutually reinforcing. If serious games are not regularly integrated into professional development or supported by dedicated infrastructure, educators face a "catch-22" because they cannot champion a tool without evidence, yet they cannot generate evidence without institutional support and time to test it. With this, the most significant barrier may not be the traditional attitude itself, but the lack of institutionalized reward and resource allocation for pedagogical experimentation in already congested curricula. This contextualizes the finding regarding time and access; the perceived "frivolousness" of games often translates into a lack of protected time to engage with them, unlike established, validated methods. Additionally, while this study mainly focuses on educators' insight, meaningful implementation also requires student buy-in. If serious games are perceived as peripheral, non-assessable, or recreational rather than academic, student engagement may remain superficial. Alignment with learning outcomes and assessment structures may therefore be critical in legitimizing serious games within anatomy curricula.

Regarding the design, the findings suggest it should be guided by the learning objectives and take a holistic team approach. This is also emphasized in review studies on the importance of incorporating educational theories into game design[47,48] and the necessity of involving key stakeholders in the design team.[12,49] However, while these alignments reinforce best practices, a deeper analysis exposes potential oversights. These studies above may prioritize theoretical integration but under-explore practical challenges, such as the barriers to interdisciplinary collaboration or the risk of overdesigning games that become too complex for everyday use. Our study's emphasis on objective-led design critically extends this by advocating for anatomy-specific adaptations, which could mitigate the one-size-fits-all critiques often leveled at generic serious games.

A novel insight from this study is the recommendation to exclude cadaveric specimens from anatomy serious games to avoid the risk of trivializing human remains. While cadaveric dissection remains a cornerstone of traditional anatomy education, its digital representation in gaming contexts raises ethical concerns among educators.[50] This finding suggests a heightened sensitivity toward preserving the dignity and solemnity associated with human donors, even in virtual environments. However, such a recommendation must consider the potential pedagogical compromise. The exclusion of models based on actual cadaveric data, which capture essential pathology and natural variation, might inadvertently reduce the realism and clinical relevance that high-fidelity games aim to achieve.[51] Furthermore, this blanket exclusion risks becoming an overly reductive solution to a nuanced problem. Instead of complete removal, the ethical challenge lies in exploring whether strict game design protocols, such as eliminating scoring/competitive elements related to the body or incorporating explicit donor acknowledgment, could mitigate the risk of trivialization while retaining the core educational value of realistic human forms. This finding extends ethical considerations of human remains into the digital sphere, but simultaneously necessitates a careful balancing act between solemnity and effective anatomical instruction.

Additionally, participants highlighted the need for inclusivity in serious game design, underscoring the importance of avoiding bias toward those with learning disabilities, the affordance of technologies, or a gaming background. Inclusive design not only fosters a sense of belonging among diverse student populations but also ensures equitable access to learning outcomes.[52] These findings align with growing calls in the literature to embed ethical and socially responsive principles into the development of educational technologies, particularly those used in healthcare training. The emphasis on inclusive design serves as a necessary counterbalance to the focus on high-fidelity technology. This concern effectively critiques the "tech-first" impulse often found in early adoption, reminding developers that even effective serious games can create new forms of inequity if they assume a universal level of digital literacy or gaming experience. The findings collectively point to a need for a mature institutional strategy, not just

for adoption, but for governance of serious games, which requires resources for game access, efficacy testing, and the development of ethically informed design guidelines that navigate the complex line between educational technology and respect for humanistic concerns.

Overall, the findings of this study align with the current literature, particularly in the contributions of excluding cadaveric specimens in game design and the inclusion of inclusivity design. The findings were synthesized into a conceptual implementation framework (Figure 1) that provides educators with prescriptive guidance for integrating serious games into their curricula while mitigating potential barriers. This framework presents a model for implementing serious games in medical education by integrating three key components: serious game design, curriculum development, and stakeholder perspectives, which encompass students and educators. Effective game design is guided by learning outcomes, accessibility, inclusivity, and usability, with a novel emphasis on excluding cadaveric specimens to maintain ethical integrity. Integration into the curriculum also requires consideration of time constraints, utility, and institutional support. Educator hesitancy is addressed through increased awareness, demonstrated efficacy, and gradual familiarization supported by technical training. This framework also highlights the importance of involving both students and educators in the design process to ensure meaningful adoption and equitable learning experiences.

LIMITATIONS OF THE STUDY

A potential limitation of this study is its lack of generalizability due to the small sample size and recruitment at a single institution. Conversely, it is arguable that, due to the purposive sampling of anatomy educators from diverse backgrounds with varying awareness of serious games and who are actively teaching, the findings may be theoretically generalizable and transferable to a similar context, rather than statistically generalizable.[25] Furthermore, although it is argued that qualitative data should achieve data saturation, this study has already recruited and included all educators who teach anatomy to undergraduate healthcare students at the University of Leeds, resulting in a 100% recruitment rate.[27]

Additionally, although subjectivity is argued to be a potential bias in qualitative research, approaches were taken during data analysis to mitigate subjectivity.[37] These included reflexive journaling and multiple iterations of theme generation. Further, as this qualitative study is based on the interpretivist paradigm and aligns with the concept of analyzing data inductively through a reflexive thematic analysis[53] this study intentionally refrained from imposing an a priori theoretical framework for coding, as doing so would risk limiting the nuanced and emergent perspectives of participants to predefined, often reductionist, themes.

Another limitation is the participants' gaming background, which has not been explored. While a conventional gaming background may influence their perspectives toward serious games, it typically refers to entertainment games, which are largely different from serious games. With that, the focus of this study was on awareness of serious games. Finally, while the proposed framework for implementing serious games is prescriptive in nature, the next step is to validate the framework with additional stakeholders and other higher education institutions.

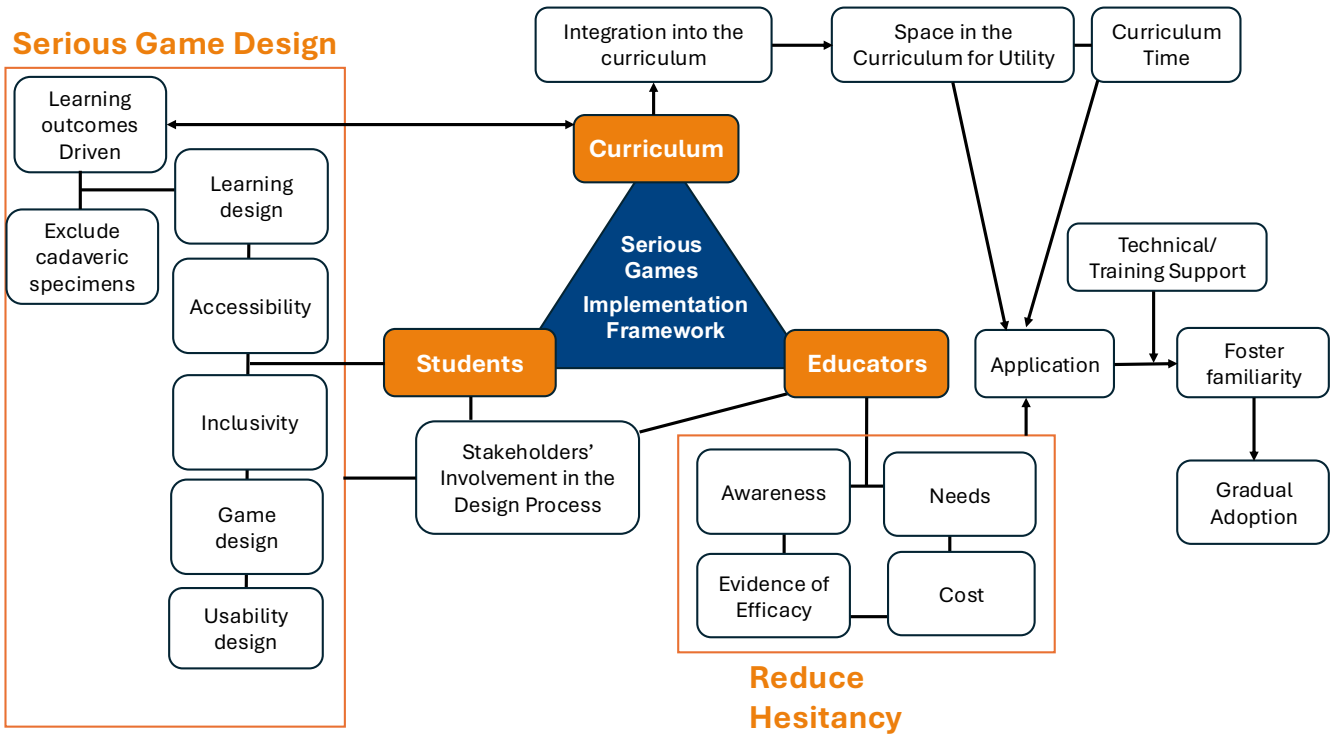

FIGURE 1 Framework for the implementation of serious games in anatomy education.

CONCLUSIONS

In conclusion, an exploratory qualitative inquiry highlights anatomy educators' cautious optimism regarding the potential use of serious games as teaching and learning tools, while emphasizing the need for ethical, inclusive, and outcome-driven design. The proposed framework provides prescriptive guidance for integrating serious games into curricula, addressing educator concerns, institutional constraints, and learner diversity, thereby supporting meaningful adoption in anatomy education.

AUTHOR CONTRIBUTIONS

Arthur Chin Haeng Lau: Conceptualization; data curation; formal analysis; investigation; methodology; project administration; writing – original draft; writing – review and editing. **James Pickering:** Supervision.

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CONFLICT OF INTEREST STATEMENT

There is no conflict of interest.

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