INTRODUCTION

Computer games have become the most popular form of entertainment globally. However, this technology has only recently been introduced as an educational intervention in tertiary institutions, under the umbrella of “serious games,” where games are primarily focused on education rather than recreation. Harnessing games in educational practices provides a new mode of information delivery and assessment that can enhance interactivity and allow self-directed learning. In comparison to traditional teaching methods, serious games also create a platform that allows students to learn and practice skills in a risk-free environment. In this Illuminations article, we outline our experience of putting evidence into practice, and outline student perceptions and responses to an in-house created learning game, The King’s Request: Anatomy and Physiology Revision Game.

The future of biomedical sciences and medical education is challenged by the demand for innovative teaching techniques to educate and train future health professionals. Advances in computer technology have enabled the development and application of various tools in modern educational practice, including the use of virtual reality (11), augmented reality (6, 10), mobile mixed reality (1), and serious games in a higher education setting (9). These tools have the potential to provide cognitive, motivational, emotional, and social benefits to students when appropriately implemented (16). Furthermore, they can be used in various educational settings, such as stimulating knowledge acquisition, simulation training, and skills development. Students are usually excited and motivated to experiment with different technologies while learning, particularly because they possess skills in the use of mobile technologies and enjoy using mobile-based applications and games (3). As such, educators can enhance their delivery of content when introducing multimodal learning technologies as part of their courses (8). Numerous studies have demonstrated the benefits of game-based learning over traditional methods, identifying significant improvements in student performance when these technology-enhanced delivery modes are employed (12).

As part of a systematic review, Boyle et al. (2) explored the use of serious games and specific outcomes, motivation, perception, behavioral changes, skills, and motor learning. The authors noted that serious games were most commonly used in biomedical and medical education, with simulation games being the most popular, as they allowed real-world applications and skills training. In terms of genre, role-playing games were the most popular, followed by adventure, strategy, problem-solving, and puzzle games. Furthermore, serious games not only were observed to be effective in enhancing motivation and knowledge, but are also associated with reduced running costs after its initial development (4, 17). However, serious games in higher education remain a relatively niche and emerging delivery mode (3), where more rigorous research is required to compare serious games with more traditional methods of learning.

Putting theory into practice. Assessing students on learned content remains one of the most utilized practices in higher education to test an individual’s knowledge. There are numerous approaches to make this type of learning more engaging and interactive, including the use of online quizzes, such as Quizlet and Kahoot. As a way to facilitate evidence-based approaches to teaching using serious games, this learning approach was offered to students during a practical laboratory held in their final week of studying a semester 1 combined physiology and anatomy Biomedical Science subject at Bond University on the Gold Coast, Australia. A learning adventure game was created in-house by Dr. Christian Moro, entitled The King’s Request: Anatomy and Physiology Revision Game (Fig. 1). Games of this nature can be created through integrating the online software Unity3D, GameMaker Studio, and RPG Maker. In many cases, the asset packs (houses, backgrounds, characters) can be procured directly from publishers (i.e., the YoYo Games Marketplace) and combined into an interactive world for the students to explore. Similar games can also be created using other software, such as Minecraft Education, which is available as a free program for tertiary educators and students. In total, 46 first-semester Biomedical Sciences students volunteered to complete the game, with the questions written around content covered in semester 1 Physiology and Anatomy. An explanatory statement was provided, and all participants provided informed consent. Ethics for the study was approved by the Bond University Human Ethics Committee.

Thirty-seven participants took part in the study, spending an average of 20 min working through the 20 revision questions included within the game (Fig. 2). Comments provided from various students regarding the answering questions through the revision game format are as follows:

Student 1: “More interactive since you have to answer questions.”

Student 2: “They are something easily done at home with no extra equipment needed.”

Student 3: “By answering questions along the way, it makes it easier to cement my learning.”
Students 4: “They were less formal and were easiest and most effective with revision.”

Student 5: “The game was funny and engaging, helped to cement knowledge.”

Of the 37 participants taking part in the questionnaire, only one response was negative, describing the game as “Not very engaging (not a gamer).” Suggestions for improvement by participants included adding more questions, creating more similar games, as well as making the game available for use at home from a computer (which was achieved later in the year).

**DISCUSSION**

Although the evidence remains limited in its scope, responses collected suggest that there are perceived benefits of incorporating serious games within a physiology and anatomy subject. Semester 1 Biomedical Sciences students reported increased motivation when learning from games as an information delivery mode. Along with the engaging aspect of playing an adventure game as a way to learn, the informal quizzing feature that was included in the game appears to have been well received.

The recent focus of serious games in undergraduate health science and medical educational practices has provided students with an additional variety of ways to revise learned concepts and apply problem-solving skills (15). Incorporating serious games in tertiary education has demonstrated the success of this tool as a supplement to traditional teaching and learning practices. This approach falls under the category of formative assessment, which generates feedback on performance to improve and accelerate learning (14) and helps students develop in a risk-free environment (5). Formative assessments can be performed in many ways, including paper-based tests and online quizzes, with effective assessments helping students scaffold their learning (7) and regulate their performance. Serious games have been found to contribute significantly to in-class formative quizzes and tests and assist students in providing an interactive and engaging mode of information delivery for physiology. Serious games are still relatively untested for summative assessment, which would
require students to demonstrate their developed knowledge and skills in a formal, mandatory assessment that is given at the end of instruction (13). In addition, serious games may also be a barrier to students who are not used to playing games, and may find the mode of delivery distracting and unfamiliar. Despite this, the benefits reported from the implementation of serious games as a learning tool in undergraduate Biomedical Sciences demonstrates the potential for game-based learning as a highly engaging and self-directed positive student experience.

DISCLOSURES
No conflicts of interest, financial or otherwise, are declared by the authors.

AUTHOR CONTRIBUTIONS
C.M. conceived and designed research; C.M. and Z.S. performed experiments; C.M. and Z.S. analyzed data; C.M. and Z.S. interpreted results of experiments; C.M. prepared figures; C.M., C.P., and Z.S. drafted manuscript; C.M. and Z.S. analyzed data; C.M. and Z.S. interpreted results of

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