Game-Based Approach to Teaching and Learning in Optometry Education

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***Abstract*—Game technologies have the potential to shift health education towards experiential learning by offering a highly realistic learning experience while facilitating student engagement and enabling students' practice and prepare for complex real-world situations and clinical decision making. This paper described the development of a gamified technology for teaching and learning red eye-pupillary reflexes for use in Optometry education. The game was developed using Autodesk Maya, ZBrush, and Photoshop. The eye model design explicitly showed the anterior iris as well as pupillary reflexes (dilation and constriction) and red eye reflexes via an interactive 3D-simulation. The RedEye Game is an innovative strategy suitable to provide a realistic display of red eye signs and pupillary reflexes in a controlled environment. The RedEye Game can support the training of optometry students by delivering and reinforcing critical knowledge and concepts while providing educators with new strategies to supplement traditional education approaches.**

Keywords— design; gamification; optometry; education; technology

I. INTRODUCTION

Technology is now fully integrated into the lives of students, and learning via technology platforms is becoming common practice in education. Mainly via experiential learning, which involves learning via using real-world experiences, reflective practices, and applying lessons learned to new situations [1]. Students enter their programs with a high level of technological literacy and experience of using video games for leisure along with several web and mobile applications, including blogging, podcasting, and social networking. As such, educational games, mobile apps, and electronic simulations may be useful for this generation of students [2].

The format and delivery of learning materials in education including medical and health sciences such as Optometry, is evolving, owing to the increased use of technology in medical education, and greater content to learn with less available time. Also, there are different generations of learners with unique learning preferences and an increased volume and complexity of information that continuously evolves in medical education. Educational technology provides an opportunity for learners to practice and make errors without adverse consequences, while instructors can focus on the learners [3]. Thus, medical education is rapidly evolving, with many schools incorporating exponential learning and instructional variety in the curriculum, such as technology-enhanced active learning and multimedia education applications via educational games and mobile learning applications [2].

Gamification varies from gaming in that it does not encompass contests entirely, but instead includes elements of gaming such as achievement, rewards, and engaging in non-game situations to enhance the learning experience [4]. Game-based learning uses game design elements in a non-game context for education, and involves using game approaches, techniques, and features to improve motivation and learning in formal and informal conditions [5].

Games are tools for relaxing, but also useful for mental and physical development because although it provides a playful social experience, it enhances educational usefulness and knowledge building [6]. Hence, gamification invites us to reconsider how games function as a platform of motivation and learning. In addition, it is an approach to education which enhances the teaching and learning experiences via designing games that trigger the "power of play" [7]. Gamification uses the creation of achievements that a user can accumulate as they increase their knowledge and is a process of enhancing services and learning via games to invoke behavioral outcomes [8]. Gamification has motivational and cognitive benefits, and fields such as Healthcare have taken advantage of the potential of game technology for learning.

A. Gamification in Health Education

The academic community was one of the first industries to introduce games as a complement to learning [9], to utilize methods and approaches that enhance active participation with strong motivation and engagement in their learning [5]. Particularly because learners today are digital natives having grown up with various technologies and with different learning styles and approaches to learning. Game-like approaches are becoming popular in education [10], and from a pedagogical perspective, game technology needs careful integration into the learning context by aligning with the learning approach and introduced in a manner that ensures relevance to learners with varying learning styles [11].

As a result of the increasing development of innovative, sophisticated interactive media platforms in recent years,

gamification strategies have become popular and often utilized for medical education [12]. Gamification in health education considers gameplay as a suite of complex, challenging, and thoughtful approaches to human learning [7]. Wherein, games can enable students to solve real-world problems by allowing students to safely apply medical theory to a case since video games set in virtual worlds are programmed to present realistic manifestations of challenges useful for real-life decision making. These challenges are also risk-free, allow for the growth of clinical reasoning and analytical skills [2], along with allowing for visual orientation and contrast sensitivity.

Optometry is a health professional field of study that diagnoses and treats visual problems and errors of refraction, and manages ocular diseases, injuries, and other disorders of the eyes. Technology in optometry education creates opportunities for transformative learning experiences, reinforces conventional teaching practices, enhances communication, and provides a rich and meaningful avenue for teaching, learning, and knowledge development in optometry [13]. Incorporation of technology approaches and platforms can be innovatively used in Optometry education to further learning.

B. Why Game-based Learning in Optometry Education

In the training of health students, meaningful learning is active, constructive, intentional, and requires the use of real-world tasks with adapted complexity within a realistic environment [3]. In addition, learning in health-related fields often involves mastering complex skills, for instance, modules/courses may require reliance on both surface (memorizing information) and deep learning (understanding information) approaches as well as learning via memorization of details which would lead to understanding the connection to details [14]. One way to promote knowledge and learning of complex health modules is via contextualized instruction and strategies aimed at understanding the relationships between the module and real-life manifestations (signs and symptoms) [14]. But learning in this real-life context is not always possible due to ethics, safety, and costs; hence, students require alternative ways to achieve clinical excellence [3].

Gamified teaching and learning have the potential to increase experiential learning by offering a realistic learning experience. Numerous studies have demonstrated improved student learning outcomes among optometry students using web-based methods, especially due to its convenience and motivation for learning provided [15]. For instance, optometry students indicated that using a graphics-oriented method along with concept animation assisted in the comprehension of difficult concepts in learning pharmacology [16]. Also, technological approaches in optometry education can facilitate student engagement, develop innovative patterns of thinking, and improve collaborative learning, which would subsequently enable practice and preparation for complex real-world situations. Virtual reality via gamification offers a transition from the two-dimensional world of textbooks to the three-dimensional world of gamified models, which allow for interaction and navigation in 3D space [17].

Hence, it is essential that optometry education schools respond to the evolving educational needs and professional requirements with pedagogical evolution by designing and providing innovative strategies for learning, as well as an interactive and engaging educational experience for students and instructors.

This research focused on the development of a gamified program for teaching and learning red eye-pupillary reflexes for use in Optometry education, called RedEye Game.

II. DESIGN METHODS

A. Theoretical Framework

Most games yield short-term engagement through extrinsic rewards; thus, for gamification to reach its full potential, it is necessary to develop gamified learning solutions on well-founded theories [18]. The underlying theory used as a guide in the development of this gamified learning program is Self-Determination Theory (SDT). SDT differentiates two forms of motivation “extrinsic motivation” which refers to performing a task due to a separable outcome, such as pressure or “extrinsic rewards” in the kind of verbal feedback, whereas “intrinsic motivation” represents the pursuit of an activity, because it is inherently interesting or enjoyable [19]. SDT consists of three constructs; competence, autonomy, and relatedness.

When perceived as informational, gamification elements, such as points, levels, and leaderboards; may afford feelings of competence, enhance intrinsic motivation, and subsequently promote performance [20]. Gamification infers that introducing game-like features would make teaching and learning activities more interactive and interesting [21]. Since games are inherently fun, they typically result in intrinsic motivation, which is essential, particularly in learning new skills and behavior change [22]. This theory is ideal for game-based learning because it emphasizes the triggers and reasons behind learning new information and skills, as well as performance and decision making.

B. Game Context- Red Eyes Pupillary Reflex

Red eye is a crucial sign in eye care because it is often triggered by various eye conditions, including irritation, allergy, infection, injury, burns, and fatigue. Red eyes could also be a sign of severe sight and life-threatening medical conditions such as glaucoma, high blood pressure, and leukemia. The pupillary reflex seen in red eyes differs based on the condition causing the red eyes. Accurate interpretation of red-eye pupillary reflex enables practicing optometrists to diagnose the underlying eye and medical condition adequately, and subsequently informs treatment and management of the condition. Thus, learning about pupillary reflexes in red eyes is essential in optometry education.

C. Development Team

Developing the gamified technology for optometry education provided an opportunity for a cross-disciplinary collaboration to design, develop, train, and implement an innovative e-technology for optometry education. This collaboration aimed to influence the adaptation of optometry courses to technology with an emphasis on integrated teaching [13]. The development team comprised of the design and health team. The health team included a Midwife and an Optometrist who provided the focus and objectives of the

gamified program. The team equally comprised of two Computer Games Art specialists who designed, developed, and tested the gamified teaching and learning program.

The development process included interaction with the health team before the design phase to understand the frame of the design, followed by a conceptual design of the learning "eye model." Fig. 1 shows the conceptual design of the Eye model as seen in the observational level.

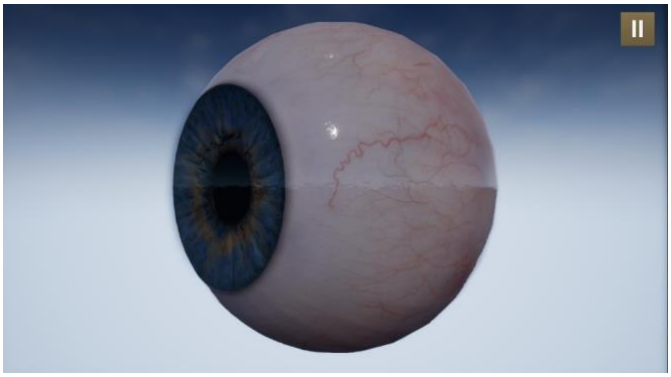

Fig.1. Conceptual Design of the Eye Model

Thereafter, the design team commenced on the project development of the customized teaching and learning application for optometry. The aim was to turn the product into a fully packaged software/game to be used by the teaching staff as a teaching and learning tool.

III. RESULTS

The project covered the ideation, production, and refinement of the following elements for the app: 3D modeling the eye, texturing the models using photorealistic physically based textures, developing photorealistic based materials in the game engine, lighting the models in the game engine, and set dressing of models in the engine. In addition, the project involved; rigging and animating the models (blend shapes, loops, animated textures, etc.), User interface/ User Experience design, level setup and design, in-game engine materials interactions, animation logic setup in the game engine, interaction game logic, scoring system, packing and optimization, questions and answers (Q & A), and testing. Fig. 2 shows the character referred to as "RedEye."

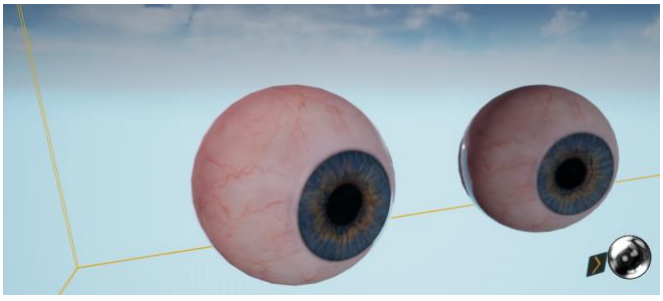

Fig.2. The Red-Eye Models

An algorithm was created, which proceduralland randomly replicated different pupillary reflexes in the program allowing the software to generate an uncountable number of symptoms based on the examples of real symptoms provided by the health team. Each replica was reviewed within the design team, validated against the documented protocol, and then presented to the health group for feedback. The entire team carried out acceptability and scientific review of the final version.

Figures 3-5 show interfaces of the gamified learning. Fig. 3 shows the first screen observed in the game, Fig. 4 presents the options for navigation on commencing with the game, and Fig. 5 shows normal versus dilated pupil observed in the game.

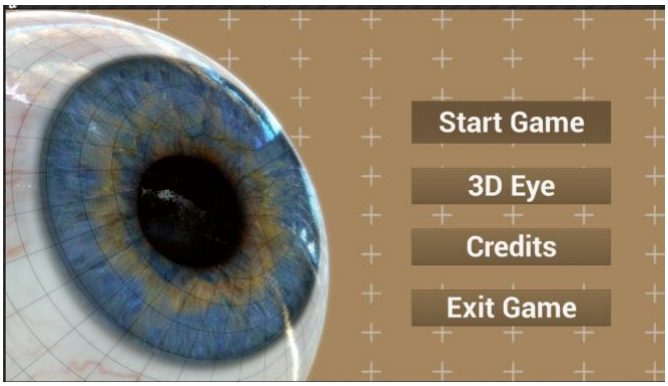

Fig.3. First screen presented in the game

Fig.4. Options for navigation

Fig.5. Normal versus dilated pupil

We named our program "RedEye Game", the game was developed using Autodesk Maya, ZBrush, and Photoshop, and it was assembled and runs on the Unreal 4 Engine. As suggested by the literature, the RedEye game includes clear enforced rules of competition for all participants [23]. However, this is the first version of the RedEye Game and it is the foundation which we can build on in the future by

including a self-assessing system, prompt feedback on the correct or incorrect response, followed by an explanation of key concepts.

RedEye Game consists of two simple levels; Main and Observation. The main level presented the students with ten pairs of eyes with procedurally generated eye signs from a library of 16 signs. In every reset, a new sequence of random eye signs is presented. here are 16 different eye conditions in the library. Students do not get the same conditions when the game is restarted. These signs can be unhealthy or healthy (i.e., red eye, white eye, dull eyes, early cataract changes, late cataract changes, etc.). The student hovers over the iris, and the game will automatically shed light to the inner eye section for the student to see the back of the eye and decide whether it is a healthy reflection or not. An example of this interactivity is shown in Figs. 6 and 7.

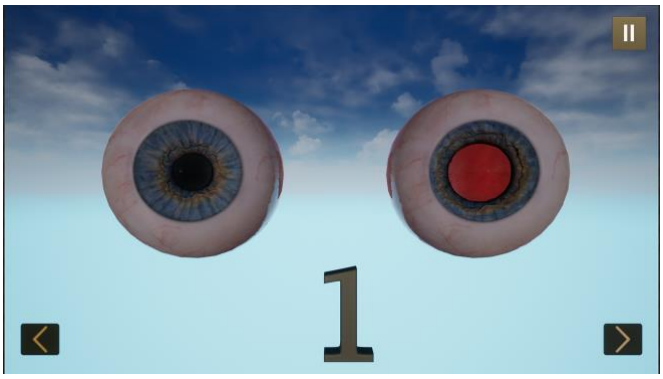

Fig.6. Eye with red eye reflex

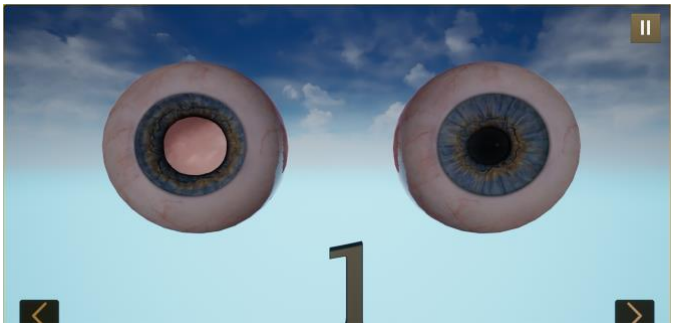

Fig.7. Eye with white eye relex

There are ten rounds with a pair of eyes each, hence 20 eyes in total. Therefore, there are 20 test opportunities. Each eye case scenario has 5 points, and for every correct analysis, the student gets the 5 points if not, a score of 0. At the end of the tenth game, the game provides a score out of 100.

The observation level was designed to support lecturers when explaining the structures and layers of the eye. The observation level contains a close-up section of the eyeball and allows for the rotation of the eye and enables splitting the sclera section and learning the names of each eye layer and its structures.

IV. DISCUSSION

Game technology was used as a strategy to strengthen engagement and further enhance learning. This approach enhanced the realism and relevance of the lesson [2], and the game was used to augment skill training related to optometry training.

Students experience and engage with game technology in different ways which should influence how gamified learning is designed [24] and design has been shown to provide engaging learning experiences for optometry students [13]. The RedEye model design here explicitly showed the anterior iris as well as pupillary reflexes (dilated and constriction) and red eye reflexes via an interactive 3D-simulation.

Games are not fun because they are games, but as a result of interesting designs [4]. Gamified applications irrespective of its use, needs good and thoughtful designs. The design was visually compelling, the colors used enhanced visual contrast. Although sounds tend to grip learners' attention and help improve the motivation and interest of students [13], the RedEye game did not have sound elements in order to enable students to carry out other task while using the application such as; listen to music or read as they learnt via the game.

A graphic and virtual medium is an effective pedagogical tool to motivate students and provide complementary support to the challenge of memorizing processes [16]. As such, the RedEye game design used images to appeal to higher education students in order to prompt intrinsic motivation, learning, and development of clinical skills. The RedEye Game provided a realistic display of red eye and pupillary reflexes in a controlled environment. Similar gamified teaching and learning practices tend to have a positive impact upon student achievement and students' attitudes toward lessons [25].

A strength of the design is that the RedEye game visually correctly represented real life situations and the design team is scaling-up the design to ensure the game can run on any form of technology/mobile device regardless of performance difference between the devices. A limitation of the design is the inability of students to provide a description of the eye condition within the game. A future feature of the game is to include an interface to enable this. Other future directions include the development of the program on android and iOS platforms for easy access and usability on mobile devices. Using smartphone-app as a tool has merit to increase portability and convenience, particularly as many people now own smartphones and it will be possible to share the game with a larger group of optometry teachers and students.

The RedEye Game may support the training of optometry students by delivering and reinforcing critical knowledge and concepts while providing educators with new tools to supplement traditional education approaches. However, a definite claim of the games' efficacy cannot be made until the game has been evaluated. The game is undergoing improvements based on students' feedback. Thus, the RedEye Game is presently been used at an Optometry school. Future directions are to test the usability of the program itself, examine the efficacy of the gamified intervention in increasing student outcomes, and determine its ability to meet pedagogical objectives.

V. CONCLUSION

Optometry education needs to address the changing educational environment and respond accordingly to meeting the learning needs of students. Modern pedagogical paradigms and trends in education, such as gamification, create opportunities to use new methods to implement active learning [5]. Although game technology can increase existing knowledge and enhance learning experiences, combining and integrating technology-based teaching with face-to-face teaching may produce the best educational outcomes [13]. Game technologies for learning and teaching may provide a promising pedagogy tool in the future of Optometry education. It is not a replacement for traditional teaching methods, but it can be used to enhance learning and is an innovative way of delivering educational materials.

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