Short-term gains in histology knowledge: A veterinary gaming application

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Abstract

Outcomes research exists incorporating non-digital games in veterinary education; however, little research examines outcomes from digital applications. Bauman's Layered-Learning Model was applied to investigate whether a digital matching game produced short-term knowledge gains in veterinary students. Two groups of students (n_1=67; n_2=55) practiced the matching game for an hour. A Wilcoxon signed rank test tested for a statistically significant improvement in pre-test/post-test scores. All statistical analyses were done using R. Mean and median pre-test scores were 15 (SD=1.88; IQR: 2) and post-test scores 16 (SD=1.80; IQR: 2). Mean and median pre-test score for Group 2 were 13 (SD=2.30; IQR=2.5) and post-test scores 15 (SD=1.93; IQR=2.5). Both groups increased significantly in post-test scores (*P* value<.0001). Statistically significant short-term increases of marginal importance in histology knowledge was seen. A greater increase might be seen with quiz revision increasing difficulty and discrimination ability. Further directions should investigate long-term knowledge retention.

Keywords: Veterinary Education, Educational Games, Histology, Digital Content, Bauman, Layered-Learning Model, Digital Native, Game-based Learning, Gamification

Introduction

Game-based learning and gamification, widely seen in popular culture, are beginning to gain acceptance as tools for professional development. Applications of game-based learning in professional and academic settings are beginning to appear in scholarly publications. Scholarly evidence related to healthcare interventions for adolescents and young adults exists demonstrating behavioral change through game-based learning (Baranowski et al., 2015; Baranowski, Buday, Thompson, & Baranowski, 2008; Kato, Cole, Bradlyn, & Pollock, 2008; Safdari, Ghazisaeidi, Goodini, Mirzaee, & Farzi, 2016). The social nature of play and the networking availability inherent to modern mobile social platforms have broadened the market for, and acceptance of serious games with the potential to drive behavioral change (Gee, 2003; McCallum, 2012; Squire, 2003).

Gamification represents the application of game mechanics to non-game processes. Gamification makes content more interesting and better engages learners in desired behaviors (Domínguez et al., 2013). Game-based learning can be even more powerful because it transcends the extrinsic system of tangible rewards to promote engagement by leveraging an intrinsic reward model. Leveraging an intrinsic model means that reward comes from mastery (Deterding, 2012). Players or learners glean a sense of accomplishment by mastering content and skills presented through the context of the game. Game-based learning need not be playful or even fun to have the potential for knowledge transfer. Difficult games are challenging, but perhaps not necessarily fun or playful. Rather, learners (the players) maintain engagement in the game because they are motivated by sense of agency. Engagement within a given game environment or ecosystem is seen as valuable by the learner as a means to a desired end, achieving and demonstrating content mastery. The most powerful games used for educational purposes will promote achievement and mastery within the situated context of an affinity group in which the learner already belongs to or is committed to joining. Game design, which moves beyond the leveraging of game mechanics should be emphasized over gamification because when games are carefully designed they have the potential to become machines for gaining and demonstrating competence (Deterding, 2015). Good games, games designed to promote knowledge transfer within authentically situated contexts create and represent designed experiences where performance within a game environment articulates real world behavior (Squire, 2006).

Successful game design encourages spontaneous game-play where initiation with the game occurs in absence of coercion. Game-play within the context of a well-crafted game represents a behavior trap. Players remain engaged in well-designed games in the same way that educators hope keep children engaged with well-designed lessons and curricula (Morford, Witts, Killingsworth, & Alavosius, 2014). Technology, particularly mobile technology, challenges the very notion of what constitutes a learning environment. Lessons traditionally taught in the physical confines of a bricks and mortar classroom or laboratory may no longer be dependent on physical academic space. Mobile digital learning environments escape the trappings of time and location – they increase the availability of learning activities. When well-crafted games designed

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to promote and scaffold the curriculum are available outside of the classroom or institution, they become an agent of anytime, anywhere learning by shifting the locus of control from the institution towards the learner (Bauman, 2012, 2016).

An early article reviewed a number of different applications in veterinary medical education including: drill-and-practice, tutorial, problem-solving, testing, educational management programs, and educational games (Cobb, 1986). Cobb (1986) concluded veterinary students who used educational applications as an integral part of their curriculum would be able to take advantage of similar technologies in their veterinary practice and would be more open to accepting similar modalities as learning tools throughout their professional careers. Short (2002) discussed the potential for the Internet to provide new opportunities to deliver e-learning to the veterinary profession both at undergraduate and postgraduate level. Short (2002) also indicated that veterinary educators will have to adapt their teaching methodologies and students who will have to develop new ways of learning as more and more content becomes available digitally. Digital content and delivery mechanisms continue to grow exponentially. Students' digital literacy and abilities often outpace their faculty. This will force a paradigm shift in the role of faculty members. Faculty will no longer be the keepers of information; rather faculty will be tasked with determining what students must commit to traditional learning versus how students will access digital content to mediate behavior change and professional performance (Prensky, 2012).

Theoretical framework

Bauman's Layered-Learning Model describes a matrix for scaffolding traditional didactic presentation or course materials with multi-media educational technology (Bauman, 2016; Bauman et al., 2014). The Layered-Learning Model presupposes that traditional didactic learning techniques such as knowledge transfer through scholarly reading and interaction with course faculty and staff still have relevance in the modern classroom. However, this model leverages contemporary educational technology to scaffold the transfer of knowledge to the learner in a situated and multi-model approach.

The Layered-Learning Model does not replace the traditional reading assignment with technology, but rather provides an approach to learning that increases access to content and avoids the pitfalls of privileging information. By making content available through digital modeling, haptic simulation taking place in brick and mortar laboratories, and finally later through supervised clinical experiences, students begin to have anytime, anyplace learning experiences. Learners can leverage an array of traditional resources, faculty led classroom experiences, books (print or digital), and multi-media games or simulations to provide as needed or just-in-time learning to meet course objectives.

Within the context of the Layered-Learning Model the role of the faculty shifts from the position of sage on the stage to a guide who determines how best to convey knowledge by leveraging contemporary and often digital or digitally enhanced learning tools and techniques. This requires a degree of digital wisdom, whereby the teacher understands that curricula, particularly the ever-expanding clinical curricula, and guides students through a vetting process that helps to parse out relevant and critical content. The digitally wise teacher provides cues for what students need to commit to memory versus what they need to be able to access within the digitally connected ecosystem (Prensky, 2010, 2012).

Purpose

While there is research examining outcomes from the incorporation of traditional non-digital games little research exists examining outcomes of digital educational applications on learning outcomes. Thus, Bauman's Layered-Learning Model was used as a theoretical framework to investigate whether a digital matching game (Histology Card!) would produce short-term gains in knowledge retention.

Methods

This study used a pre-test/post-test quasi-experimental design. There were two groups of students who participated in the investigation approximately six weeks apart. Students were recruited from a convenience sample of veterinary medical students who were enrolled in the required histology course at a large international veterinary medical school. Students were compensated $25 for their time. The Ross University School of Veterinary Medicine Institutional Review Board approved this study and it was conducted in accordance with the tenets espoused in the Declaration of Helsinki (World Medical Association, 2013).

Sample

The Ross University School of Veterinary Medicine is located on the island of St. Kitts. It is fully accredited by the American Veterinary Medical Association (AVMA). Students enrolled at the university complete a Doctor of Veterinary Medicine (DVM) degree upon successful completion of seven 15-week semesters of in-residence coursework at the St. Kitts campus in the West Indies prior to completing three clinical semesters at an AVMA-affiliated institution in the United States, United Kingdom, Ireland, or Australia. Admission is granted three times per year in September, January, and May.

Study Design

The histology game (Histology Card!) was pilot tested in May of 2016 and July of 2016. Students entered a large classroom and were shown 20 histology slides on a screen and were asked to identify the tissue type. Students indicated their responses on a Scantron® (Tustin, CA) form. Students were then given the opportunity to practice their histology for an hour using the digital Histology Card! matching game. Students were then shown the 20 slides again and indicated their responses on a Scantron® form.

Histology Card! Matching Game

The Histology Card! matching game is a digital riff on a traditional card matching game such as concentration. Players are presented with a histology image card and up to seven additional images that they hold in their "hand". The player is asked to match each of the newly presented images with a matching histology card that they hold in their "hand". The image cards held in the player's virtual hand always contain an appropriate match for each image or card presented to the player. While there will always be a correct image in the player's hand to match with the presented histology image, these images will represent different views of the same histology image (for example, different magnifications).

When the player makes a correct match, they are then quizzed via a multiple-choice question as to the specific histology structure that has been matched. When players correctly match images their hand shrinks. When they fail to make a correct match, their hand expands.

Analysis

Students recorded their answers to the pre-test and post-test on Scantron® forms. Students were assigned study identification numbers to anonymize the data and the number of correct answers for the pre-test and post-test were transcribed in a comma-delimited file using Microsoft Excel® (Redmond, WA). Means and standard deviations (SD) were calculated as well as median and interquartile ranges (IQR) of pre-test and post-test values. A one-tailed Wilcoxon signed rank test was used to detect if there was a statistically significant improvement in histology scores from pre-test to post-test. Since this is an educational intervention an *a priori* alpha level of .10 was specified. All statistical analyses were done using R (Vienna, AT).

Results

Sixty-seven students took part in the first pilot study. The mean pre-test score was 15 (SD=1.88) and the median pre-test score was 15 (IQR: 2). The mean post-test score was 16 (SD=1.80) and the median post-test score was 16 (IQR: 2). There was a statistically significant increase in the post-test scores (P value<.0001); there was a one-point increase in means and medians from the pre-test to post-test scores.

Fifty-five students participated in the second pilot investigation. The mean pre-test score was 13 (SD=2.30) and the median pre-test score was 13 (IQR: 2.5). The mean post-test score was 15 (SD=1.93) and the median pre-test score was 15 (IQR: 2.5). There was a statistically significant increase in the post-test scores (P value<.0001) and an important post-test difference of two points representing a 10% increase in scores.

Discussion

Mobile applications focusing on veterinary medicine and education are beginning to emerge. However, most applications designed for the popular Apple and Android devices represent mobile content reference tools and content aggregators. Few if any of the commercially available mobile applications appear to leverage game-mechanics, let alone dive deeper into the realm of game-based learning. Even fewer applications have been subjected to outcomes-based educational research, thus the literature on the efficacy of digital game-based mobile learning strategies is scant.

This investigation employed digital gaming technology to pilot test short-term knowledge retention of veterinary histology content. Through traditional didactic learning, students were presented with histology material – a presupposition of Bauman's Layered-Learning Model. In the pilot, the faculty member leveraged a digital learning tools and techniques to teach identification of veterinary tissue.

The study demonstrated, in two separate trials, statistically significant increases in short-term knowledge gains. These statistically significant knowledge gains can be attributed solely to the Histology Card! matching game as participants were tested after "playing" the game. In the first trial there was 5% increase in scores (moving from 15 to 16, on average) and increasing by 10% (moving from 13 to 15) in the second trial. This increase is an important increase. For example, suppose the histology course grade is composed of 65% tests, 10% homework, 10% participation, and 15% quizzes. This 10% increase would translate to a two percent increase in a final grade. If, for an hour investment, a student could potentially increase her or his final grade by two percent this could significantly influence student grades.

This investigation confirmed similar findings in the veterinary education literature. In one study, testing the effectiveness of crossword puzzles as a learning aid to veterinary terminology researchers concluded students using the crossword puzzles performed better in the post-intervention test, correctly retaining more terms than the students using only rote learning (Abuelo, Castillo, & May, 2016). The crossword intervention was not a digital game; however, the gaming concepts similar to this study are applicable. In another study, again not using digital gaming, card games were used to supplement learning about radiographic image quality and differential diagnoses in urogenital imaging and found students playing the card games performed better on post-tests than students not playing the card games (all P value <.01) (Ober, 2016). Like both of these studies, this investigation found an educational intervention significantly improved short-term learning.

This investigation, using Bauman's Layered-Learning Model, is an implementation of what was suggested by Short (2002) – an adaption of teaching methodologies via a new way of learning with short-term outcomes. It is hoped the benefit of more educational games can be demonstrated with short-term and long-term outcomes to better accommodate the digital natives of the 21st century.

Limitations

The first limitation of this investigation is that it only demonstrated short-term, albeit statistically significant, gains in histology knowledge. This would have been a much more powerful study if long-term outcomes could have been assessed. However, for logistical reasons such as the cost of providing all students with iPads® this was not possible. A second limitation is that the results showed a marginal increase in histology scores – a five and ten percent increase. Most assuredly the statistically significant results with respect to these modest increase is due to overpowering of the investigation. Perhaps a greater increase in scores could be seen if the quiz were revised to increase it psychometric difficulty and discrimination ability.

One criticism of most pre-test/post-test investigations is their lack of a control group. Perhaps this was the reason for the increase in scores. It is a possibility the pre-test sensitized the students to what they should be learning and by doing so facilitated in increase in post-test scores. The only way to assess this is to use a Solomon four group design. Future considerations should include the implementation of such a design.

Despite these limitations the authors argue the investigation has merit because it fills a knowledge gap in the literature. There are few studies of the application of digital gaming technology in veterinary medical education examining outcomes.

Conclusions and future directions

This investigation employed an application of Bauman's Layered-Learning Model with a novel intervention (a digital educational game) to assist veterinary students in learning histology. The study demonstrated statistically significant short-term increases in histology scores on a 20 item quiz. However, the results were of marginal importance – a one-point, five percent, increase in one group and a two-point, ten percent, increase in the other group. As educators, we would like to see an intervention that makes a bigger difference in scores. An increase in scores might be seen with a revision of the quiz to increase its difficulty and discrimination ability.

Further directions include assessing whether regular use of Histology Card! improves student's ability to identify and remember cell patterns with repeated use and over the long term and studies using a Solomon four group design to test for possible sensitization by the pre-test.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

EBB, and GEG contributed to study conception and design and GV and Learning Games Network, Inc. designed and programmed the Histology Card! game. GEG drafted the original manuscript and EBB and GV edited the original manuscript making critical revisions. EBB drafted the Introduction, Theoretical Framework, and Discussion. GEG authored the Methods section and the Results section and served as the statistician for the investigation. All authors contributed substantially to subsequent revisions of the manuscript. GEG formatted the final manuscript and serves as corresponding author. All authors approved the final manuscript.

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