Examination Outcomes Following Use of Card Games for Learning Radiographic Image Quality in Veterinary Medicine

Christopher P. Ober

ABSTRACT

Understanding the concepts of radiographic image quality and artifact formation can be difficult for veterinary students. Two educational card games were previously developed to help students learn about factors affecting contrast and blackness as well as radiographic artifacts. Second-year veterinary students played one of the two card games as a part of their normal studies for their veterinary imaging course and later took the radiographic physics quiz normally administered during the course. Performance on quiz questions related to each of the two games was compared between students who played each respective game and those who did not. The hypothesis was that students who played a game would perform better on related questions than those who did not play that game. For the contrast and blackness questions, students who played the associated game as part of their studies performed better than those who only studied by conventional means (mean 4.3 vs. 3.8 out of 5 points, $p = .02$). However, there was no significant difference in results between groups for artifacts questions (mean 4.7 vs. 4.5 out of 5 points, $p = .35$). Based on these results, educational game play can have benefits to student learning, but performance may be dependent on specific game objectives and play mechanics.

Key words: card game, radiology, artifacts, image quality, radiography game, gamification

INTRODUCTION

Diagnostic imaging is a key component of veterinary curricula, as radiography is a commonly used diagnostic tool in veterinary practice. While much of imaging instruction focuses on recognition of lesions and development of appropriate lists of differential diagnoses for those lesions, assessment of radiographic quality is also important, as failure to recognize a low-quality image or specific radiographic artifacts could lead to misdiagnosis. However, many students find understanding factors that affect radiographic quality challenging. In addition, understanding of radiographic quality factors often does not improve in the clinical practice setting, as is demonstrated by the significant technical limitations identified on the majority of referral radiographs received by the University of Minnesota Veterinary Medical Center.

Although instruction in radiographic quality is generally included as a part of radiology courses, the inadequate level of student understanding suggests that improvements to the teaching process are needed. Educational board and card games in the classroom and in laboratory sessions can be used to provide students new and additional means of learning material. Several board games have been described for use in medical education and continuing medical education,[1–3] but many of these have not been evaluated for actual educational utility. In those studies where there has been assessment of outcomes, results generally indicate that students show improved understanding of the topics after playing the games, but evaluations are almost invariably performed immediately after game play.[4–7] Thus, there are no assessments of examination outcomes achieved with use of board or card games in medical education.

Similar limitations are identified in the veterinary literature. Few educational games are described in veterinary medicine.[8,9] Outcomes in studies in veterinary radiology indicate that students demonstrate improved immediate understanding of radiographic physics and uroradiologic differential diagnoses.[9] Nonetheless, again, there has been no evaluation of more extended understanding of the material.

The purpose of this study was to determine if educational card games could be used to improve intermediate-term retention of radiographic quality information by second-year veterinary students enrolled in a veterinary radiology course, as assessed by examination outcomes. The hypothesis was that students who played a card game would demonstrate higher scores on associated questions on the quiz administered as a normal part of the radiology course.

METHODS

Study Design

I previously developed two card games for use in a second-year veterinary class to help students learn about radiographic image quality, specifically radiographic artifacts and factors contributing to radiographic contrast and blackness.[9] Participants played at least one of the card games during a laboratory session and as part of their studies. At a later time, all students in the class took a radiographic physics quiz containing questions relating to each game as well as other concepts discussed during classroom and laboratory sessions. The Institutional Review Board of the University of Minnesota granted the study a Category I Exemption for study of an instructional strategy in an educational setting (US federal guidelines 45 CFR Part 46.101[b] category #1).

Game Design

Design of the games used in this study has been described previously.[9] In brief, the artifacts game contains cards that represent different radiographic artifacts as well as those representing means of correcting and preventing those artifacts. Artifact cards depict the artifact in question and include a brief explanation of that artifact's formation. During the game, players place artifact cards on opponents' play areas with the intent of forcing opponents out of the game by causing them to accumulate too many artifacts. Players can remove artifacts from their play areas by playing the correct prevention or correction card. The winner of the game is the last player remaining in the game. The educational aim for this game is for students to recognize common radiographic artifacts and become familiar with how they are created and how they can be prevented.

In the contrast and blackness game, students explore factors that affect radiographic contrast and optical density. (The term *blackness* has been used to replace *optical density* in the game to attempt to minimize confusion between the opposing concepts of optical density and radiographic density.) Using game mechanics analogous to dominoes, players must match cards depicting general conditions of radiographic quality, such as high contrast or low blackness, to cards representing factors that may produce those states, such as decreased kVp. Players receive points when factor cards adjacent to a condition card cause that condition, and players lose points when factor cards adjacent to a condition card actually cause the opposite condition. The player with the highest score at the end of the game is the winner. Factor cards depict their scoring conditions, so the aim is for students to learn about technical components of image quality during game play without having to consult other references.

Sampling Size and Sampling Method

Opportunity to play the radiology card games was provided to all 101 veterinary students enrolled in the second-year veterinary medical imaging class at the University of Minnesota College of Veterinary Medicine during one semester. Participation in the study was optional.

As a part of the course, each student attends one of two laboratory sessions dedicated to radiographic physics, which occurs after all lectures related to that topic area. The laboratory sessions were offered in the mornings of two consecutive days. Students who were interested in playing a card game divided into groups as they desired, with each group composed of two to four students. At the beginning of their respective laboratory sessions, each group was randomized to one of the two card games, and all participants received a copy of that game for use in the laboratory session and their studies.

Data Collection

Each participant played his or her game at least twice during the laboratory session or at home as a part of his or her studies. The exact number of times that the games could be played was not constrained, nor was the precise timing of the game play. The only restriction on game play was that each participant should have completed all game plays before taking the radiography physics quiz given as a normal part of the course.

All participants took the online radiographic physics quiz during the normal window of opportunity provided as a part of this course. The quiz was opened on the evening of the day of the second lab session, 6 hours following the close of that lab session. The quiz was open for 6 days. Because students were allowed to play the card games at times of their choosing (in lab or at home), and because students were also allowed to take the quiz at times of their choosing, intervals between game play and quiz taking were variable.

The radiographic physics quiz consisted of 5 questions specifically related to the contents of the artifacts game, 5 questions specifically related to the contents of the contrast and blackness game, and 15 questions not specifically related to the contents of either game (such as basics of X-ray generation and radiation safety). All questions related to game content were covered in the traditional didactic and laboratory sessions of the course, and thus previous game play was not required to answer any of the questions. In addition, participants were asked to state how many times they had played their respective games and were also given a free-response section to provide comments about the games.

Data Analysis

Data were analyzed with commercially available statistical software (JMP 11.0.0, 2013, SAS Institute, Cary, NC). Means and standard deviations as well as medians were calculated for results of artifacts questions and contrast and blackness questions for both game groups. Due to the non-normal distribution of the data for both the artifacts questions and the contrast and blackness questions, a Wilcoxon rank sum test was used to compare results of students who played the associated game to the results of the students who did not play that game. Statistical significance for all analyses was set at less than 5% ($p < .05$). Student comments were not statistically evaluated but were read to look for common themes.

RESULTS

All 101 students in the class participated in the study. Of those students, 7 played both card games before taking the radiographic physics quiz; there were 48 students who played only the artifacts game and 46 students who played only the contrast and blackness game. For the purposes of statistical comparisons, results of artifacts questions were compared between 55 students who played the artifacts game and 46 students who did not; results of contrast and blackness questions were compared between 53 students who played the contrast and blackness game and 48 who did not.

Based on self-reporting of game plays, students who played the artifacts game played a mean of 2.0 times before taking the quiz, and students who played the contrast and blackness game played a mean of 2.1 times before taking the quiz. There were no differences in number of game plays between groups ($p = .39$).

On quiz questions relating specifically to radiographic artifacts, students who played the artifacts game had a mean score of 4.7 out of 5 (SD 0.5, median 5), and students who had not played the artifacts game had a mean score of 4.5 (SD 0.7, median 5). There was no statistically significant difference in scores between the two groups ($p = .35$).

For quiz questions regarding radiographic contrast and blackness, students who played the contrast and blackness game had a mean score of 4.3 out of 5 (SD 0.7, median 4), and students who had not played the contrast and blackness game had a mean score of 3.8 (SD 1.1, median 4). Scores of students who played the contrast and blackness game were significantly higher than those who did not ($p = .02$).

When providing feedback, students provided overwhelmingly positive responses for both games. Most of students found the games to be fun. For both games, many students reported that they felt that playing games helped them learn the content, especially as the format was different from usual lecture and laboratory formats. Multiple students also specifically commented that the cards were useful for studying alone, that is, using them as flash cards for the concepts. Both games had specific positive comments regarding utility in studying—multiple students who played the contrast and blackness game liked the simple graphical nature of those cards, while numerous students who played the artifacts game commented positively about the use of example images and brief text descriptions of the relevant artifacts. The primary negative points for both games were that a few students found the rules complicated, forcing them to initially focus on learning the rules rather than learning the material (especially in the contrast and blackness game) and that several students found themselves focusing on the competition of the game (just looking at the point values on the cards) rather than trying to learn as they played.

DISCUSSION

The results of this study demonstrate that use of card games as an adjunct learning and studying tool can be useful for improving students' intermediate-term understanding of principles of radiographic quality. However, it must be noted that, as with any other educational tool, not all games are equally beneficial to students' learning. In this study, students who played the contrast and blackness game had higher scores on questions of contrast and blackness than did their classmates who did not play the game. However, scores on artifacts questions were not significantly different between students who played the artifacts game and those who did not.

Findings from this study are similar to those previously found in studies where students' understanding was assessed immediately after game play: some games lead to improvement in scores,[4–7,9] but playing games does not invariably result in better scores than more conventional learning opportunities.[3,9]

The contrast and blackness game may have led to better results for participants than the artifacts game because of differences in game play mechanics. In the contrast and blackness game, students must think about the various radiographic factors to optimize placement of the card, possibly leading students to internalize the information. The artifacts game, however, can be played without focusing on the artifact images and explanatory information. Thus, learning in the artifacts game is either more passive or requires more concerted effort on the part of the participants. Either way, the learning component of the artifacts game is not as inherent to game play as it is in the contrast and blackness game, possibly decreasing its utility as a learning tool.

An additional factor that may have contributed to the lack of difference in artifacts scores between the two groups is the relatively high score achieved even by those students who did not play the game. The mean score for the students who did not play the game (4.5 out of 5) was higher than I expected on the basis of experience from previous years, meaning that there would be little room for improvement regardless of the intervention. It is possible that the relatively high control scores are due to students studying more because they recognized my emphasis regarding this topic or because additional study materials related to the game were available online for in-depth studying. Interestingly, however, similar effects were not identified with contrast and blackness questions despite equivalent instructor emphases; the cause for this disparity is not clear, although it is likely that contrast and blackness is simply a more difficult topic than artifacts. Keeping this premise in mind, it would seem that topics that are best suited for game development are those that are truly challenging to students, not those that are merely underemphasized. Of course, differentiating those two states can be difficult.

It is important to note that the card games were not intended to be a substitute for conventional teaching methods such as didactic lectures and case studies. Over the course of the study, students' game play was in addition to whatever additional studying each student found appropriate. In addition, support resources for each game were available for all students on the course's website, so differences in results between groups would be limited to game play itself, not access to resources.

The objective results of this study and the student comments underscore several important considerations for development of educational games. First and foremost is that the learning opportunities must be inextricably tied to the game play mechanics. The differences in student performance between the two games in this study suggest that learning is more likely to occur when it is an integral part of the game and is much less likely to occur if learning is secondary to (or unrelated to) game play. Game rules must be kept simple so that the emphasis of game play can remain on the learning, not on the understanding of game procedures. Nonetheless, game play that is too simplistic may not be sufficiently engaging. The novel formats used by board and card games will keep many students engaged in learning, perhaps more so than conventional studying, but competition can also be a distraction from learning. A few students did not find the games to be particularly helpful, which is not surprising considering the wide variety of learning styles identified in professional students.[10,11] Nonetheless, even those students who did not find group play to be beneficial generally stated that the games were useful as flash cards for solitary studies. As students were allowed to use the games in their studies as they saw fit, either in a single-player or multi-player setting, evaluation of specific benefits of competition versus self-study is beyond the scope of this assessment.

The primary limitation of this study was the lack of a strictly defined control for each game. Results of game play relative to conventional studies could be more directly compared if game play was restricted to a certain amount of time and if students who didn't play the game were instructed to study the given topic via conventional means for the same amount of time. However, this was considered to be too constrictive given the wide variety of study preferences exhibited by students. Thus, students who played a given game and those who didn't play that game were allowed to use their discretion regarding how much time to spend in their respective activities; this is relevant to normal circumstances, as home study time allowed is generally not prescribed by instructors for any course.

Another limitation of this study is that there was not a strictly prescribed interval between students playing the game and taking the quiz. As the intent was for students to use the game as part of their studies, participants were not limited as to when they were allowed to play the game or take the quiz. Thus, some students may have played the game immediately before taking the quiz, while other students may have let several days pass between playing their game and taking the quiz. Because of this, it is not possible to draw conclusions regarding the longevity of recall that can be attributed to the games.

While this study demonstrated that educational games can be used to improve student understanding of material in the intermediate term, addition evaluation will be required to determine if long-term understanding is affected by game play. Assessment of students' knowledge of the material could be performed at the end of the semester or even during subsequent years to determine if there is a long-standing benefit of game play.

CONCLUSION

The results of this study demonstrate that card games can be useful as a supplement to normal studies in improving student understanding of concepts of radiographic quality. However, specific game mechanisms and focus may determine how successful a game is in meeting its objectives. Thus, while continued use of some games as a study tool is warranted, play testing is also useful to determine the utility of a given game.

CONFLICT OF INTEREST

The author declares no conflict of interest. The author alone is responsible for the content and writing of this article. Partial funding support for this study was provided by a University of Minnesota College of Veterinary Medicine Educational Development/Curriculum Implementation Grant.

REFERENCES

1 Bochennek K, Wittekindt B, Zimmermann S-Y, et al. More than mere games: a review of card and board games for medical education. Med Teach. 2007;29(9–10):941–8. https://doi.org/10.1080/01421590701749813. Medline:18158669

2 Akl EA, Pretorius RW, Sackett K, et al. The effect of educational games on medical students' learning outcomes: a systematic review: BEME Guide No 14. Med Teach. 2010;32(1):16–27. https://doi.org/10.3109/01421590903473969. Medline:20095770

3 Akl EA, Kairouz VF, Sackett KM, et al. Educational games for health professionals. Cochrane Database Syst Rev. 2013;(3). https://doi.org/10.1002/14651858.CD006411.pub3.

4 Steinman RA, Blastos MT. A trading-card game teaching about host defence. Med Educ. 2002;36(12):1201–8. https://doi.org/10.1046/j.1365-2923.2002.01384.x. Medline:12472757

5 Michel da Rosa AC, Osowski LF, Tocchetto AG, et al. An alternative teaching method for the regulation of the immune response. Med Educ Online. 2003;8(1):4335. https://doi.org/10.3402/meo.v8i.4335. Medline:28253158

6 Da Rosa ACM, Moreno FL, Mezzomo KM, et al. Viral hepatitis: an alternative teaching method. Educ Health (Abingdon). 2006;19(1):14–21. https://doi.org/10.1080/13576280500524330. Medline:16531298

7 Girardi FM, Nieto FB, Vitória LP, et al. T- and B-cell ontogeny: an alternative teaching method: T- and B-cell ontogeny game. Teach Learn Med. 2006;18(3):251–60. https://doi.org/10.1207/s15328015tlm1803_11. Medline:16776614

8 Ober CP. Assessment of student engagement when using a novel board game for teaching thoracic radiography to fourth-year veterinary students. Med Sci Educ. 2016;26(1):39–42. https://doi.org/10.1007/s40670-015-0222-7.

9 Ober CP. Novel card games for learning radiographic image quality and urologic imaging in veterinary medicine. J Vet Med Educ. 2016;43(3):263–70. https://doi.org/10.3138/jvme.0715-108R. Medline:26966984

10 Lujan HL, DiCarlo SE. First-year medical students prefer multiple learning styles. Adv Physiol Educ. 2006;30(1):13–6. https://doi.org/10.1152/advan.00045.2005. Medline:16481603
11 Neel JA, Grindem CB. Learning-style profiles of 150 veterinary medical students. J Vet Med Educ. 2010;37(4):347–52. https://doi.org/10.3138/jvme.37.4.347. Medline:21135401

AUTHOR INFORMATION

Christopher P. Ober, DVM, PhD, Dipl. ACVR, is Associate Professor of Medical Imaging, Department of Veterinary Clinical Sciences, University of Minnesota College of Veterinary Medicine, 1365 Gortner Avenue, St. Paul, MN 55108 USA. Email: cpober@umn.edu. His research interests include both development and improvement of new teaching strategies (especially educational game play) and assessment of diagnostic imaging accuracy in naturally occurring disease states.