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Practice testing is an effective learning strategy, but it can lead to increased test anxiety and often has low voluntary participation rate. This paper describes a case study on the effects of a re-designed practice test using game-like elements. The results indicate that the gamified practice test had a high student participation rate and showed improved test performance.

INTRODUCTION

Research shows that practice testing is an effective learning strategy for students (Dunlosky, Rawson, Marsh, Nathan, Willingham, 2013). Practice testing builds upon the testing effect, where participants exhibit better delayed recall performance after experiencing practice tests prior to the final test (Karpicke & Roediger, 2008; Roediger & Karpicke, 2006). Practice testing, however, can lead to increased test anxiety (Nguyen & McDaniel, 2015). Furthermore, when practice testing is optional, participation and completion rates of students are low (Griffin & Gable, 2016; Kromann, Jensen & Ringsted, 2009). This study proposes a novel way to design a practice testing strategy that involves elements of gamification. A gamified learning strategy retains the long-term recall effect of practice testing, while increases students' willingness to participate in the practice test.

The *testing effect* is the phenomenon where repeated testing increases delayed recall performance (Karpicke & Roediger, 2008; Roediger & Karpicke, 2006). Studies have shown that, while repeated studying increases immediate recall performance, they are not effective in promoting long-term recall (Roediger & Karpicke, 2006). This seems to indicate that long-term recall performance is dependent on the number of

prior retrieval practices and not on the number of encoding sessions. The more practice recall that participants engage in, the slower is the process of forgetting. The testing effect appears to be the strongest when the practice test and the final test use the same questions and answers (Nguyen & McDaniel, 2015). However, if the practice test questions differ from the final test questions but are on similar topics, practice testing still provides positive benefits to long term retention (Batsell, Perry, Hanley & Hostetter, 2016). This implies that practice testing is not just an effective strategy because students are seeing the same test questions multiple times. There is still a positive effect of practice testing even when the questions in the final testing phase differ from the questions in the practice testing phase. This testing effect can be observed both in the laboratory and classroom settings (Batsell et al., 2016).

Although the testing effect is an effective strategy for promoting long-term recall, it has its limitations. For example, in order to achieve the testing effect in the classroom, teachers must give regular quizzes prior to a unit exam, and these quizzes can induce test anxiety and cause increased stress (Chapell, Blanding, Silversteing, Takahashi, Newman, Gubi & McCann, 2005; Nguyen & McDaniel, 2015). Conversely, when the practice testing is voluntary, students' participation is low (Griffin & Gable; 2016; Kromann, Jensen & Ringsted, 2009).

In the study conducted by Griffin and Gable (2016), students' participation level in pre-exam review sessions varied by the course level and student classification. Less than 40% of the freshmen and sophomores in the lower level course attended the review session.

The incorporation of gamified elements into learning appears to be a good solution to some of the problems surrounding the practice testing strategy. In the specific context addressed by this paper, gamification is the incorporation of game-like elements (e.g., points, leaderboards, challenges, rewards) in teaching (Deterding, Khaled, Hacke & Dixon, 2011; Hamari, Koivisto & Sarsa, 2014). The elements that are most relevant to the implementation of practice test should include a leaderboard, a clear challenge, and a reward for the winner. Past studies have shown that a gamified learning strategy provides more motivation for the students and can lead to greater levels of enjoyment and engagement (Felicia, 2012; Stansbury & Earnest, 2017). The incorporation of game-like elements is therefore a suitable strategy in re-designing the traditional practice test.

THE CURRENT STUDY

The current case study describes the procedure and the outcome of a gamified practice test in an introductory psychology course. One of the considerations in implementing practice tests in an introductory psychology course is the balance between the amount of effort expected from the students and the resulting long-term retention level. Past studies have shown that repeated retrieval attempts enhance learning:

the more retrieval trials one engages in, the better is the person's long term retention (Karpicke et al., 2008). This learning effect occurs even when students don't do well on the practice tests (Kornell, Klein & Rawson, 2015). Taken these two findings together, it seems that the best way to promote learning is to require students to take as many practice tests as possible. The problem with this "more is better" logic in designing a practice test is that it could lead to excessive anxiety and stress on the students. A gamified, optional practice test that allows students to voluntarily participate is thus a good compromise which allows students the freedom to choose the amount of time and energy spent. The current study describes a gamified practice test and compares students' participation rate against previous research.

Method

Participants

Participants were 81 students in an Introduction to Psychology course at a large state university. The class met twice a week and had a flipped-classroom model, with many of the reading assignments and quizzes delivered through an online learning management system (LMS). Each class session was split, with 30% of the time spent on a short lecture and 70% of the time spent on team-based problem solving tasks.

Materials

Students were instructed to participate individually on an online timed-quiz hosted in Blackboard LMS, and to complete as many quiz questions as possible in a span of 10 minutes. The quiz questions were pulled from a collection of 363 questions,

curated from a publisher provided test-bank. The questions were either factual recall questions or novel application questions. The order of the questions was pseudo-random, such that students would receive a different set of questions in each attempt. Students were given unlimited attempts on the quiz and only the highest score was registered by Blackboard LMS.

The actual unit exam happened two hours after the deadline to participate in the practice quiz. The unit exam was presented to students on paper in the classroom. The exam had a total of 56 multiple choice questions. The questions on the unit exam were derived from similar topics as the practice quiz but they were a different set of questions.

Procedure

The gamified practice quiz was presented to students as a "King of the Hill Challenge" one week prior to the unit exam in the class. Students were told that they could take a voluntary quiz challenge in Blackboard LMS that had a 10-minute timer. The student who received the highest score in a span of 10 minutes was exempt from taking the exam with an automatic 56/56 grade on the exam. In case of a tie, the top scorers would still need to take the exam and share the 56 points evenly as bonus points up to 100%. Students had one week to participate in the challenge and the challenge ended two hours prior to the unit exam. The students took the unit exam individually in class. They had 75 minutes to complete the unit exam.

Students were instructed to update their personal high score on the practice quiz on a class discussion forum hosted in Blackboard LMS. Students were required to update their highest score immediately or they would risk disqualification.

Students were not penalized for any of quiz attempts and they were only required to report their highest score on the discussion forum.

Results

Of the 81 students, 59 students (73%) participated in the optional gamified practice quiz and 43 students (54%) took the practice quiz two-times or more. The average number of attempts per student, for those that attempted the practice test, was 7.7, which translates to approximately an hour and seventeen minutes spent on the practice quiz. The highest number of attempts recorded by an individual student was 65, which translates to 10 hours and 50 minutes spent on the practice quiz.

Correlation analysis revealed that there was a significant positive correlation between the number of attempts on the practice quiz and the score on the unit exam ($r(79)=0.313$, $p<0.01$). To examine the effect of practice quiz attempts on the unit exam's score, we divided the students into six groups in a post-hoc analysis: Group 1 included students who made zero attempts on the practice test (n=22); Group 2 made 1-5 attempts (n=36); Group 3 made 6-10 attempts (n=12); Group 4 made 11-15 attempts (n=2); Group 5 made 16-20 attempts (n=3); and Group 6 made 20 or more attempts (n=6). Data from the winner of the challenge was included in the group with 20 or more attempts. Figure 1 summarizes students' performance on the unit exam; the error bars denote ±1 standard error.

A one-way ANOVA test revealed that there was a main effect of the attempts made during the practice quiz on student's test performance on the exam ($F(5, 75)=4.620$,

$p<0.01$, partial $\eta^2=0.235$). Planned contrasts revealed that the group that did not attempt the practice quiz had significantly worse performance than the groups that did attempt the practice quiz at least once ($t>2.5$, $p<0.05$), except the attempt group that made between 6 and 10 attempts on the practice test ($t=1.5$, $p=0.14$). A small sample size and random error probably contributed to the non-significant comparison between the group with 6-10 attempts and the group that made no attempt on the practice test.
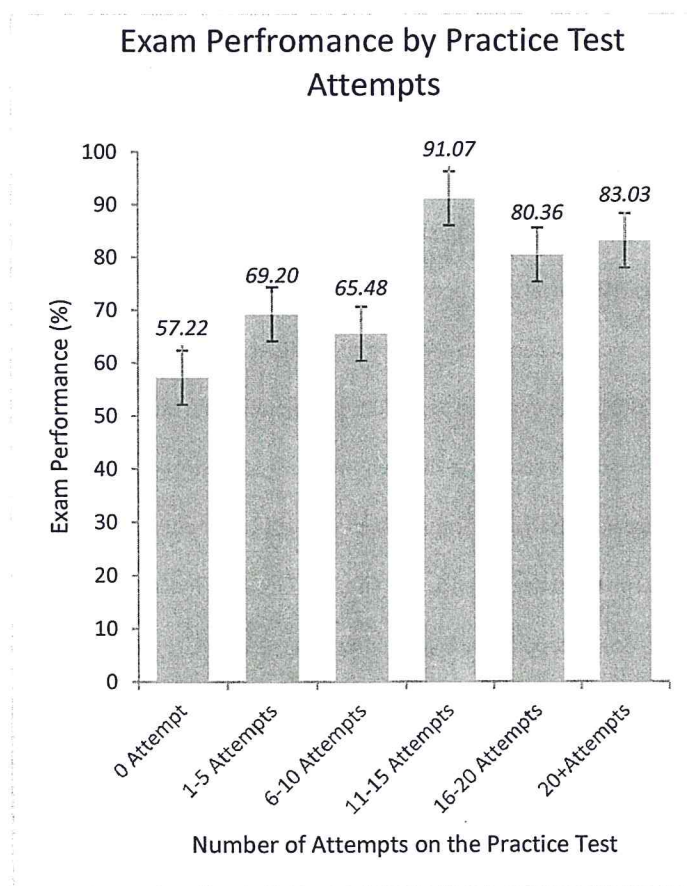
Exam Perfromance by Practice Test Attempts

Figure 1. Students' performance on Exam 1 (error bars denote one standard error)

Discussions

The current study describes a novel design of a practice test by inserting game-like elements. The advantage of this design is that instructors can easily implement the game-like elements using existing functions within most online learning management systems, such as Blackboard or Canvas. A gamified practice test also encouraged engagement and motivation as shown by the high participation rate. The study showed that close to 73% of the students voluntarily took the practice test under the current design with 28% of the students taking the practice test six or more times, spending at least one hour on the practice test. The participation rate was high compared to a previous study that showed less than 40% participation rate (Griffin & Gable, 2016). The gamified practice test also appeared to be an effective review strategy for students, yielding better exam performance for those that participated.

There are several limitations to the current study. First, the described study was a case study instead of an experiment. There was a lack of a comparison between a gamified practice test and a non-gamified traditional practice test. Second, as with any study that requires voluntary participation, the findings in this study might be the result of participants' inherent motivation and self-selection. It is possible that those who attempted the practice test were better students to begin with. Nonetheless, the important finding in this study is that over 70% of the students, most of whom were college freshmen, voluntarily participated in the practice test. The participation rate was much higher compared to a similar study that targeted college freshmen and sophomores (Griffin & Gable, 2016).

Future studies should involve a quasi-experiment design for ecological validity, comparing the participation rate between a gamified practice test versus a traditional practice test without gamification.

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