The Educational Value of Online Mastery Quizzes in a Human Anatomy Course for First-Year Dental Students

Lisa M.J. Lee, Ph.D.; Rollin W. Nagel, Ph.D.; Douglas J. Gould, Ph.D.

Abstract: The purpose of this study was to evaluate the effectiveness of online mastery quizzes in enhancing dental students’ learning and preparedness for anatomy examinations. First-year dental students taking an integrated anatomy course at The Ohio State University were administered online mastery quizzes, made available for five days before each examination. The mastery quizzes were comprised of ten multiple-choice questions representative of the upcoming examination in content and difficulty. The students were allowed to access this resource as many times as they desired during the five-day window before each examination; the highest score for each student was added to his or her final course grade. The results indicate that almost all the students took advantage of this resource to reinforce content, clarify concepts, and prepare for the examinations. Statistical analyses of the students’ exam performance showed that the mastery quizzes neither improved nor reduced their exam scores, but multiple regression analyses showed that the initial mastery quiz scores had a predictive value for their examination performance, suggesting a potential for mastery quizzes as an intervention tool for such a course. Online mastery quizzes, when used effectively, may be an effective resource to further engage dental and other students in educational endeavors and examination preparation and as a predictor of success.

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Mastery learning is based on the idea that, given appropriate learning conditions, time, and resources, every student can achieve content mastery.1-3 Techniques for teaching and learning for mastery involve allowing students to advance to the next level of a learning task only when they demonstrate proficiency on the current learning objective.3 Demonstration of proficiency is achieved through various forms of assessment such as quizzes, tests, and practical exams.4,5 Studies have confirmed that mastery learning increases student performance on course exams6,7 however, prior investigations have been performed at the secondary education level, rather than addressing the utilization of mastery learning pedagogies in professional science curricula. With advances in educational technologies such as sophisticated online course management software and other web-driven applications, promoting mastery learning has become much easier for instructors. With the new generation of digitally savvy students, the idea of using technology for education has never been so welcomed and readily adapted by students as today.8-11

A series of online mastery quizzes for first-year dental students were developed, using course management software at The Ohio State University, to leverage the new technology and the students’ abilities, and their educational value was evaluated. The human anatomy course sequence at The Ohio State University is a required one-year integrated curriculum for first-year dental students, comprised of the four subdisciplines of anatomy: embryology, histology, anatomy, and neuroanatomy. For a number of reasons, many students find this course to be one of their most challenging. Reasons include the large amount of content to cover, heavy curricular hour commitment, and difficulty adjusting to the new professional learning environment that most students are experiencing for the first time. To make the challenging human anatomy sequence more effective and efficient for both instructors and students, online mastery quizzes were utilized throughout the year in 2008–09. Each online mastery quiz was designed to provide students with immediate feedback on their learning progress and assessment of their readiness for examinations; in the process, the quizzes helped
students identify areas of weakness and solidify concepts toward content mastery.

In this study, we evaluated the educational impact of the online mastery quizzes by quantifying their effectiveness in promoting the students’ anatomy content mastery as measured by exam performance throughout their first year in dental school. As Dental Admission Test scores and undergraduate grade point average are frequently used by dental schools as part of their admissions criteria and predictors of students’ curricular success, we comparatively analyzed the mastery quiz scores to these predictive figures. Furthermore, in this report, we present the results gathered in a survey of the students’ perceived educational value of the online mastery quizzes and the quizzes’ effects on students’ exam preparedness, self-efficacy, and anatomy content mastery.

Methods

Each online mastery quiz, comprised of ten multiple-choice questions representative of the upcoming examination, was generated using Carmen (an Ohio State University course management and delivery system based on Desire2Learn technology). The quiz was made available online five days before each examination to the 106 first-year dental students enrolled in the integrated anatomy course sequence (Anatomy 601, 602, and 603) at The Ohio State University during the 2008–09 academic year. Questions for each mastery quiz consisted of quantitatively validated exam questions from previous years, written by the instructors who taught the courses.

During the five-day window, the students were able to take the quiz as many times as they wanted, and the highest score for each student was added to his or her final course grade. At the end of each quiz session, students were provided with a score but no answer key; hence, the only way to obtain a perfect score was to take the quiz over. While the set of questions remained the same, the multiple-choice options for each question were randomized every time a new quiz session began, so the students could not memorize answer choices.

To evaluate the students’ perceptions of the online self-testing resource, an online, anonymous survey was generated in Carmen and made available to the students at the end of the integrated anatomy course. The students were awarded a bonus point toward their final grade for completing the survey. The survey questions were developed by the same instructors who taught the course and generated the mastery quiz questions. Survey questions were reviewed in a focus group discussion among three educational specialists conducted by the educational and survey specialist in the Center for Educational Scholarship at The Ohio State University College of Medicine. This group’s suggested changes were made to the final survey taken by the students. The survey consisted of ten Likert scale questions (Table 1).

To evaluate the educational value of the online mastery quizzes, the average of nine anatomy exam scores of the experimental group (2008–09 class) were compared with those of the control group (106 students in the 2009–10 class). Other than the mastery quiz variable, there was minimal change in the courses taken by the experimental and control groups; both had the same instructors, contents, and textbooks. Multiple regression analyses were used to evaluate whether Dental Admission Test total average (DATTA), undergraduate grade point average (UG-

<table>
<thead>
<tr>
<th>Survey Item</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I used mastery quizzes (MQs) as a resource to measure my knowledge and preparedness for exams.</td>
<td>4%</td>
<td>7%</td>
<td>89%</td>
</tr>
<tr>
<td>2. I took MQs primarily to get additional points.</td>
<td>16%</td>
<td>22%</td>
<td>61%</td>
</tr>
<tr>
<td>3. I prefer to access MQs online rather than on paper.</td>
<td>3%</td>
<td>1%</td>
<td>96%</td>
</tr>
<tr>
<td>4. I took MQs alone.</td>
<td>4%</td>
<td>4%</td>
<td>92%</td>
</tr>
<tr>
<td>5. I took MQs as soon as they were made available.</td>
<td>53%</td>
<td>18%</td>
<td>28%</td>
</tr>
<tr>
<td>6. My initial MQ score was indicative of my exam score.</td>
<td>59%</td>
<td>18%</td>
<td>22%</td>
</tr>
<tr>
<td>7. MQs were representative of the exams.</td>
<td>27%</td>
<td>21%</td>
<td>51%</td>
</tr>
<tr>
<td>8. I identified my area of weakness after taking MQs.</td>
<td>10%</td>
<td>5%</td>
<td>85%</td>
</tr>
<tr>
<td>9. MQs helped solidify concepts.</td>
<td>9%</td>
<td>23%</td>
<td>68%</td>
</tr>
<tr>
<td>10. MQs are a valuable learning resource.</td>
<td>5%</td>
<td>11%</td>
<td>84%</td>
</tr>
</tbody>
</table>

Note: Percentages may not total 100% because of rounding.
GPA), and initial mastery quiz (MQ) scores (from the first completed submitted quiz) predicted the examination scores. The percent score was used as the examination performance measure. This study was reviewed by The Ohio State University Institutional Review Board and was determined to be exempt.

Results

Students’ Use of Quizzes

One hundred percent of the first-year dental students enrolled in the 2008–09 academic year’s dental gross anatomy course took the online mastery quizzes—on average taking it five times per exam block. The students indicated on the survey that their primary motivation for taking the mastery quizzes was to evaluate their content knowledge and preparedness for examinations (Table 1, survey item 1). The secondary motivation for taking the online mastery quizzes was to get additional points toward their course grade (Table 1, survey item 2), indicating students’ priority was on evaluation of their content mastery. The results also indicated that the students welcomed the use of technology for accessing the mastery quizzes, with over 90 percent of the students reporting their preference for online rather than paper mastery quizzes (Table 1, survey item 3).

Though the students were neither encouraged nor discouraged to work in groups when taking the mastery quizzes, the students seemed to prefer taking the quizzes independently rather than in a group, as 91 percent reported taking them alone (Table 1, survey item 4). This finding suggests that the format of the online mastery quizzes used in this study is probably not conducive to team-based or collaborative learning.

The majority of the students (78 percent) also indicated that they did not take the online mastery quizzes as soon as they were made available, which in most cases was five days before the examination (Table 1, survey item 5). This may suggest that the students were prone to “cram” for the examinations.

Effect on Exam Performance and Students’ Perceptions

Independent t-test analyses comparing the nine anatomy exam scores between the control group (106 first-year dental students in the 2009–10 academic year who did not have the mastery quizzes) and the experimental group (106 first-year dental students in the 2008–09 academic year who had the mastery quizzes) showed no consistent difference in exam performance between the two classes. The course format, instructors, and course content per exam were unchanged between the two groups. The 2008–09 experimental group performed significantly better (p≤.05) on examinations 2, 6, and 7 than the 2009–10 control group; the 2009–10 class performed significantly better on examinations 1, 3, and 5; and there was no difference between classes for exams 4, 8, and 9. These findings indicate that the online mastery quizzes in their current format may not be the most effective resource to enhance students’ anatomy examination performance.

Multiple regression analyses revealed that the combination of DATTA, UGGPA, and respective initial MQ scores significantly predicted (p≤0.05) each of the examination scores except for the fifth exam. The R-square for these significant predictions ranged from 0.120 to 0.294. For six out of nine exams, students’ initial MQ score was a significant predictor of their corresponding exam performance independent of their DATTA and UGGPA. Students’ UGGPA was a significant predictor of their exam performance for seven of the exams, while their DATTA was a significant predictor for only four of the exams (Table 2).

The students’ perception of the mastery quiz’s predictive value was incongruous as the majority (59 percent) disagreed with the survey item “My initial mastery quiz scores were usually indicative of my examination scores” (Table 1, survey item 6). The majority of the students (51 percent) agreed that the online mastery quizzes were representative of their corresponding examinations in content and difficulty (Table 1, survey item 7).

Despite the absence of a consistent exam performance improvement as a result of online mastery quiz implementation, the majority of the students reported a positive perception of the resource and evaluated its educational value as high. Most of the students reported that they were able to identify areas of content weakness after taking the online mastery quizzes (Table 1, survey item 8); that the quizzes helped them solidify concepts after taking the mastery quizzes (Table 1, survey item 9); and that they found the mastery quizzes to be a valuable learning resource (Table 1, survey item 10). The most common student comment on the survey called for larger numbers and a greater variety of mastery quiz questions.
driven, dynamic mastery quiz and its impact on mastery learning in an anatomy course should be investigated in the future.

The current format of the online mastery quiz in our study led to an interesting discovery: that the initial mastery quiz scores had a statistically significant predictive value for students’ examination performance independent of their undergraduate GPA and DAT scores. Dental school admissions criteria such as undergraduate GPA and DAT scores have been used in the past as performance prediction tools, but our study suggests that the DAT may not be the most accurate predictor of students’ success in gross anatomy. In contrast, undergraduate total GPA was a more consistent predictor of the first-year dental students’ performance on the gross anatomy exams. This is consistent with previous findings that undergraduate GPA tends to have stronger predictive value than DAT scores for dental school performance. As undergraduate total GPA of the first-year dental students is commonly not available to these course instructors, the initial mastery quiz scores may serve an even greater educational value. In fact, the ability of mastery quizzes to accurately predict anatomy exam performance should be considered as a useful admissions, curriculum development, or academic intervention tool as they provide accurate performance status of the students in real time. If applied and analyzed in a timely fashion, curricular areas and course topics that need additional attention may be identified.

Contrary to the multiple regression findings, the students’ survey revealed that the majority did not perceive their initial mastery quiz scores to be

Discussion

In our study, the online mastery quizzes neither consistently improved nor reduced the first-year dental students’ anatomy examination performance. This may be a result of the mastery quiz format in our study in which only the answer choices are randomized while the questions remain the same. This format may not be conducive to mastery testing and learning in the truest sense. In recent years, different forms of mastery quizzes have been used as a part of the mastery learning pedagogical tool to call students’ attention to important concepts in class or as a diagnostic pre-assessment to assess the content objectives accordingly. Two studies have reported primarily a positive educational impact in their experimental groups’ performance. In addition, Cees and Hans implemented adaptive mastery testing in both a sequential manner and an adaptive sequential manner and found that the format of mastery quizzes that introduce progressively more challenging questions increased students’ simulation performance in comparison to a fixed test, with the adaptive testing producing higher performance results. While the technology for adaptive sequential mastery testing is still lagging in most course management software, it is possible to create randomized mastery quizzes that introduce different questions every time the mastery quiz is repeated. This technique may ensure that students do not memorize the questions and, instead, truly engage in the mastery learning process through problem-solving activities. Practical application of this type of technology-driven, dynamic mastery quiz and its impact on mastery learning in an anatomy course should be investigated in the future.

The current format of the online mastery quizzes in our study led to an interesting discovery: that the initial mastery quiz scores had a statistically significant predictive value for students’ examination performance independent of their undergraduate GPA and DAT scores. Dental school admissions criteria such as undergraduate GPA and DAT scores have been used in the past as performance prediction tools, but our study suggests that the DAT may not be the most accurate predictor of students’ success in gross anatomy. In contrast, undergraduate total GPA was a more consistent predictor of the first-year dental students’ performance on the gross anatomy exams. This is consistent with previous findings that undergraduate GPA tends to have stronger predictive value than DAT scores for dental school performance. As undergraduate total GPA of the first-year dental students is commonly not available to these course instructors, the initial mastery quiz scores may serve an even greater educational value. In fact, the ability of mastery quizzes to accurately predict anatomy exam performance should be considered as a useful admissions, curriculum development, or academic intervention tool as they provide accurate performance status of the students in real time. If applied and analyzed in a timely fashion, curricular areas and course topics that need additional attention may be identified.

Contrary to the multiple regression findings, the students’ survey revealed that the majority did not perceive their initial mastery quiz scores to be

Table 2. Statistical analyses of correlation between students’ exam performance and DATTA, UGGPA, and initial MQ scores

<table>
<thead>
<tr>
<th></th>
<th>Exam 1</th>
<th>Exam 2</th>
<th>Exam 3</th>
<th>Exam 4</th>
<th>Exam 5</th>
<th>Exam 6</th>
<th>Exam 7</th>
<th>Exam 8</th>
<th>Exam 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATTA</td>
<td>0.306*</td>
<td>0.179</td>
<td>0.114</td>
<td>0.280*</td>
<td>-0.021</td>
<td>0.264*</td>
<td>0.119</td>
<td>0.314*</td>
<td>0.099</td>
</tr>
<tr>
<td>p-value</td>
<td>&lt;0.001*</td>
<td>0.069</td>
<td>0.246</td>
<td>&lt;0.003*</td>
<td>&lt;0.010*</td>
<td>0.231</td>
<td>&lt;0.002*</td>
<td>&lt;0.002*</td>
<td>&lt;0.002*</td>
</tr>
<tr>
<td>UGGPA</td>
<td>0.345*</td>
<td>0.222*</td>
<td>0.288*</td>
<td>0.088</td>
<td>0.220*</td>
<td>0.260*</td>
<td>0.233*</td>
<td>0.185</td>
<td>0.241*</td>
</tr>
<tr>
<td>p-value</td>
<td>&lt;0.001*</td>
<td>&lt;0.024*</td>
<td>&lt;0.003*</td>
<td>0.358</td>
<td>&lt;0.035*</td>
<td>&lt;0.008*</td>
<td>&lt;0.021*</td>
<td>0.062</td>
<td>&lt;0.018*</td>
</tr>
<tr>
<td>Initial MQ score</td>
<td>0.183*</td>
<td>0.179</td>
<td>0.209*</td>
<td>0.332*</td>
<td>-0.080</td>
<td>0.299*</td>
<td>0.212*</td>
<td>0.186</td>
<td>0.278*</td>
</tr>
<tr>
<td>p-value</td>
<td>&lt;0.036*</td>
<td>0.065</td>
<td>0.032*</td>
<td>&lt;0.001*</td>
<td>0.432</td>
<td>&lt;0.003*</td>
<td>&lt;0.032*</td>
<td>0.065</td>
<td>&lt;0.006*</td>
</tr>
</tbody>
</table>

Note: Beta weight regression analysis reveals that the initial mastery quiz score has statistically significant predictive value for students’ examination performance, at a similar rate as the undergraduate grade point average. Total DAT score had the least predictive value for first-year dental students’ examination performance.

DATTA=Dental Admission Test total average; UGGPA=undergraduate grade point average; initial MQ score=mastery quiz score from the first completed submitted quiz

*Statistical significance
indicative of their exam performance, which may reflect one of the characteristics of the new generation of self-sufficient and highly confident group of students exhibiting unrealistic self-efficacy or, perhaps, a trait of self-deception.9,11,19 Although some research has found a positive relationship between self-efficacy and academic performance,20,21 Lee and Klein describe their study’s findings of a complex relationship among conscientiousness, self-efficacy, self-deception, and the time factor that plays a role in educational settings.19 As such, based on our study’s findings, students’ awareness of the predictive value of the online mastery quizzes may serve as a “wake-up call” to some students to adjust their studying habits. It is also worth noting that, though the survey items were critically reviewed by a focus group of educational and survey specialists and their recommended changes were implemented, the instructor-run nature of the survey may have introduced potential bias into students’ responses. Such potential bias should be minimized in the future by introducing an impartial party to conduct the survey after the course has concluded.

The ability of the online mastery quizzes to predict exam performance may be temporal in nature. As the students delayed taking the mastery quizzes until immediately before the exam, they were presumably using it as a gauge of preparedness when they felt ready for the exam. This finding points to the need for more innovative instructional methods or resources to engage students in more consistent, ongoing, and active learning both in and outside of the classrooms. Based on students’ largely positive response to the online mastery quizzes’ accessibility and educational value, combined with their consistent course performance predictability, additional research on technology-driven, online resources is warranted to explore the value of mastery learning in dental anatomy education.

REFERENCES