

Impact of Interactive Instructional Tools in Gross Anatomy for Optometry Students: a Pilot Study

Patricia C. Sanchez-Diaz, DVM, PhD

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Background and significance: Virtual resources have become a popular way to enhance lecture and laboratory instruction; however, there is no experimental data assessing their effectiveness in optometry. This study evaluated the effects of different interactive strategies on student motivation and learning outcomes.

Methods: Sixty-five optometry students were assigned to control and intervention groups for the anatomy laboratory. Post-laboratory quizzes and questionnaires were used as assessment tools.

Results: Although questionnaires revealed a positive response, no significant differences were found in quiz scores between the intervention and control groups.

Conclusion: Interactive and audiovisual instructional resources might increase student motivation in anatomy. This may be beneficial for healthcare programs without cadaver labs.

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Introduction

A strong foundation in the basic sciences is essential to ensure the achievement of clinical competencies in our future graduates.¹ Clinical anatomy is a challenging discipline in most health-care programs, including optometry. It requires deep knowledge of anatomical structure, function and their relationships in order to fully understand the clinical correlates. Classical approaches to learning anatomy have emphasized the memorization of lists of descriptive anatomical terms and features, proof of which is the endless and maybe creative catalog of mnemonics commonly used to better retain the information. Different studies have historically aimed to find the perfect strategy for obtaining the best educational outcomes fitting the peculiarities of Malcolm Knowles' adult learning theories.^{2,3} Some recent studies support the effectiveness of student motivation and the utilization of interactive and experience-based learning methods (i.e., constructivism) in anatomy courses.^{4,5,6,7} However, it seems that there is not a perfect recipe for success in this matter.

New technologies are having a tremendous impact on the way we learn and teach. Computer and/or Web-based resources are gaining popularity as lecture- and laboratory-enhancing tools. In fact, virtual dissections and 3D interactive anatomical models, which aim to provide visualization and a better understanding of the potential clinical implications of anatomical dysfunction, are emerging as convenient supplementary methods, or even substitutes, for the use of cadavers.^{5,8,6,7,9}

The purpose of this study was to evaluate the effects of different educational strategies in motivation and in learning outcomes of first-year optometry students. The results of this work suggested that the utilization of supplementary audiovisual resources and virtual 3D models, along with the creation of critical-thinking questions and clinical scenarios, may enhance the laboratory instruction in anatomy by promoting student motivation. The results obtained with this pilot study may allow us to apply similar strategies in more

Patricia C. Sanchez-Diaz, DVM, PhD, is an Assistant Professor at the University of the Incarnate Word Rosenberg School of Optometry in San Antonio, Texas. She teaches anatomy and molecular genetics to first-year optometry students and is also involved with the undergraduate vision science program.

clinical courses in optometry and possibly in other health sciences programs.

Methods

This study was conducted with approval from the Institutional Review Board Committee of the University of the Incarnate Word (protocol #11-08-005). Invitation letters were sent to the university’s 65 first-year optometry students. All 65 students enrolled in the Anatomy and Histology course (fall semester 2011) signed the consent letter, and they all completed the study.

Design overview and instructional tools

Students were assigned to two laboratory groups (control and intervention) based on their last names in alphabetical order. In both groups, laboratory instruction was performed in two-hour laboratory sessions for a period of 13 weeks. Results from post-laboratory quizzes were collected only during the first seven laboratory sessions. During this initial period, laboratory instruction did not include the use of any interactive or audiovisual instructional tools for the control (Tuesday) group. Only traditional methods, e.g., atlases, textbooks and anatomical laboratory models, were used. Instruction for the intervention (Thursday) group was enhanced by the addition of interactive and audiovisual tools, which included iPad applications (Table 1), YouTube videos (related to cadaver dissections, medical procedures or functional anatomy), clinical scenarios and/or the elaboration of critical-thinking questions. In both the control and intervention groups, five to six students sat at each table, and teamwork was strongly encouraged. At the end of the laboratory session, students were asked to take a post-laboratory quiz consisting of applied and clinical questions.

Students tend to share information they consider relevant for their learning. In order to prevent this from affecting the study results, I did the following. 1) The control group for each laboratory session met prior to the intervention group so that students in the intervention group were only able to share the supplemental tools with students in the control group once the control group

had already taken the lab quiz. 2) Students in the control group were asked not share quiz questions with students in the intervention group. 3) Students were aware that the grades obtained in these laboratory quizzes did not count toward their course grade. The fact that the control group scored slightly higher on all laboratory quizzes than the intervention group further confirmed that students did not discuss any information relevant to this study.

Data analysis

Averages and distribution of post-laboratory quiz scores were compared between the control and intervention groups. An anonymous laboratory eval-

uation form comprising a five-point Likert scale questionnaire and three open-ended questions (Table 2) was given to the students at the end of the 13th laboratory session to gather their feedback. Data is presented as average plus/minus (±) standard deviation. Linear regression analyses (SPSS predictive analytics software, IBM) were performed to determine statistical differences between group quiz scores. To compensate for potential inherent differences between the control and intervention groups, student demographic (gender, age and ethnicity) and academic (if they had a bachelor’s degree, if they had taken a pre-optometry anatomy course and the final grade

Table 1
iPad Applications Used in this Study

1.	Netter's Anatomy Atlas
2.	Gray's Anatomy for Students Flash Cards
3.	Netter's Concise Radiologic Anatomy
4.	Netter's Advanced Head and Neck Flash Cards
5.	Human Body 3d 2
6.	Heart Pro (NOVA Series) - iPad edition by 3D4Medical
7.	Skeletal System Pro II - (NOVA Series) - iPad edition by 3D4Medical
8.	Clemente's Anatomy Flash Cards
9.	Digestive System - iPad edition by 3D4Medical
10.	Brain Pro Nova series
11.	Muscle System Pro II - (NOVA Series)
12.	Nervous System - iPad edition by 3D4Medical
13.	Skeletal 3d Anatomy for iPad

Table 2
Five-Point Likert Scale Questionnaire and Open-Ended Questions

Questionnaire	
1: strongly disagree	2: disagree 3: neutral 4: agree 5: strongly agree
1.	The laboratory learning objectives were met by using Interactive Instructional Tools (IIT)
2.	The use of IIT allowed you a better understanding of important concepts
3.	The use of IIT improved your performance in this course
4.	The IIT offered in this course were user-friendly
5.	The IIT offered in this course were convenient learning methods
6.	The IIT offered in this course were stimulating and engaging learning methods
7.	The IIT offered in this course allowed you to be less dependent on the instructor
8.	The IIT offered in this course resulted in a more efficient utilization of the instruction time
9.	The experience was overall effective for your learning
10.	You would like to use IIT in other courses
Open-ended questions	
1.	From the IIT used in this course, which one did you find most beneficial in your learning?
2.	Which IIT did you like best?
3.	Please provide any suggestions that may improve laboratory instruction

obtained in this anatomy course) information was included as variables in the regression analyses. $P < 0.05$ was used as the cutoff to determine statistical significance.

Results

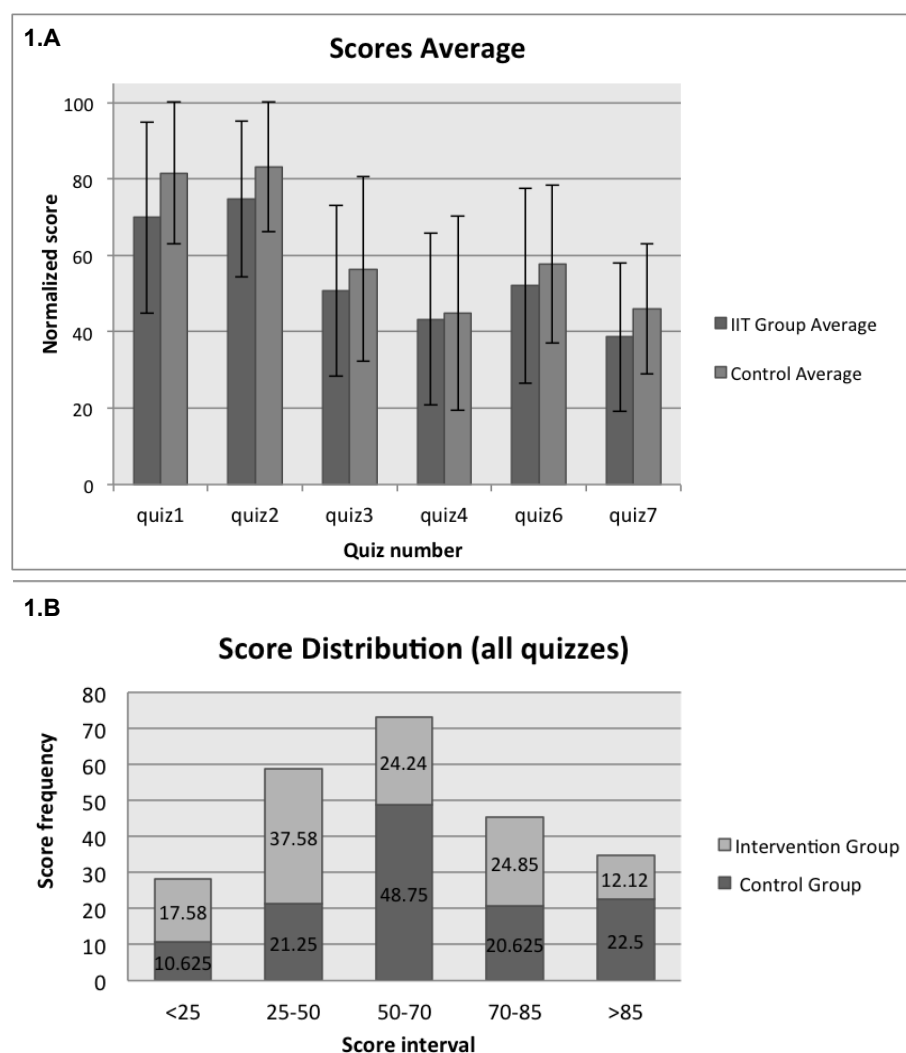
In this study, I evaluated the impact of the incorporation of several supplementary resources in the gross anatomy laboratory. Learning outcomes and student perceptions were evaluated in control and intervention groups as described in the Methods section. Although groups were not randomly

generated, no statistical differences were found in course grades between the control and intervention groups — average course grade for the control group was 77.57% vs. 78.42% for the intervention group ($p = 0.713$) — or between any of the other academic or demographic variables included in the regression analyses (data not shown). While the control group seemed to consistently score higher in the quizzes (Figures 1.A and 1.B), no statistically significant differences were found between the control and intervention groups.

Anonymous evaluation questionnaires were collected from 52 of the students (80% return rate) at the end of the semester. At that point, both the control and intervention groups had had access to the same instructional resources for a period of five weeks. The results from the five-point Likert scale questionnaire and from the three open-ended questions (Figures 2 and 3) showed that students truly enjoyed the audiovisual and interactive tools. Figure 2.A shows the distribution of the student responses in the five Likert categories (strongly

Figure 1
Quiz Grade Average and Distribution in Interactive Instructional Tools (IIT) (intervention) Group and Control Group

A. Score averages for each independent quiz. Quiz grades for intervention ($n = 32$ students) and control group ($n = 33$ students). Average quiz grades and standard deviations are plotted in the graph for each group. Although the control group seemed to score slightly higher in each quiz, the differences failed to be statistically significant (p values ranging from 0.051 to 0.76). **B.** Score distribution for all quizzes combined. The number of students scoring in each interval is shown in the plot for all six quizzes combined. Quiz number five had to be dropped due to unforeseen circumstances.



disagree, disagree, neutral, agree and strongly agree), and **Figure 2.B** shows the average value on a 1 to 5 scale for each question. Generally, the students felt that these supplementary tools were, over a total of five points, user-friendly (4 ± 0.76 ; for Q4), convenient (3.98 ± 0.77 ; for Q5), stimulating and engaging (3.82 ± 0.77 ; for Q6), effective (3.76 ± 0.79 ; for Q9) and that they would like to incorporate them in additional courses (4.04 ± 0.88 ; for Q10). Of note, the lowest score in the five-point Likert questionnaire (3.2 ± 0.95 ; for Q7) was recorded for the item “the IIT (interactive instructional tools) offered in this course allowed you to be less dependent on the instructor.”

In the open-ended questions, students selected dissecting videos as the most effective instructional tool (26 out of 64 responses; 40% of collected responses) and also as the best liked along with iPad applications (22 out of 56 responses for each tool; 39% of collected responses). The results from the open-ended questions are plotted in **Figure 3**. Very interestingly, iPad applications scored lower than the other tools regarding their benefits toward learning (9 out of 64 responses; 14% of collected responses).

Discussion

Interactive learner-centered strategies, such as problem-based approaches, seem to foster essential attributes in health sciences students, including life-long learning, critical thinking, decision-making and communication and reflective skills.^{2,10,4} New computerized and Web-based technologies are becoming popular in teaching and self-directed learning of anatomy. These materials are, most of the time, convenient and easily available to students and thus may provide them with a collection of instructional tools they can access anytime. However, the actual value of these methods in enhancing learning in anatomy compared to cadaver dissections remains controversial.^{11,12,13,14,15} In our study, the supplemental tools did not seem to have a significant impact on student learning outcomes. Intriguingly, and although the difference fails to be statistically significant, it seemed that the control group actually scored higher in the post-laboratory quizzes

Figure 2
Results of the Five-Point Likert Questionnaire

A. Distribution of student responses. The plot shows the number of students answering: strongly disagree, disagree, neutral, agree and strongly agree, for each of the 10 questions in the questionnaire. **B.** Average Likert value of student responses. Average Likert values with standard deviations are plotted for each question. The values in the plot were obtained using the following conversion: strongly disagree = 1; disagree = 2; neutral = 3; agree = 4; and strongly agree = 5.

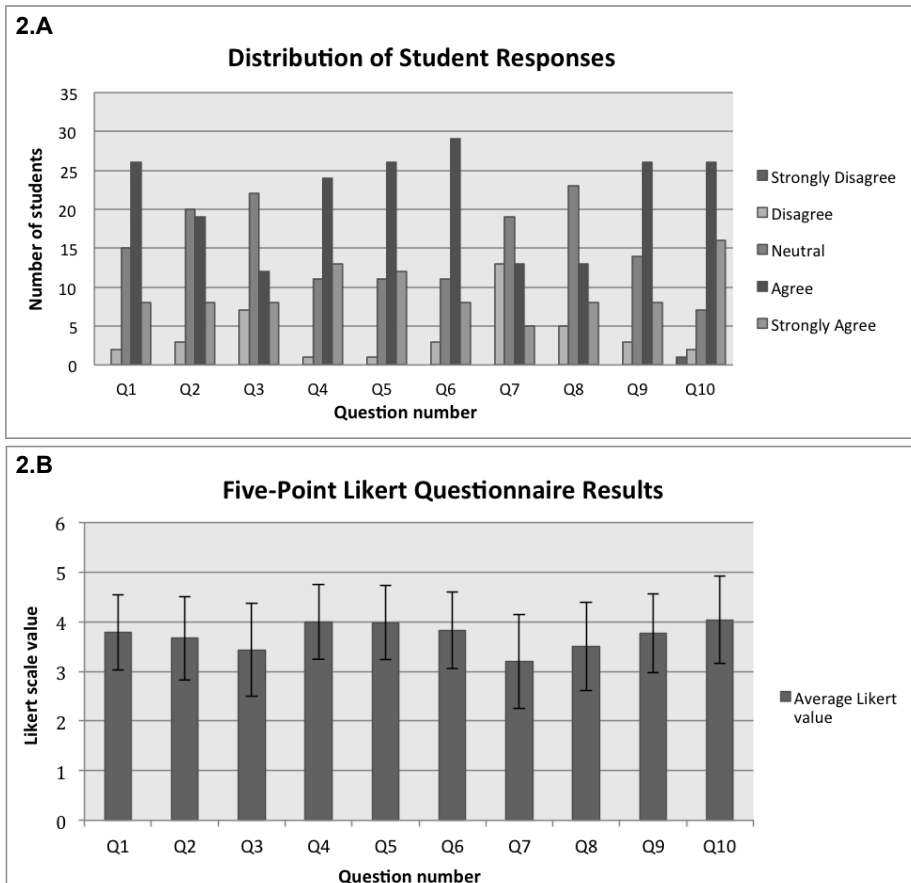
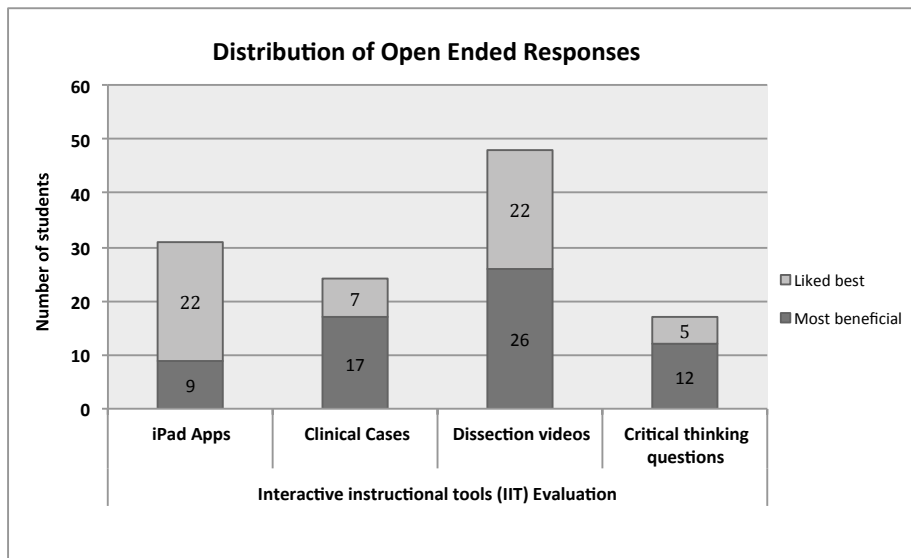


Figure 3
Results of Open Ended Questionnaire

Students were asked to indicate which of the utilized methods they liked best and, in their opinion, which was/ were the most beneficial for their learning. From the questionnaires, dissection videos seemed to be the best instructional tool. Students also liked the iPad applications; however, they scored lower than the other tools regarding their benefits toward learning.



than the intervention group (Figures 1.A and 1.B). A possible explanation for this may be the time students invested to become proficient with the use of the iPad and its applications. If this were the case, students in the control group might have been more cost-efficient at least in the short term by just using their atlases and anatomical models. In fact, some students stated so in the course evaluation forms that were collected at the end of the semester. One student commented: “the iPads are great. However, there is a learning curve to using them and that cost us instruction time in the lab.” Because the post-lab quizzes were given only during the first seven weeks, the long-term effects of these tools in learning outcomes are beyond the capabilities of this study. Additional research would be needed to determine the long-term effects of these strategies.

After the eighth week of lab instruction, both the control and intervention groups had access to the same educational tools. This was decided in order to allow all students to obtain the potential benefits of using the supplementary tools. The questionnaires collected at the end of the semester showed that students enjoyed the audiovisual and interactive tools. Therefore, it appeared that once they overcame the initial learning phase, most students were comfortable with the new methods.

Efficient use of faculty time is a must in healthcare programs. According to the students’ perceptions, the enhancing plan did not seem to help them to become more independent from the instructor (3.2 ± 0.95 in the five-point Likert scale; Q7, Figure 2). However, as instructor I observed a decrease in the amount of time I needed to devote with students reviewing essential concepts compared to the previous year’s class.

In the students’ questionnaire responses, dissecting videos were selected as the most effective instructional tool (40% of the responses; Figure 3) and also as the best liked along with iPad applications (39% of the responses for each method; Figure 3). This could be consistent with a high prevalence of visual learners within the subjects of our study. However, there might be additional reasons that would explain why the clinical scenarios and the prepara-

tion of critical-thinking questions did not reach the same levels of popularity as the dissection videos. Most likely, the type of activities that promote problem-based learning and metacognitive skills require the utilization of higher-order cognitive skills. Thus, possibly our students needed to dedicate a substantial effort to solving the clinical scenarios and writing the critical-thinking questions. I believe this may explain why fewer students selected these two learning tools in the questionnaire.

Regarding their benefits toward learning, iPad applications scored surprisingly low (14% of collected responses) followed by critical-thinking questions (19% of collected responses), clinical scenarios (26% of collected responses) and dissection videos (the preferred one; 40% of collected responses). Very interestingly, although students really liked the iPad applications, they ranked critical-thinking questions and clinical scenarios higher when it came to their educational value. Some of the students’ comments were striking, such as 1) “maybe the lab can be more structured instead of letting us loose on our own”; 2) “instructors could do a short briefing so that we stay on the right track”; 3) “instructors could use the iPads together with us.” These comments and others along the same lines suggested that high levels of learner control might have been, to some extent, detrimental for learning. As demonstrated by Steinberg¹⁶, this situation might be of special concern if students have limited pre-existing knowledge in anatomy and/or limited metacognitive skills.

Conclusion

The results of this study suggested that iPad applications, dissection videos, clinical scenarios and critical-thinking questions are instructional resources that can be successfully incorporated into the gross anatomy laboratory. Although the supplementary approaches used in this study did not seem to improve learning outcomes, students liked them. Thus, the use of these materials might boost their interest for learning anatomy. The fact that our students needed to get accustomed to some of the supplementary tools (e.g., iPad applications) was a limitation of this short-term study and, perhaps, a long-term experience involving a high-

er number of students would have uncovered different results. Nevertheless, for future studies, it would be wise to realize that this initial learning period might be distractive for students and might even interfere with their learning. To my knowledge, this is the first study of this kind performed in an optometry school. The results obtained could be also relevant to additional health sciences programs not using cadavers in their labs.

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