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The Pedagogical Value of Mobile Devices and Content-Specific Application Software in the A&P Laboratory

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Abstract

The purpose of this study was to evaluate the pedagogical utility of mobile devices and content-specific application software in the Anatomy and Physiology laboratory. Four core topics were examined: Tissues and Integument, Skeletal System, Muscle System, and the Heart. Five lab instructors were involved; each instructor taught one "experimental" lab section where students used mobile devices with histology and anatomy apps, and taught a second "control" lab section in which students used their lab manuals. The experimental students' metacognitive responses were measured via exit surveys; the instructors were also surveyed and interviewed. Using a Likert-type scale we analyzed the student response, which indicated that overall the students reacted positively to the digital technology in the lab, felt that this modality was effective in motivating them to learn the subject matter, and considered the apps to be more effective as a learning tool than the lab manual.

Key Words: iPad, tablet, histology, anatomy, learning

Introduction

In today's super-charged information age, most of us expect information to be at our fingertips and this is especially true of our current students, who are more likely to look for information on the Internet than to reach for a book or visit a library. Mobile devices have become an extension of personal outreach to the world, the last thing our students use before falling asleep and the first thing they reach for when they wake up. Mobile devices offer many pedagogical opportunities, especially easy access to textual information and visual resources, three-dimensional representation of anatomical structures, as well as the ability to study dynamic processes, powerful capabilities that traditional textbooks cannot match.

We conducted a survey among our own students, which revealed growing use of electronic devices in the study of Anatomy and Physiology, with a variety of mobile devices playing an important role (Figure 1). A recent systematic literature review of the use of mobile devices in higher education indicated that while instructors and students are positively inclined toward the use of such devices, there is a great need for longitudinal and large-scale studies to explore and assess the best pedagogical strategies for digital mobile learning (Nguyen et al. 2015).

Furthermore, there is a dearth of studies relating to mobile device use in the environment of biology laboratory classes at urban community colleges. In the current study, our primary hypothesis going forward was that mobile devices and content-specific apps would increase student enthusiasm and engagement.

Anatomy and Physiology 1 (A&P 1) is a required course for pre-nursing students at Hostos Community College of the City University of New York (CUNY). The demographic profile of our students is predominantly female and minority. Because there is no science prerequisite for A&P 1, students may enroll

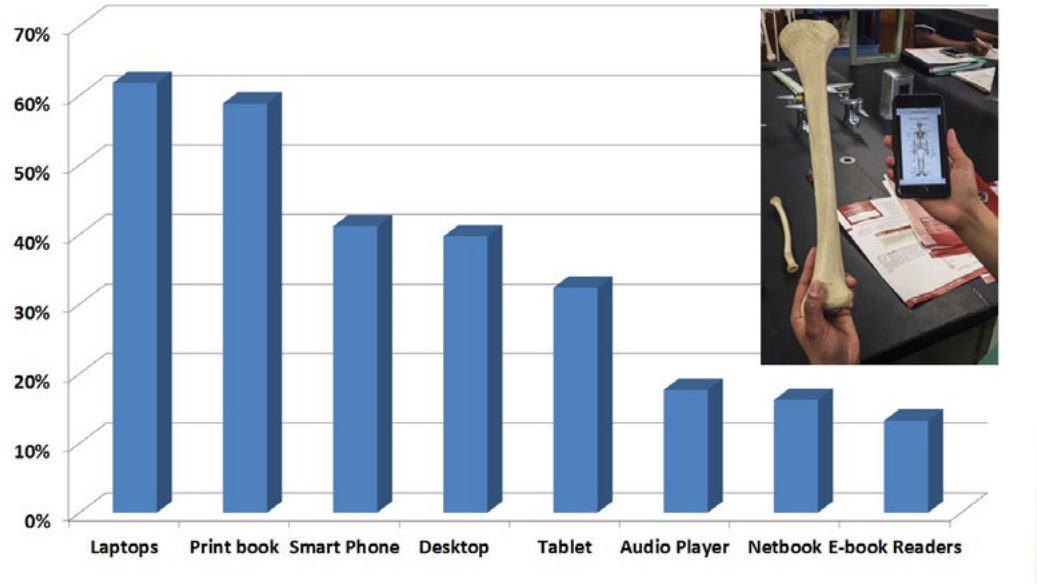

Figure 1. What devices students use to study A&P. Respondents may list multiple devices: the Y-axis indicates the percentage of respondents that use each device. N = 180.

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without a background in biology or chemistry. The course consists of a three-hour lecture and a separate three-hour laboratory. Experiments and dissections make up only a small part of the lab work, which mostly consists of examining tissue slides under the microscope or looking at skeleton, muscle, or heart models. Many of our students are disengaged from lab work, and it is often difficult to motivate students to devote sufficient time to viewing the tissue slides or studying the models.

We decided to explore the possibility that introducing digital technology, tablet mobile devices and software applications (apps) into the A&P 1 lab would stimulate student engagement and active learning. Histology and anatomy apps provide powerful features that are not available in the traditional lab: all structures are labeled and may have detailed annotations, there is no need to focus slides, and anatomical structures can be viewed in three dimensions as well as rotated and sectioned. Such apps would reduce the frustrations that many students have when attempting to identify tissue or organ structures without the assistance of the instructor.

METHODOLOGY

A one-semester study was designed to investigate the pedagogical efficacy of using tablet mobile devices and apps in the laboratory portion of the A&P 1 course. Our main focus was on student attitudes towards the digital technology, and whether student engagement with lab work could be increased. To that end a qualitative approach was taken, using exit survey questionnaires that the participating students and instructors completed, as well as in-depth interviews with each of the instructors. Conventional quantitative assessment was also carried out, albeit without statistically significant results. As such, therefore, our results and discussion are mostly couched in general principles and observations.

Because our project involved live subjects, we submitted our study plans to our University Integrated IRB, which approved the study and determined that it was exempt from IRB Review, qualifying as research conducted in established or commonly accepted educational settings involving normal educational practices (Collaborative Incentive Research Grant C3IRG-2015). Informed consent was obtained from all participants.

The study involved five laboratory instructors and ten A&P 1 laboratory sections, representing a student enrollment of two hundred and eighty (i.e., N = 280). Five lab sections used tablet devices and apps; these sections were designated as "experimental." The other five sections, which used the assigned lab manual and did not use digital technology, served as the "controls." Each of the five instructors taught one "experimental" lab section and one "control" lab section.

Five lab exercises, each representing one lab period, were included in this study: Tissues 1, Tissues 2 and Integument, Skeletal System, Muscle System, and Heart. (At our institution, the cardiovascular system is taught in A&P 1 instead of the nervous system).

Students in the "control" lab sections participated in traditional lab exercises with lab manuals, microscopes and slides, and models. Specifically, during the two Tissues labs, students used microscopes to view tissue slides, and looked at related photomicrographs in their lab manuals. During the Skeletal System and Muscle System labs, students used anatomical models to study these organ systems, with the assistance of diagrams in their lab manuals. During the Heart lab, students dissected a sheep heart and looked at heart models.

In contrast, students in the "experimental" lab sections used tablet mobile devices and content-specific apps to complete the work, instead of the traditional lab manuals, microscopes, or models. During the two Tissues and Integument labs the students used Smart Histology v1.1.3 (Smart in Media 2014), a virtual microscopy app that contains 103 human tissue slide images annotated with identifying labels and brief descriptive annotations describing the tissues (Figure 2). For the three anatomy labs—the Skeletal System, Muscle System, and the Heart—students used Essential Anatomy 5 (3D4Medical.com, LLC, 2016), a three-dimensional anatomy app with identifying labels that can help the student visualize the different layers and cut-away views of body structure (Figure 3).

Two sets of detailed lab worksheets were created to guide the students through their lab activities. Worksheets for the traditional "control" lab sections were designed to be used in conjunction with the regular lab manual for the course, whereas worksheets for the mobile-device enhanced "experimental" lab sections were designed for use with the histology and anatomy mobile apps.

We used Apple iPads as mobile device platforms to run the digital apps in the experimental lab sections. The educational technology office at our college provided the iPads for each lab period, and removed the iPads afterward. Therefore, students in the "experimental" lab sections had the use of an iPad and associated apps only during the lab period, and could not use the apps for personal study unless they had their own mobile device and purchased the app.

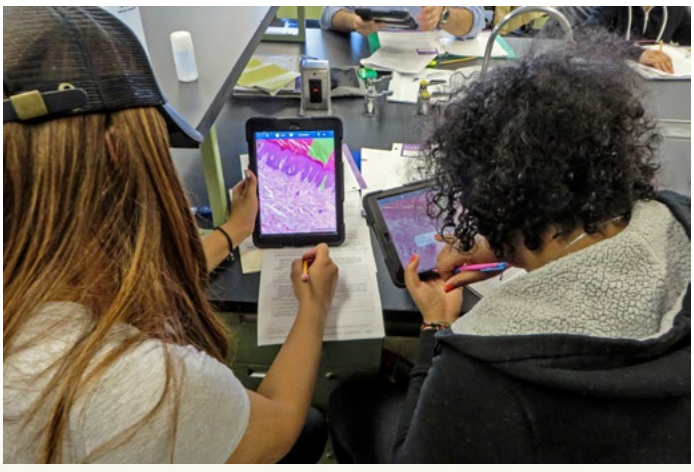

Figure 2. Students use the Histology app in conjunction with worksheet.

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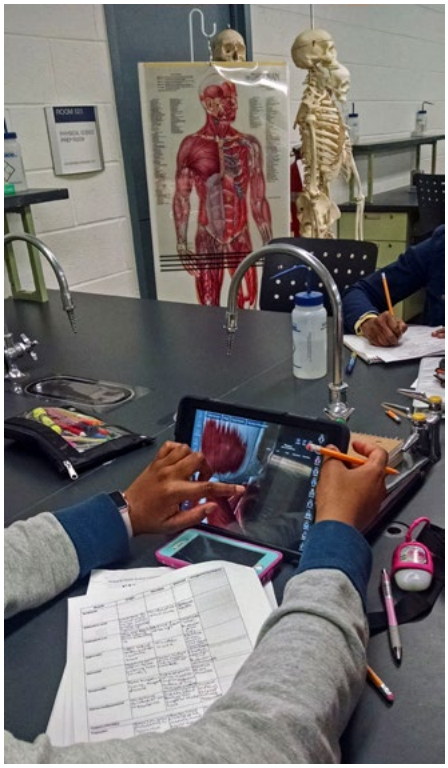

Figure 3. Students use the Anatomy app in conjunction with worksheet.

Pedagogical Assessment

At the beginning of the semester all students (both the experimental and control groups) completed a questionnaire concerning their use of technology. At the end of the semester, students in the experimental sections were asked to complete an online survey to elucidate their metacognitive reflection on the effectiveness of the apps in helping them process, absorb, and retain the information that they learned in the lab. Because student participation in all aspects of the study was voluntary, as per IRB requirements, and because of the usual student attrition during the semester, only a subset (N = 37) of the original experimental group of 140 students completed the end-of-semester exit survey.

At the end of the semester, participating instructors were individually interviewed. The instructors also completed an online survey, where they could express their views on the relative effectiveness of the app-assisted experimental lab exercises.

Students

A survey of student opinion at the end of the semester indicated that most students were enthusiastic about the apps, and valued the introduction of digital technology into the lab (Table 1). Overwhelmingly, they enjoyed using the iPads and apps in the lab and had a positive learning experience (86% agreement), and felt that they were motivated to learn more about the subject matter (81% agreement). Students reported that the digital technology made it easier for them to learn about the topics covered in the study, tissues and skin, bone, muscle, and the heart (ranging from 81 to 95% agreement). They also identified the two most helpful aspects of the apps, first, that the anatomy app helped them to visualize structures in three dimensions more clearly, and second, that the histology and anatomy apps provided a convenient source of information about the structures.

In comparing the benefit of using digital devices and apps instead of the traditional mode that used the lab manual, 73% of the students thought that using apps enhanced their knowledge and understanding. However, only 57% said that they preferred replacing the lab manual with the apps, indicating that many students still resist a complete shift to digital technology. This may have been because the students' own learning styles did not find a comfortable fit with the apps' format, or because of the complexity of the apps, particularly the anatomy app. Several students explicitly commented that they had experienced difficulty in mastering the two apps.

Instructors

In general, the five instructors who participated in the study found that mobile devices and apps could play a positive and useful role in the lab. This modality was a "new and attractive way of presenting the material taught for that class," which kept the students engaged in learning. Information in the apps helped students to see details as well as the whole structure, and provided "an efficient and easy" way for students to access information. In addition, the instructors felt that the novelty of the apps triggered a positive response from the students, who were then stimulated to engage in active learning.

With respect to the histology app, the instructors agreed that such apps could have a positive value in helping students understand tissues. The histology app was more successful than the microscope in holding the attention of students. Additionally, the app facilitated learning by making information about the tissues more accessible, it allowed students to move from one tissue image to another more efficiently, and it provided a uniform learning experience in the classroom compared to the variety of glass slides that students use in a typical microscope lab exercise. However, as a practical matter, all of the instructors found that the histology app used in the study lacked sufficient resolution to allow students to clearly visualize tissues and cell types at high magnifications.

Regarding the anatomy app, the instructors recognized the value of anatomy apps in helping students identify, slice, layer, and rotate anatomical structures, as well as in helping students understand the location and orientation of structures in the body. The anatomy app kept the students engaged, and also solved the ongoing problem in our labs of not having enough muscle and bone models to go around; with individual mobile devices and apps, each student had immediate and personal access. Although all of the instructors liked the anatomy app's treatment of bone and muscle, they found fault with the lack of detail in the heart.

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The instructors had mixed feelings about the amount of student learning that was actually taking place when the students used the digital technology. On the one hand, the apps engaged the students and helped them to see the lab material in a fresh way. On the other hand, some instructors felt that this modality added a new layer of confusion to the lab work, because some students had difficulty in mastering the apps, especially the feature-rich anatomy app. It was suggested that increased access to the mobile devices and apps throughout the semester would obviate this problem, because then the students would have enough time to become proficient.

Table 1. Results of an exit survey conducted online, as measured by a Likert-type 5-point scale. The two "Agree" categories were combined, as were the two "Disagree" categories. Respondents are a subset of students enrolled in the experimental lab sections. N = 37.

#	Question	% Responding		
		Agree	Neutral	Disagree
1	I enjoyed using the iPads and Apps in lab.	86	8	6
2	Using the iPad and Apps in lab was a positive learning experience.	86	11	3
3	Using the iPad and Apps in lab motivated me to learn more about the subject matter.	81	16	3
4	Using the iPads and Apps helped me to increase my knowledge and understanding more than if I had used the lab manual.	73	19	8
5	The iPad and Apps made it easier to learn about TISSUES and SKIN structures.	81	14	5
6	The iPad and Apps made it easier to learn about BONE structures.	95	5	0
7	The iPad and Apps made it easier to learn about MUSCLE structures.	89	11	0
8	The iPad and Apps made it easier to learn about HEART structures.	86	11	3
9	I prefer using the iPads and Apps in lab instead of the lab manual.	57	24	19
10	I would prefer to take an Anatomy & Physiology II lab that used the iPad and Apps.	62	24	14
11	I would prefer to take an Anatomy & Physiology II lab that did NOT use the iPad and Apps.	24	27	49
12	I found it helpful to use the lab Worksheets that accompanied the iPad exercises.	78	8	14
13	I would buy an Anatomy App for my own smart phone, tablet, or computer to help me in my studies.	73	22	5
14	I would prefer taking lab quizzes on the iPad.	59	19	22

Discussion

Our goal in this study was to analyze the pedagogical usefulness of histology and anatomy apps as a means of encouraging student enthusiasm and engagement, and thereby increasing student learning and information retention in the A&P 1 lab.

Our primary hypothesis was that mobile devices and content-specific apps would increase student enthusiasm and engagement. This hypothesis was confirmed by the Likert-type scale survey data from the experimental group (Table 1), which showed that most students enjoyed using the apps and mobile devices in the lab, had a positive learning experience, felt that this modality motivated them to learn the subject matter and was more effective as a learning tool than the lab manual. Our results here are consistent with other studies, which find that students like using tablets and other mobile devices in the classroom, and report greater student engagement with the material as well as a potentially "enhanced learning experience" (Morris *et al*. 2016, Quant *et al*. 2016, Raney 2015, Wilkinson and Barter 2016).

It is clear that histology and anatomy apps have the potential of adding greatly to the A&P lab experience. Anatomy apps allow students to view and identify the structures three-dimensionally, to learn the location and orientation of structures in the body, and to interact actively by rotating the structures and by removing and replacing body layers. Histology apps present a large screen image of each tissue

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that can be moved around and magnified in the same manner as a slide under the microscope, but without worrying about focusing, lighting, field of view, etc. Information added to the image can help the student identify cells types and tissue layers. The use of digital imagery increases the opportunity for group-work; for students to gather around a tablet screen to discuss what they are seeing. Digital imagery also makes it easier for a lab instructor to engage with students and to have more of a discussion about what they are seeing than is possible when students are looking through microscopes.

Increased integration of mobile devices and apps into the A&P lab may reduce the tendency of students to become distracted by their own digital devices. As Figure 4 shows, students use smart phones in class for multiple purposes, only some of which relate to the course itself. Thus, introducing a course-related digital device and app into the classroom would at least provide a competitive alternative (Bice *et al.* 2016). Using digital technology in the lab also makes it easier for students to access information. In an earlier unpublished study, we measured throughput, the amount of information that students could enter on their lab worksheets within a measured amount of time. Students using digital technology were able to access and enter approximately 50% more information about the muscles (actions, synergists, antagonists) on their worksheets than students using the traditional lab manual. Although increased throughput does not necessarily translate into learning and information retention, it may be useful as a first step in that direction.

As a cautionary note, findings such as those reported above must be examined for the confounding influence of either a "novelty" or "Hawthorne" effect. That is, students in the experimental group might be reporting a positive learning experience merely because they were doing something novel, such as using mobile devices and apps, or were participants in a study (Wilkinson and Barter 2016). Additionally, the "glow of technology" may create a favorable reaction among the participating students (Girlando and Eduljee 2016). However, regardless of the underlying reason for the students' metacognitive assessment that the mobile devices and apps had a positive effect, students were undeniably more successful in focusing their attention on their lab work when it involved interacting with their histology or anatomy app.

Our secondary hypothesis, that the digital technology would increase student learning and information retention, was not confirmed. Although a small preliminary study that we conducted indicated a 10% higher average lab test score among students who used the digital technology, in the present study the analysis of quantitative test data did not yield statistically significant results, and is not reported here. Many authors (Perez *et al.* 2011, Raney 2015, Scibora and Mead 2015) indicate how difficult it is to extract meaningful data from experiments designed to measure the impact of mobile devices in the classroom. We anticipate continuing our investigations with a larger student sample size and increased access by the experimental group to the mobile devices and apps. These modifications in the experimental design should provide a better environment to test the pedagogical effectiveness of this modality.

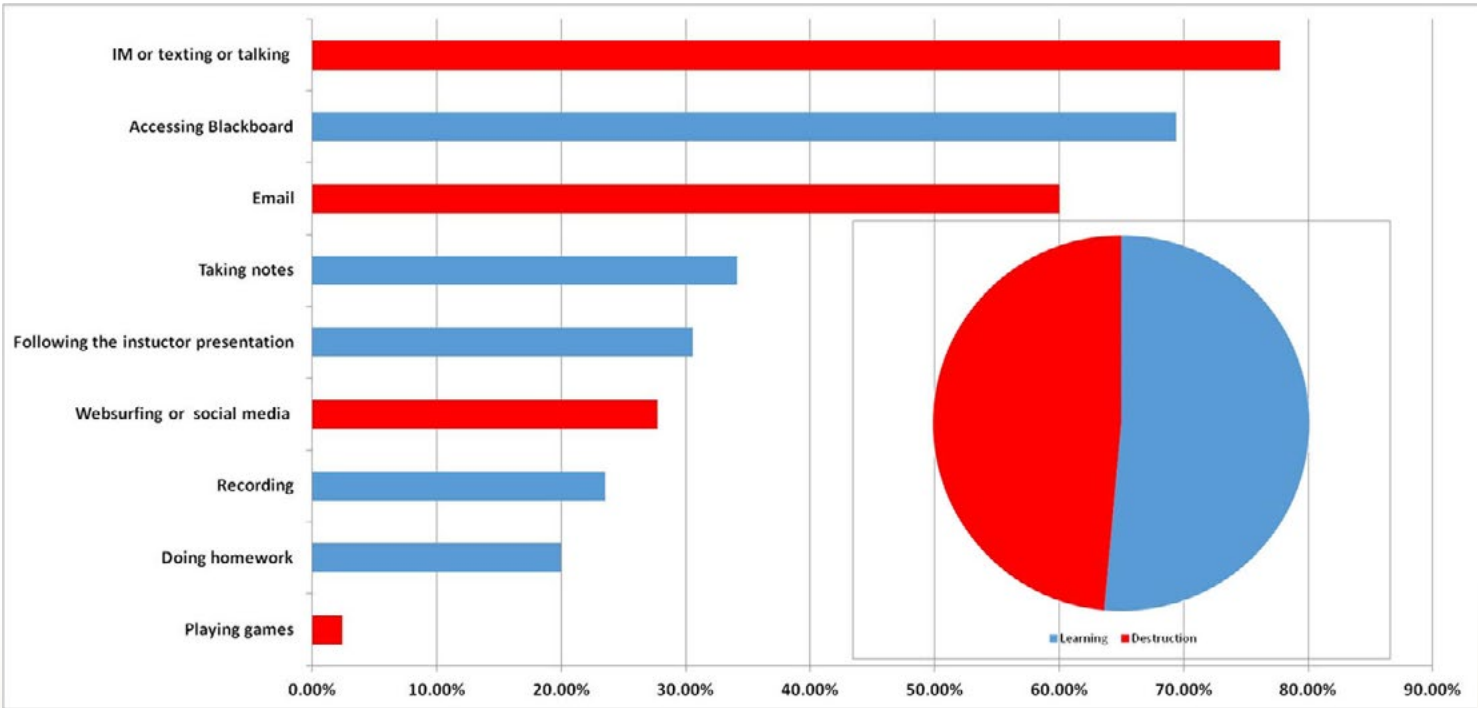

Figure 4. Students use smart phones in the classroom for both academic (blue) and non-academic (red) purposes. Respondents may list multiple uses: the X-axis indicates the percentage of respondents reporting each use. N = 180.

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Two additional issues will need to be addressed as our research goes forward. First, although the histology app that we were using had a convenient layout, many tissue examples, and was easy to view at lower magnifications, when the tissues were viewed at maximum magnification the app did not always provide sufficient resolution to distinguish cell characteristics. In our future work, we will explore other options, including virtual microscopy resources available on the web.

Second, we underestimated the difficulty that some students would have in mastering the apps. Although the worksheets contained detailed instructions for the apps, some students struggled with the software, which adversely affected their lab work. The problem was compounded by the fact that the students had only limited access to the apps, three hours spent with the histology app, spread over two lab periods, and four and a half hours spent with the anatomy app, spread over three lab periods. Other researchers have also reported that students may have difficulty in mastering anatomy apps (Morris *et al*. 2016).

One solution would involve formal app training sessions, but that would use up valuable lab time. Alternatively, students could be given increased access to the apps, so that they could familiarize themselves with the apps outside of the lab. This would also enhance their learning. Rainey (2015) found a correlation between student performance and the amount of access to a mobile device and apps. Students with "unlimited access" outperformed students with "limited access," and in turn the "limited access" students outperformed the control group of students who had "no access." Of course, such a solution would require either that the institution provide the apps (and perhaps the mobile devices), or that the students purchase the apps for their own mobile devices, e.g. a "Bring Your Own Device" (BYOD) solution, which might provide the best results. Indeed, students appear ready to buy such apps. In our survey of the experimental student cohort, 75% said that they would be willing to buy an anatomy app for their own mobile device.

Conclusion

Our data support the conclusion that mobile devices and content-specific apps increase student enthusiasm and engagement in the A&P 1 lab. Metacognitive assessment of the students revealed a perception that using the apps and mobile devices in the lab was enjoyable, provided a positive learning experience, motivated them to learn the subject matter, and was more effective as a learning tool than the lab manual. Further research is needed to clarify the extent to which students' positive response to digital technology translates into gains in learning, understanding, and information retention.

The students were not fully committed just yet to replacing the A&P lab manual with digital technology. This suggests that the apps are most useful as a tool, and not as an entire strategy, to present information in the classroom and lab.

In anatomy, mobile devices and apps are best suited as a supplement to traditional modes of presentation and learning, e.g. recitations, models and preserved specimens. However, there are indications that histology mobile apps or online resources with improved design and high-resolution imagery may well supplant the traditional use of the microscope.

About the authors

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