Incorporating mobile technology for college science laboratory instruction: Our experience using an interactive multi-media system

I.U. Willcockson¹, R. Zeng¹, M.S.Iyengar¹²³

¹School of Biomedical Informatics, UTHealth, 7000 Fannin Suite 600, Houston, TX 77030
²NASA Johnson Space Center, 2101 NASA Parkway, Houston, TX 77058
³Advanced Guidance Systems, LLC, 15711 Park Center Way, Houston, TX 77059-4051

College science laboratory instruction is shifting from prescribed to inquiry-based labs, using mostly lab manuals developed by each college. At the same time, class sizes are increasing and most colleges report having only one instructor in the lab. This combination leaves many instructors handling largely managerial tasks as opposed to engaging students in higher-level thinking. Multimedia step-by-step instruction for laboratory procedures may allow students to perform laboratory tasks more independently while freeing the instructor for deliberate student interactions. We developed a multimedia intervention for one lab exercise and piloted it with graduate students. The intervention was rated highly by the students, and allowed the instructor to focus on engaging each student group in higher-level thinking. Further refinement of the software should make multimedia laboratory instructions more useful in the lab setting and take full advantage of the mobile platforms becoming more ubiquitous every month.

Keywords: college; mobile learning; laboratory instruction

1. Introduction

1.1 Overview of college laboratory instruction

Labs continue as an integral part in undergraduate science education [1]. Hofstein & Lunetta [2] argue that labs have a unique ability to educate students, from allowing students to understand scientific concepts and practice skills to enhancing their enjoyment of science and motivation to learn more. A meta-analysis of four types of course innovations including inquiry-based projects found generally positive effect sizes [3]. However, realizing the benefits of labs can be difficult. Increasing class sizes combined with the presence of a single instructor require instructors to spend most of their time in managerial and technical tasks [2]. Furthermore, it is possible that different groups receive different content from the instructor, leading to possible different learning. The majority of institutions surveyed use inquiry labs [1], however, most instructors report they do not have time to engage students in higher level questions.

Current laboratory manuals contribute to the challenges. Most institutions are using internally developed manuals [1] in a paper format. Many manuals have large amounts of information which can obscure the tasks and the reasons those tasks are performed [2]. Audiovisual material tied to the specific lab exercises is frequently unavailable.

We propose that delivering task-based just-in-time instruction to each student or groups of students using a mobile learning solution will increase the effectiveness of labs. Instead of focusing on managerial and technical tasks the instructor can engage students in higher level questions. Providing students with a library of lab procedures they can select from allows them to address an inquiry-based projects without having the instructor responsible for teaching/reviewing each procedure with each student group. Different groups can select the procedures and their order to best fit their inquiry.

1.2 Theoretical grounding

To guide the intervention, we utilized the emerging Technology Integration Model for Education (eTIME) [4]. To arrive at a preliminary solution, instructors are encouraged to consider three aspects together, the problem to be solved, the technology and the theory. Using this model helps prevent several common issues. Frequently, interventions are based on the latest technology but do not solve the teaching/learning problem posed. Alternatively, the technology does not support the instructor’s preferred theories about learning and teaching. Further refinement using instructional design leads to the final solution, which is implemented and iterated. Figure 1 shows the model annotated for this project. “To deliver task-based instruction in a laboratory environment based on social learning theory, mobile multimedia learning was selected” reflects the preliminary solution.
1.2.1 Problem description

The problem description has to consider the topic, setting, and student and instructor characteristics. The course topic was human anatomy and physiology, taught face-to-face in a classroom setting. In the context of teaching either nurse anesthesia or health informatics master’s students, there was no access to laboratory facilities. Lack of access precluded using either preserved human or animal tissues, as these would have to be stored from one class period to the next. Instead, a laboratory exercise modified from [5] was used to provide hands-on experience with a fresh chicken leg thigh. This dissection allowed students to understand the relative position of different body tissues, as well as experience firsthand the different dimensions of bones, joints, muscles, fat deposits, blood vessels and nerves.

1.2.2 Theories used in the intervention

Several learning theories and constructs were used in the design of the intervention. Table 1 provides an overview of the theories and constructs along with an example of how each was implemented within the intervention.

<table>
<thead>
<tr>
<th>Theories and Constructs</th>
<th>Brief Description</th>
<th>Example from the Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual Coding [6]</td>
<td>Learning is enhanced by presenting information in both visual and verbal forms.</td>
<td>Many screens combined narrations with still images.</td>
</tr>
<tr>
<td>Social Learning [7]</td>
<td>Role modeling allows students to imitate desired behaviors.</td>
<td>Pre-lab safety video allowed instructor to demonstrate safe handling of dissection tools.</td>
</tr>
<tr>
<td>Cognitive Load [8]</td>
<td>Students learn about concepts just before applying them.</td>
<td>Each step in the procedure was presented one at a time and students watched it right before performing that step. Students could review the lab on their device to prepare for assessments.</td>
</tr>
<tr>
<td>Subsumption [9]</td>
<td>Instruction should proceed from general to specific. Advance organizers help students connect new knowledge to previous knowledge.</td>
<td>First part of instruction introduced and defined action and observation components in this lab.</td>
</tr>
<tr>
<td>Usability Principles [10]</td>
<td>Designing with good usability improves learning.</td>
<td>Common conventions were used for button labels and placements within the screen. The same button had the same effect.</td>
</tr>
</tbody>
</table>
1.2.3 Technology selection

Several considerations went into selecting the technology. Because it would be used in the lab setting, mobile technology was preferred. Limited production time and programming expertise along with availability encouraged us to look at guideVue as the authoring tool. Preliminary exploration of guideVue demonstrated ease of use and fit between the software and the desired outcome, task-based learning.

1.2.4 Preliminary Solution to Final Solution

Since the instructor (IW) was familiar with both the laboratory and the technology, the preliminary solution was created in story board format. Instructional design was applied to prepare for gathering the media. After obtaining the media (see methods for details), authoring was done in guideVue. The guideVue product was reviewed by the instructor and edited once before being used with the students.

1.3 Background on guideVue™

GuideVue™ was originally developed and used for task-based support for lay health workers [11,12]. It allows for easy authoring of a mobile application using a graphical user interface. Figure 2 is an example of the authoring environment. Objects such as text, graphics, video and audio can be dropped into the appropriate screen. Allowing users to experience different branches of the program depending on a choice made is intuitive to implement, and multiple branch points can be allowed within one product. Research has demonstrated good usability and acceptability in the health worker setting [13].

Each guideVue is downloaded to and stored on the mobile device (cell phone or tablet), allowing use even when network connectivity is absent. Operating systems supported include IOS (iPhone, iPod Touch, iPad), Android, Windows Mobile 6.5 and Blackberry.

---

**Fig. 2** Screenshot of the GuideVue authoring environment. The right side is the flowchart of the product, the left side allows editing of each individual screen. Media files are added using a drag and drop interface.
2. Methods

2.1 Development process

The development team consisted of a subject matter expert (SME, IW), who also served as the instructor in the courses, an instructional designer (ID, RZ) and an audio-visual technician (AVT). The SME was responsible for the initial story board, which was annotated by the ID prior to video and still photography. All three team members were present for the video shoot, with the ID directing the shoot and checking to make sure all necessary video and still shots had been taken. The AVT processed the video and images after the shoot, while the ID was responsible for authoring the product. Review of the initial product by the SME allowed for iteration before pushing the final product to the devices. Time commitment was about 10 hours from the SME, 16 hours from the ID and 3 hours from the AVT. Figure 3 shows a screen shot from the final product authored for this project.

2.2 Technologies used

While guideVue was the authoring tool, other technologies were used to collect and process the multimedia files. We used a Canon DS6031 XLS1 video camera to record the video and Premium Pro for post-processing. For the photos, we used a Canon XLS1 camera and Adobe Photoshop and SnagIt for photo editing.

2.3 Experimental Design

Volunteer participants were recruited in one anatomy and physiology course taught at the School of Nursing to nurse anesthesia Master’s students. All students were exposed to the product; data was collected only from those who consented. To eliminate possible undue influence, consent and collection of data was handled by the ID, with the instructor receiving the data only after grades were assigned. A demographic survey and usability and motivation survey were administered after the lab to participants. Both the ID and the instructor made notes about the class session during and immediately after the session.

Each group of students used either an iPod Touch or an iPad with the guideVue. The guidevue chicken dissection lab instructions were preloaded to the mobile devices and were opened when the devices were given to students. Students were instructed to proceed at their own pace. Following the instructions given by GuideVue, each group dissected one chicken leg thigh. The ID observed the class session, while the instructor ran the lab. At the end of the class session, the devices were collected and the instructor left the room during survey administration.

3. Results

3.1 Subjects

All 22 nurse anesthesia students participated in the study, 16 females and 6 males. All students were between 25 and 45 years old. Five identified themselves as hispanic or latino, four met the criteria for minority students (Native American, Black American). Most students (13) reported no prior experience with mobile learning materials, while some reported occasional (5) and frequent experience (4).
3.2 Student feedback

Student feedback was overwhelmingly positive, irrespective of the device used. Table 2 summarizes the student responses.

Table 2  Student responses on the Student Reaction Survey. The total number of students was 22.

<table>
<thead>
<tr>
<th>Questions</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strongly disagree (n)</td>
</tr>
<tr>
<td>1. I enjoyed following lab instructions on mobile devices.</td>
<td>2</td>
</tr>
<tr>
<td>2. Compared with watching an onsite instructor demo, I prefer following instructor’s lab instructions on a mobile device.</td>
<td>1</td>
</tr>
<tr>
<td>3. I felt I had more flexibility using mobile learning material than following printed out lab instructions or in person demo.</td>
<td>1</td>
</tr>
<tr>
<td>4. I received on time technical support when needed.</td>
<td>2</td>
</tr>
<tr>
<td>5. At the end of my class, I still had difficulty using the mobile learning material.</td>
<td>10</td>
</tr>
<tr>
<td>6. I had difficulty watching the video on the mobile device.</td>
<td>9</td>
</tr>
<tr>
<td>7. I had difficulty following the instructions on the mobile device.</td>
<td>10</td>
</tr>
<tr>
<td>8. I had difficulty seeing the picture detail on the mobile device.</td>
<td>8</td>
</tr>
<tr>
<td>9. I was interested in learning using the mobile device.</td>
<td>1</td>
</tr>
<tr>
<td>10. Guidevue (the mobile learning app) provides a user-friendly learning environment.</td>
<td>12</td>
</tr>
</tbody>
</table>

Additional feedback from the students pointed to device and software limitations. As several groups were using the devices in the same classroom at the same time, audio volume was not loud enough. Students were also reluctant to touch the device with contaminated hands and suggested that voice navigation would be useful.

3.3 Instructor notes

Overall flow of the lab was very smooth, with whole class directed teaching and demonstration replaced by the instructor walking around and problem-solving with each group. All groups were able to complete the lab in the allotted time. Instead of moving from group to group based on students’ questions, the instructor was able to interact with each group and do informal formative assessment of progress. Questions were designed to encourage close observation and thinking. The rushing from group to group and interacting only with groups who had questions was replaced by deliberate interaction with each group during the lab.

During the lab, each group selected one member to handle the device, interacting with it as necessary. In previous classes, all students handled the chicken leg. The instructor did not anticipate this change in group roles.

4. Discussion

Mobile learning in the context of an anatomy and physiology lab was relatively easy to implement. Most students were interested in and enjoyed using the device, preferred it over an instructor-led demonstration and felt it provided increased flexibility. Despite differences in device screen size, most students had no difficulty viewing the images and videos. Students judged the guideVue environment a user-friendly learning environment. The instructor noted increased opportunity to engage each student group in questions and a decreased need to answer individual student group questions.

Strengths of this study include using a development team with strong expertise and good theoretical grounding to create the product. Two different devices with different screen sizes were used, and student and instructor feedback were recorded. However, although undergraduates present a far larger population of lab students, only graduate students were used in this study. Whether mobile learning is as effective with undergraduates as with graduate student remains to be tested. A single group design was used, and any effect on student learning was not measured. Although
students were asked which type of device they used during the lab, no independent record of device assignments was kept, and correlation between the device and student responses could not be analyzed.

A few recent studies have examined the impact of mobile learning. Abilene Christian University [14] found that pre-lab podcasts were just as effective at preparing students for labs. Podcasts decreased the number of instructor interactions and allowed the instructor to spend more time on concepts in a chemistry lab. While our study used mobile learning during the lab as opposed to pre-lab, our findings with respect to student-instructor interactions are similar.

This study represents a preliminary study using guideVue in a science lab setting. Student acceptance of the technology was good, suggesting that mobile learning can play a role in improving lab instruction. More and more students will come to college owning a mobile device capable of playing guideVue products, alleviating the need for institutions to buy and maintain devices. The ability to create mobile learning solutions without programming expertise increases the number of people who can author and take advantage of customized solutions for their classes.

While we have no control over device functionality, several planned software upgrades should improve the usability of guideVue products for lab instruction. Voice navigation will allow all students to interact with the lab materials as well as the devices, without concern about contamination. The ability to collect free text user input may allow students to write the lab report as they go along. Expanding the population to undergraduates will further explore the usability and acceptability of guideVue. With a larger study population, two group experimental design with crossover will provide more robust analysis of the advantages and disadvantages of mobile technology in the lab. Finally, collecting multi-faceted outcomes data related to learning as well as attitude toward science will strengthen the conclusions regarding mobile learning’s role.

5. Conclusion

Mobile technology is a useful addition to the science lab classroom. With increasing class sizes, it is difficult for the instructor to provide individualized technical assistance to each group. Mobile technology allows students to view lab procedures where and when they need them and perform procedures at their own pace, guided step-by-step by the software. Inquiry based labs can be designed under the guidance of the instructor, while students can learn and perform required procedures in their groups. The role of the instructor changes from manager and technical advisor to guide, encouraging higher level thinking. Designing mobile learning applications to accompany labs is feasible using authoring software such as guideVue.

Acknowledgements We thank the students of UTHealth who participated in this research. The support of the Office of Academic Affairs is gratefully acknowledged. Marcos Hernandez was the audiovisual technician.

References