Final Project Report for Mobile Learning Fellows Program 2010-2011 Academic Year

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One of the difficulties in any science laboratory is preparing students to use and understand lab techniques that they have not used previously. Research done in General Chemistry laboratories using mobile devices have shown them to be a good tool for delivering student support during laboratory sessions. To extend this research we proposed recording podcasts during the 2010-2011 academic year that students could view to aid them in the performance of new techniques during Biochemistry lab and General Science lab. Our hypothesis was that the use of podcasts on the iPhone/iPod Touch would allow students in the Biochemistry Laboratory and students in a laboratory for Pre-service teachers to perform tasks during the lab period more independently and with higher achievement on laboratory practical exams than when podcasts were not available.

These two courses have very different student populations. Students enrolled in Biochemistry laboratory during the 2010-2011 academic year were upper division science majors (n=27) and students enrolled in the sophomore level General Science course during the same time period were pre-service elementary teaching majors (n = 29). The populations were compared using the Group Assessment of Logical Thinking (GALT) test and the Experiences of Teaching and Learning (ETL) Questionnaire that were administered to all students enrolled in these courses at the beginning of the semester. The data from the two courses were compared and statistical analyses were performed using R and SPSS.

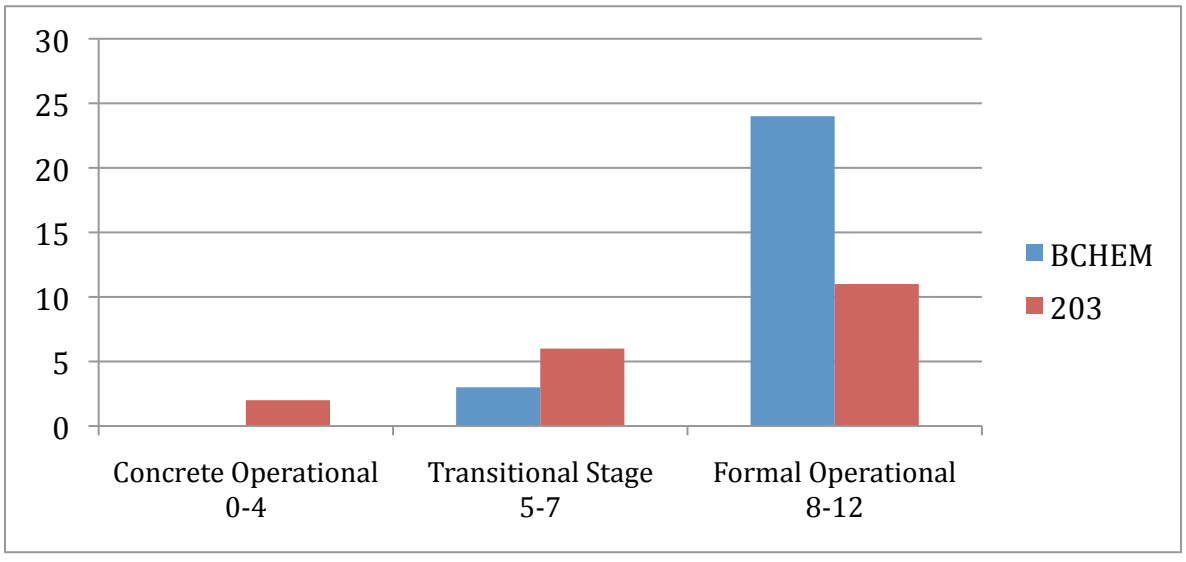
Cronbach's alpha for this administration of the GALT was .6982. The mean score for students in the General Science course was 7.8. The mean score for the students enrolled in the Biochemistry laboratory course was 9.9. Table 1 shows that statistically significant differences between the two populations are evident in proportional, correlational, and combinatorial reasoning abilities as measured by the GALT. The GALT can also be used to categorize students according to three operational stages described by Piaget. Figure 1 is a representation of the populations of each course and the distribution by operational stages. GALT scores for two students in the General Science course place them in the concrete stage, six are in the transitional stages and the remaining are in the formal reasoning stage while GALT scores for all but two of the Biochemistry students were in the formal reasoning stage.

Table 1: GALT Scores by Course

Logical Reasoning Mode	Question	Mean Score		p- value
		BCHEM	CHEM 203	
Mass/Volume Conservation	One	0.926	0.895	0.7273
	Two	0.852	0.789	0.6025
Proportional reasoning	Three	0.889	0.632	0.0563
	Four	0.815	0.474	0.02067
Experimental variable control	Five	0.842	0.842	0.661
	Six	0.741	0.789	0.7074
Probabilistic reasoning	Seven	0.926	0.947	0.772
	Eight	0.889	0.737	0.2174
Correlational reasoning	Nine	0.741	0.211	0.0001866
	Ten	0.481	0.053	0.0004261
Combinatorial reasoning	Eleven	0.889	0.895	0.9512
	Twelve	0.889	0.579	0.02585
Total Galt Score	All	9.9259	7.7894	0.002254

Cronbach's Alpha = 0.69

Figure 1: Operational Stages by Course



Data collected from the ETL survey allows comparison of student attitudes toward the teaching-learning environments they had previously experienced in science courses as well as a measure of their approaches to studying and ways of thinking about and practicing science content. The student responses are Likert scale rankings. Statistical analysis highlights two differences in ETL data for the two populations. The General Science group

shows significantly higher scores in surface approach to learning than the Biochemistry group. Surface approach includes memorizing without understanding, struggling to remember things that didn't make sense and accepting whatever information was presented in class without questioning. In addition, General science students rated themselves significantly higher on the scale of organized studying including preparing for class and general time management, than the Biochemistry students. In conclusion, GALT and ETL data indicate that the Biochemistry students are on average at a higher operational stage with stronger logic skills and are less likely to take a surface approach to learning and studying new science content. The General Science students consider themselves to be more organized and to have better time management skills with respect to academic tasks.

Table 2: ETL Data by Course

ETL Sub-Scales	**Cronbach's Alpha**	**T-Test Results**		
		BCHEM	203	p-value
Intrinsic Learning Orientation	.444	4.740	4.807	0.3475
Intrinsic Reason	.516	4.321	4.197	0.4114
Extrinsic Reason	.453	2.885	3.136	0.1327
Deep Approach	.819	4.197	3.955	0.1869
Surface Approach	.765	2.2596	3.074	0.01582
Monitoring Studying	.763	4.139	4.193	0.7554
Organized Studying	.846	3.737	4.253	0.02918
Effort Management	.705	4.167	4.318	0.3636

Podcasts prepared on laboratory techniques for the two populations were very different in content and scope. Due to the differences in populations and types of techniques required for the curricula, the approach to deploying and tracking usage and the expectations at the time of a laboratory practical were also unique.

In the General Science laboratory five techniques were taught and then assessed using practical tests. Techniques were chosen based on the Texas Essential Knowledge and Skills for sixth grade students. Future teachers who will be responsible for teaching these techniques must be adequately trained in their use. Using a triple beam balance, using an electronic balance and making charts using google spreadsheets were taught via podcast. Measuring using correct significant figures and using a compass were taught using a traditional pre-lab lecture format with supporting written notes. The technique of using a compass was re-taught by creation of a podcast after multiple students taking the laboratory practical could not complete the basic function of determining the direction they were facing using a compass despite professing "understanding" the use of a compass during the previous laboratory week when the skill was taught despite their review of a thorough written description of the use of a compass in preparation for the practical. The podcast was created at the students' request.

The methodology for teaching and assessing a General Science technique was as follows: each technique was taught during a regular laboratory period by either pre-laboratory lecture or podcast. Students were allowed to practice with the correct equipment and the instructor and teaching assistant were available to answer any questions and assist students if they were having difficulty. During the laboratory period of the following week each student was individually tested on the technique using a carefully developed grading rubric. Since many of the techniques taught in the General Science class may have been first introduced to students during high school science courses, at the time of the administration of a practical, students were asked whether they had used the technique previously and whether they had used the podcast or written notes outside of class time to review the technique before taking the laboratory practical. This data may provide insight into whether students "needed" or felt they "needed" to learn more about the technique and may affect trends in podcast usage and preparation for a practical.

Some distinct trends can be noted in General Science student podcast usage. First, when comparing the techniques taught by podcast, data analysis indicates that students were much more likely to use a podcast outside of class time to review a technique that was less familiar than they were to use a podcast to review a more familiar technique. "Familiarity" was judged by their responses to the question about previous exposure to the technique. The data in Table 3 illustrate this trend. This is a predictable outcome. It is notable that even when a technique was familiar to 86.2% of the population, 31.0% still chose to review the podcast in preparation for the practical assessment.

Table 3: Podcast Review by Familiarity

Podcast	Percent familiar	Percent used podcast outside of class time
Triple beam balance	86.2%	31.0%
Electronic balance	56.0%	48.0%
Using a compass	25.0%	89.3%

Table 4 shows the mean percentage values earned on the three laboratory practicals taught via podcast sorted by previous exposure and by use of podcast for review after the initial viewing and practice session. The N values represent scores on individual practical tests taken by 29 different students over 3 techniques. The total N value of 82 was slightly below 87 (3x29) due to absences or incomplete data on assessment. T-tests and ANOVA analysis indicate that the differences in mean values are not statistically significant. The limited number of data points and outliers in each category influence this outcome.

Table 4. Review and Exposure Rates for Techniques Taught Via Podcast

Used podcast to review before practical assessment of technique?	Previous exposure to the technique assessed?	Mean practical score
yes	Yes (N=20, 24.4%)	87.5%
	No (N=26, 31.7%)	86.0%
No	Yes (N=28, 31.7%)	84.8%
	No (N=10, 12.2%)	84.1%

Due to time constraints only one laboratory practical was completed on a technique presented solely by pre-laboratory lecture for General Science students. Compass usage was originally taught using lecture only, but practical data for all students was not collected because the scores for the first group of students taking the compass practical were so poor that the practical was aborted and a podcast was prepared for re-teaching this technique. Data collected must be interpreted carefully due to low number of students in some categories and due to student resourcefulness in recording their own "impromptu podcasts" during lectures teaching techniques. Multiple students used their iPhones/iPods to record my verbal explanation of how to report data in the correct number of significant digits using a measuring device. So, though I did not prepare a video podcast on this topic, many students had both their notes and an impromptu audio "podcast" describing the technique. The student's desire to record my explanation is indicative of their belief that this resource would be helpful in reviewing for the laboratory practical. Table 5 shows the mean percentage values earned on the "measuring" laboratory practical sorted by previous exposure and by use of notes and or personal recording in preparation for the practical.

Table 5: Data for Measuring Practical by Preparation and Exposure

Used written or recorded notes to review before practical assessment of technique?	Previous exposure to the technique assessed?	Mean practical score
yes	Yes (N=10)	57.5%
	No (N=8)	70%
No	Yes (N=7)	65.8%
	No (N=3)	83.3%

Performances on practicals for techniques taught by lecture were lower than those taught using podcast. T-tests confirm that this difference is statistically significant when comparing the collected data for the "measuring" technique with the data for the three techniques taught via podcast. Overall mean for the podcast-taught techniques was 86.8%,

while the overall mean for the "measuring" practical was 67.8% ($p < .01$). This difference became very evident on practical scores for using a compass after the technique was taught using a pre-laboratory lecture with thorough written instructions. The lab practical scores of the first 10 students tested were so abysmal (each less than 20%) that the practical assessment administration was abandoned for a week and a full data set was not collected. A podcast was prepared and the practical was given the following week without additional lecture support or in-class practice time. During the second attempt at practical testing on this topic, the mean score was 86.86%. This is evidence of the advantage of a podcast for this unfamiliar technique. Student responses to the availability of podcasts were very positive. Due to the limited amount of data, however, conclusions are preliminary.

Seven podcasts were prepared for Biochemistry Lab I and II that covered three major topics. In the first set, four podcasts covered the used of the GeneSys 20 Spectrophotometer and the SpectroPro software that runs it. This instrument is used in twelve of twenty-two labs, but is not used the six weeks prior to the lab practical. The second set contained two podcasts that covered the pouring of an agarose gel and the diluting of samples to load into an agarose gel. The final podcast covered the transformation of *Escherichia coli* cells.

At the end of Biochemistry Lab II a lab practical was given in which students were required to determine the concentration of a protein concentration. They were also required to dilute a sample and load an agarose gel. The students were able to review the use of the spectrophotometer, the making a standard curve to determine an unknown concentration and the dilution a sample for agarose gels via podcasts. The students' scores showed no significant difference from the students in the previous year. However, the overall grades of the 2011 students were significantly lower, so students who did not perform as well overall in the class performed nearly as well on the practical. This demonstrates that podcasts supported students in learning a variety of techniques as well or better than pre-lab lecture.

Table 6. Lab Practical and Overall Course Grades for 2010 and 2011 Biochemistry Lab II

		T-Test	
	2010 (n=18)	2011 (n=14)	p-value
Lab Practical (out of 60)	54.2	56.7	0.083
Course Grade (out of 100)	85.5	94.7	0.00000010

One of the issues in biochemistry lab is that the experiments are very long and push the limits of the scheduled four hours. The use of podcasts shortened the length of pre-lab lectures giving students more time in the laboratory. It also allowed the students tools to assist them in carrying out techniques so that they did not have to wait for the instructor or teaching assistant to answer basic questions.

This pilot project has provided data on the usefulness of podcasts in Biochemistry and General Science laboratories and allowed the researchers to begin the process of integrating mobile devices into the curriculum for the two courses. The two populations have very different GALT and ETL profiles and are enrolled in courses with vastly different

curricula, but both groups responded positively to the availability of podcasts teaching laboratory techniques. Both researchers have continued to develop skills in planning and producing podcasts and in how to present the podcast materials, as well as how to assess their effectiveness. Future work in this area should include editing and improvement of podcasts based on areas of weakness seen through lab practical scores and on leveraging the advantages of mobile devices for maximum benefit.