Student and Faculty Impressions of an Online Computer Based Signal Processing Lab

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Abstract – Introduction to Signal Processing at Armstrong Atlantic State University is a four credit hour course consisting of three lecture hours and three lab hours (3-3-4). Prior to fall 2012, this course has been offered using traditional face-to-face lectures and face-to-face laboratory time. In fall 2012, the course was offered as a hybrid course with the traditional face-to-face lecture component but with the lab component online. This was necessary due to the larger than usual number of students enrolling in the course and a shortage of computer lab space due to some campus renovations.

This paper presents student impressions of the online lab format, lab material dissemination, availability and convenience of help, lab assignment submission, return of graded lab assignments, as well as some initial comparison of student performance in the online lab versus past student performance in the face-to-face offerings of the lab. The paper also presents faculty impressions on lab preparation, mechanics of receiving and returning assignments, and grading lab assignments.

Keywords: online lab, virtual lab, hybrid course, online course

INTRODUCTION

The ability to provide laboratory experiences online is a hurdle to offering engineering and science courses via online delivery. There is enthusiasm for offering engineering courses online and online engineering instruction can be effective, see [10] and the references contained within. As internet bandwidth and personal computer processing power have increased, there has been more development and assessment of remote [2] [3] [4] [5] [9] [13] [14] and virtual labs [1] [3] [7] [8] [16]. Virtual labs are experiments performed using emulation or simulation software such as LabVIEW [12] or MATLAB [11] and remote labs are physical experiment setups that are controlled remotely.

Virtual labs, those based on emulation, simulation, or CAD tools, readily lend themselves to being offered in an online environment as they do not require a special setup for remote access or the student to own any special equipment other than a personal computer and the software. As the price of software, data acquisition hardware, and electronic development boards comes down, more electrical and computer engineering laboratory courses will be practical to offer online.

The Introduction to Signal Processing course, ENGR 2025, offered at Armstrong Atlantic State University (Armstrong) is a four credit hour sophomore level signals and systems course taken predominantly by electrical and computer engineering majors. The course prerequisites are calculus II and a scientific/engineering programming course which at Armstrong is taught using MATLAB. The course and laboratory are modeled after Georgia Institute of Technologies' Introduction to Signal Processing course, ECE 2025. Course topics are taught using signal processing as a backdrop and the laboratory component of the course emphasizes computer based signal processing.

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The Introduction to Signal Processing labs emphasize computer based signal processing. Lab assignments involve: analysis and design work, advanced programming (writing MATLAB code describing and implementing signal processing systems), and interpretation of results. The labs require a personal computer and MATLAB along with the SPFirst toolbox [6]. The equipment outlay for this laboratory is much less than most electrical and computer engineering laboratories. Students taking an online course should already have a personal computer, the student edition of MATLAB is available for $99 from The MathWorks [11], and the SPFirst toolbox comes with the course textbook. The Introduction to Signal Processing lab is easier to convert to an online format than most engineering labs since it is computer based (virtual lab) and the equipment outlay for students is minimal. Many of the students have previously purchased MATLAB when they took their introductory programming course.

TRADITIONAL COURSE WITH FACE-TO-FACE LABORATORY

Introduction to Signal Processing has been taught at Armstrong since fall 2003 and prior to fall 2012, ENGR 2025 has been offered using traditional face-to-face lectures and face-to-face laboratory time. The course instructor has always been the first author although several instructors have taught the laboratory component including the authors.

Course material including lecture notes, class examples and class work, formula sheets, exam topics, sample exams, and laboratory assignments were posted on an instructor maintained web site as Adobe Portable Document Format (pdf) files. Laboratory assignments were posted on the web site approximately a half week before lab. The course main page included announcements for the week at the top, a chronological list of class materials and assignments below, and links at the left to supplemental course materials. Announcements and class materials were posted every Friday for the following week and could be easily updated if needed. Class materials including the lab assignments were also typically posted Friday for the following week and could be easily updated by modifying the document and uploading a new version with the same name. Depending on the lab instructor, lab assignments were submitted and returned via email, submitted via email and hardcopy with the hardcopy returned, or submitted electronically and returned via other means. Students were required to use their university-supplied student email account for assignment submissions and receiving returned assignments.

Lab assignments consisted of four parts: background, pre lab, lab check offs, and lab results. Students were to read the background material and complete the pre lab exercises before coming to lab. The face-to-face lab met three hours a week one afternoon a week and was run by the lab instructor. During the face-to-face lab, students would complete the lab check offs either singly or in groups of two students. Lab check offs would be verified and graded during lab and students could work on the check offs until they completed them correctly.

Remaining face-to-face lab time could be used by the individual or lab group to work on the lab results which were due the following week. The lab results portion of the lab expanded on the work done for the lab check offs. The lab results were to written up using a prescribed Microsoft Word format and file naming convention. The results were to be submitted by midnight of the due date as an email attachment. The due date was typically the same day as the following week's lab although the instructor generally did not penalize students for submissions made before 8:00 AM the following morning.

Students could get help from the lab instructor as needed and there was no penalty on the check off grading as long as the check offs were eventually completed correctly during the face-to-face lab time. Students could get help on the lab results from the course instructor before or after the class lectures, from the lab or lecture instructor during regularly scheduled office hours, or from the lab or lecture instructor via email. Announcements were also made at the start of each class lecture and the lecture instructor often answered lab questions at the start of lecture.

HYBRID COURSE WITH ONLINE LABORATORY

In fall 2012, Introduction to Signal Processing was offered as a hybrid course with a traditional face-to-face lecture component but with an online lab component. This was necessary due to the larger than usual number of students enrolling in the course and a shortage of computer lab space due to some campus renovations. At Armstrong, a hybrid course is a course where technology is used to deliver 50% or less of class sessions (one class session up to 50% online). Two laboratory sections were offered, one taught by each of the paper's authors.

Fully online, partially online, and hybrid courses are required to use Armstrong's Learning Management System (LMS) which for fall 2012 was Blackboard Vista. Course materials had to be provided through the LMS and

assignments for the online lab had to be submitted and returned via the LMS. Vista has a course home page that can be customized and a course tools toolbar to access the various elements of the LMS such as announcements, learning modules, assignments, assessments, discussions, etc. The instructors set up the Introduction to Signal Processing Course to have as similar of a layout in Vista (Figure 1) as the previously used course web site (Figure 2).

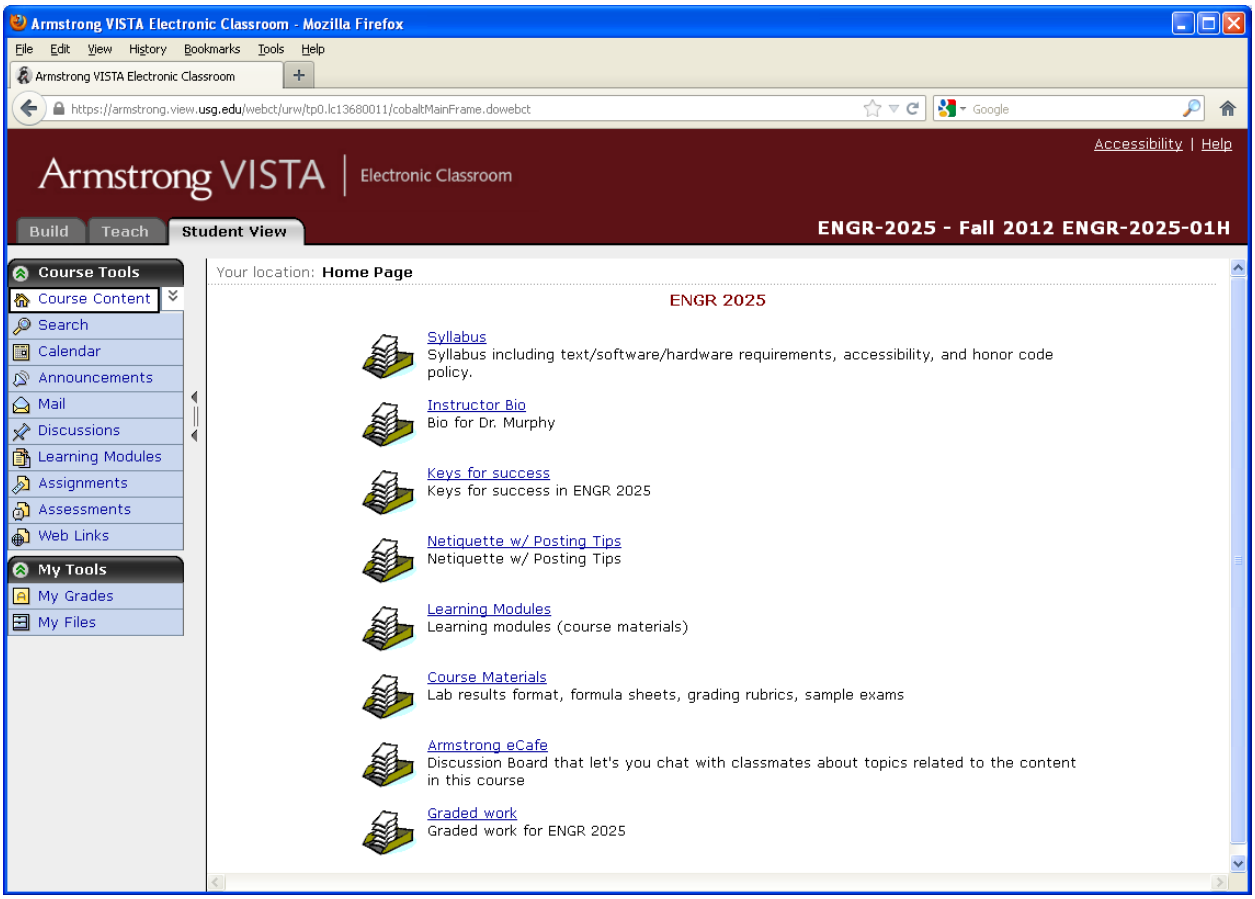

Figure 1, Hybrid Course Vista Layout

Announcements for each week were set to start being displayed 12:01 AM Saturday morning and end Friday at midnight. The announcements would be shown as a pop up window and could be viewed from the announcements tab in the toolbar. Announcements were also made at the start of each face-to-face lecture. The course syllabus, documents specific to the online lab such as netiquette, and handouts other than course and lab materials such as results format and sample exams were posted in folders off the course home page. Course material was grouped in learning modules according to topic and listed chronologically except that lab materials were always at the bottom of the module. The materials appear in an area accessed as a web link.

The Introduction to Signal Processing lecture portion was taught the same as in previous semesters. Labs were to be completed in an eight day span, Tuesday to the following Tuesday. Labs were generally posted Friday before the start of the eight day span although in two instances the labs were not posted until Monday. The lab window typically started towards the end of a learning module and ran into the middle of the next learning module. Check offs were due by midnight on the Wednesdays following the start of the lab window with lab results due by midnight of the following Tuesday. Tuesday and Wednesday are considered good days for assignment submissions as LMS updates are commonly done on weekends.

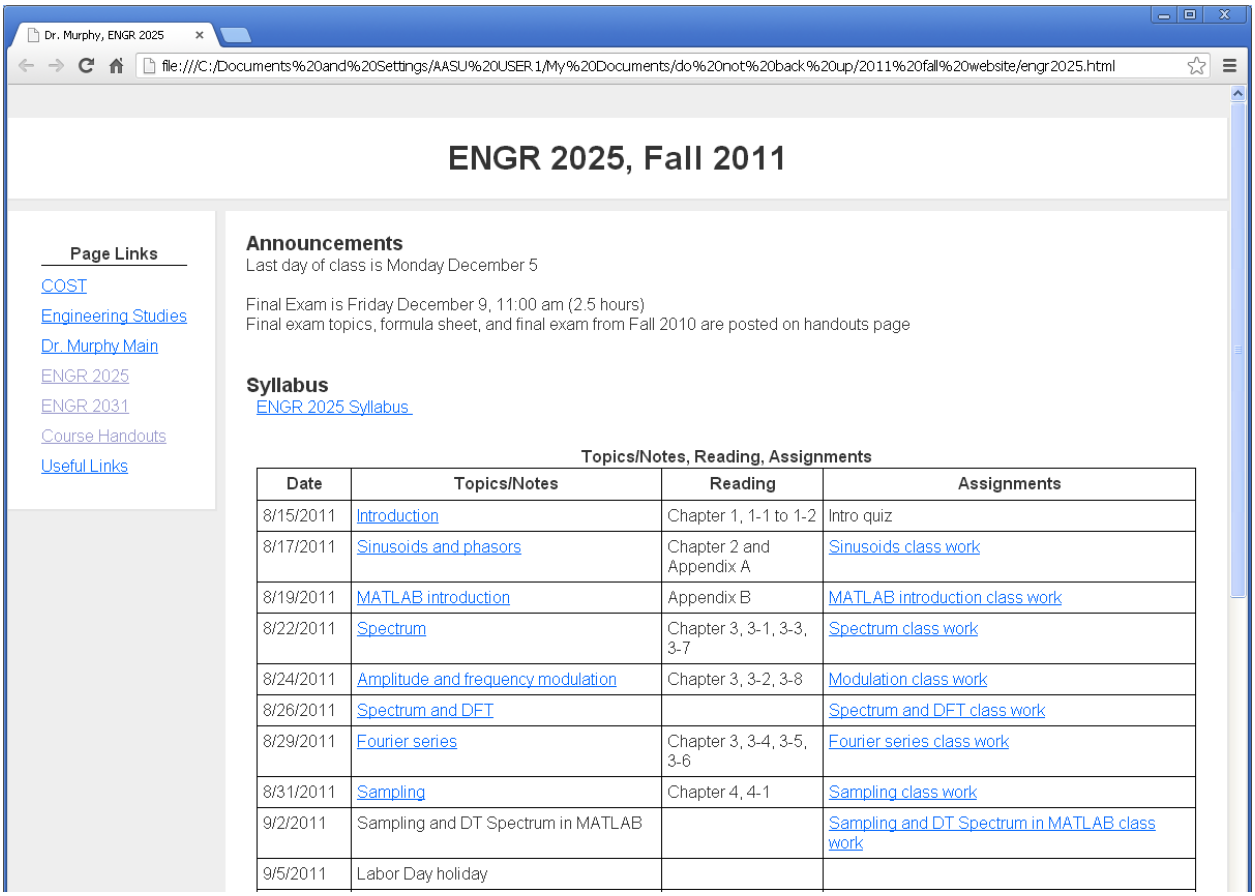

Figure 2, Course Website from Previous Semesters

Assignment links were created for each lab check off and results. Students submitted lab assignments using the LMS by attaching Microsoft Word documents to the assignment link page. A similar lab results format and file naming convention for submissions was used for the online laboratory as for the face-to-face laboratory in previous semesters. Lab assignments were returned by posting the graded and commented documents in a graded work folder off the LMS course home page that was viewable only by the particular student.

Since many students had signed up for Introduction to Signal Processing before it was changed to a hybrid course (it was originally scheduled as a traditional face-to-face course and lab) and were concerned about taking an online laboratory, the instructors ran a face-to-face lab help session one afternoon a week on the same day and time that the original face-to-face lab was scheduled. The computer lab reserved for the help was not large enough to accommodate the entire class but no more than 15 students ever showed up for lab help during these sessions.

INSTRUCTOR IMPRESSIONS

The instructor workload to prepare for the hybrid course offering was much higher than preparing for the face-to-face course. Even with the majority of materials already in electronic format, course materials still had be accessible to students with disabilities (508 compliant) requiring conversion of all posted materials. Converting equations and figures with MATLAB code and plots was particularly time consuming. A few additional documents outlining hardware/software requirements, how to get technical support, how to succeed in the course, how to get academic help etc. had to be created for the hybrid course. Laboratory assignments were edited to ensure clarity and clearly list what was to be turned in for check offs and results (deliverables). A lot of time was spent adding announcements, links, and posting materials than in past semesters although some of this can be attributed to the instructors familiarity with their own course web sites and this being their first semester teaching with the LMS.

ENGR 2025 has always had a heavy laboratory grading load and this remained the same with the online lab. Providing feedback on the check offs before the lab results were due was difficult for the online section whereas in the face-to-face lab students received immediate feedback on the check off portion of the lab. A disadvantage of having the check offs turned in after the lab period was that students often spent their in-lab time working on the previous week's lab results instead of starting on the new lab check offs. If a student did not understand a lab during the check off phase, they often ended up turning in two assignments (check offs and results) with the same misconceptions and mistakes.

Since the instructors held face-to-face lab help every week, an extra three hours that would have typically been used to provide online feedback or grade was consumed by running the lab help sessions. Without spending this time, grading could have been more timely although some of this time would be needed to answer lab questions online whereas this semester the instructors received very few email or discussion post questions in the LMS.

In the face-to-face version of the lab course, lab results were graded by typing comments in red in the document and returning the lab results with comments and grade to the student via email. Students submitted electronic lab reports under specifically created sections within Vista. Each lab had two submissions; a check-off section and a final lab report were required for each lab. Students were encouraged to work in teams of two with only one of the students submitting a document for grading. The lab reports were evaluated by the instructors and returned to the student with comments and grades added at the bottom. Those graded documents were then uploaded back into Vista with the graded version being viewable only the students who submitted that specific lab.

Returning graded work took about twice as long to upload and attach to the student area as opposed to email mostly due to the awkward file management system in Vista. There is an option in Vista to place comments in a text box of the assignment link which makes returning comments and grades much easier but this does not allow comments to be placed by the portion of the assignment they go with. However, with a more detailed labeling/numbering system for lab deliverables this may make it possible in future semesters to use this feature and clearly indicate what the comment refers to. Group assignment links were not very practical as the groups were changed for every lab and the instructors wanted the students to self-select their groups. It would have been more manageable to have set up either permanent lab partners or randomly assigned groups so then either student could submit from a common assignment link.

STUDENT IMPRESSIONS

All students taking the course with the online lab except one were traditional students, approximately 18 – 22 years old. All students except for one were full time students. This is a typical makeup for this course at Armstrong.

Anecdotally students were not pleased about having to use the LMS. Both during lecture and during the lab help, students regularly complained about Vista especially the submission issues. Students often had problems with submitting lab assignments via the LMS for the first two assignments. Common problems were: students not being able to submit assignments due to browser or JAVA runtime environment incompatibility with Vista, students in groups thinking the other member would submit, students submitting assignments via email instead of the LMS, and submitted assignments not following the file naming convention. These are similar problems, except the LMS incompatibility, the instructors encountered in other classes where they received assignments via other electronic methods. With the exception of the LMS submission issues, the other problems mostly disappeared by the third lab which is also consistent with previous semesters. The submission problem was not surprising as there is an issue between certain web browsers and the Java plug-in version required to upload/attach files for assignment submission.

An online survey was given to the class using SurveyMonkey [15] just after midterm. There were 28 students enrolled in the course at that time, three had withdrawn before midterm. Of the 28 students enrolled, 24 students completed the survey. Most survey questions used a Likert scale for responses with the choices ranging from very easy to very difficult.

Even though students regularly complained about using Vista, approximately 80% of students indicated they had little difficulty using the LMS for the laboratory component of the course. Ease of submitting assignments was the biggest problem area for students with 25% of students having difficulty in this area. Table 1 summarizes the responses of the ease of using Vista, Armstrong's LMS, for the online laboratory component of the course.

	Very Easy	Easy	Neutral	Difficult	Very Difficult
Ease of following course announcements	4 (16.7%)	8 (33.3%)	7 (29.2%)	5 (20.8%)	0 (0.0%)
Ease of obtaining lab material	5 (20.8%)	10 (41.7%)	4 (16.7%)	5 (20.8%)	0 (0.0%)
Ease of submitting lab assignments	7 (29.2%)	6 (25.0%)	5 (20.8%)	3 (12.5%)	3 (12.5%)
Ease of checking graded lab assignments	8 (33.3%)	4 (16.7%)	7 (29.2%)	5 (20.8%)	0 (0.0%)

Table 1, Summary of Student Survey Responses on using the LMS

Of the students completing the survey, 22/24 had taken a course from the first author previously. Table 2 summarizes the responses of these students about the use of an instructor maintained web site instead of the LMS. Students found the ease of use of the LMS versus the instructor web site plus email submission comparable. Students indicated that assignment submission was easier via email, but that opinion is most likely due to the browser/JAVA issues with Vista. The slightly higher indicated ease of use of the previously used instructor site could be due to the fact that is what the student first encountered and got accustomed to using.

Of the students completing the survey, 21/24 (87.5%) indicated that they took advantage of either regularly scheduled lab help or instructor office hours for lab help. This is consistent with the instructors' records of 20 students receiving face-to-face, office hour, or email help throughout the semester (this excludes the students who withdrew). Of the 20 students that sought face-to-face lab help, 12 students sought help seven or more times, three students sought help 3-5 times, and five students sought help once or twice.

	Very Easy	Easy	Neutral	Difficult	Very Difficult
Ease of following course announcements	7 31.8%	8 34.6%	6 27.3%	1 4.5%	0 0.0%
Ease of obtaining lab material	9 40.9%	7 31.8%	5 22.7%	1 4.5%	0 0.0%
Ease of submitting lab assignments	7 31.8%	6 27.3%	7 31.8%	2 9.1%	0 0.0%
Ease of checking graded lab assignments	8 36.4%	7 31.8%	4 18.2%	3 13.6%	0 0.0%

Table 2, Summary of Student Survey Responses on using Instructor Web Site and Email

There appears to be a disconnect between students who thought they needed more face-to-face lab help and actually sought face-to-face lab help. All students enrolled in the course had access to face-to-face help, either during the face-to-face lab help or instructor office hours. From instructor records, 38.7% (12/31) of students regularly sought face-to-face lab help (this includes the three students who withdrew). However, 75% (16/24) of the survey

respondents indicated they needed more face-to-face lab help with the lab component and one might assume that at least some students who regularly attended the face-to-face lab help received enough face-to-face help. For the lab assignments following when this survey was given, face-to-face lab help was not sought by any larger number of students than before the survey.

STUDENT PERFORMANCE

Compared with previous semesters, student performance on the lab results portion of the labs was comparable. The lab results average of the face-to-face fall 2008 to fall 2011 labs was 22.2/30 and the average of the online fall 2012 lab was 22.6/30, see Table 3. This was not unexpected, as students who had a face-to-face lab in prior semesters did most of the lab results work outside of the face-to-face lab time and did not seek help very often to complete the lab results which was the same as encountered in the online lab. The quality of the lab results was more dependent on the individual student than whether they sought face-to-face help. There were fewer instances of no lab submission in the online lab than in many of the previous face-to-face labs.

Student performance on the lab check off portions of the labs was significantly better in the face-to-face labs in previous semesters than the current online lab. The lab check offs average of the face-to-face fall 2008 to fall 2011 labs was 9.7/10 and the average of online fall 2012 lab was 7.5/10, see Table 3. This also was not unexpected as students in the previous face-to-face labs had multiple attempts and face-to-face help on the check offs and only students who sought face-to-face help during the lab help time (in effect taking the lab face-to-face) had a similar experience in the online version. Most students taking the face-to-face lab in previous semesters completed the check offs for full credit during the face-to-face lab time. Almost no students taking the online lab sought help the way an online student would be expected to, via email or discussion post for instructor. The instructors did not encourage or discourage students seeking help this way versus face-to-face help. There were more instances of no check offs submitted in the online version since the check off portion was designed to be completed during the face-to-face lab time of prior semesters.

	Fall 2008	Fall 2009	Fall 2010	Fall 2011	Face-to-Face Average	Online Fall 2012
Check offs	9.5	9.5	10.0	9.8	9.7	7.5
Results	23.4	21.3	21.9	22.4	22.2	22.6
Number students	10	10	12	19		29

Table 3, Summary of Student Lab Grade Averages, Fall 2008 to Fall 2012. Values of students who withdrew or stopped attending class are not included. Values scaled so check offs are out of 10 and results out of 30.

The instructors expected the relatively low rate of students seeking lab help as the students taking the course were primarily traditional students who often waited until the last minute to work on assignments. This suspicion was confirmed to some degree by the submission times of assignments regularly being near midnight of the due date or slightly late.

CONCLUSIONS AND FUTURE WORK

Students found the LMS comparable to using an instructor website plus email for following course announcements, obtaining laboratory materials, and checking graded assignments. Students found submitting assignments via email easier than using the LMS. Armstrong student opinions of LMSs should improve when Armstrong switches to a newer LMS, Desire2Learn, in 2013.

Students indicated they needed more face-to-face help with the lab component of the course, but only about a third of students took advantage of the scheduled lab help or office hours available. The addition of a dedicated discussion board for lab help could replace some of the immediate feedback one gets in a face-to-face lab and allow both students and the instructor to answer student questions. This would require additional instructor time to monitor and

post answers in a timely manner but time that otherwise would have been spent monitoring a face-to-face lab could be shifted to this. This idea was discussed for this semester, but due to the time commitment of the face-to-face lab hours and impending switch to a new LMS in spring 2013, was decided against.

A discussion board could allow both students and instructors to post and answer questions. A possible downside to a forum of this nature is the potential spread of incorrect or slightly incorrect answers, terminology, or ideas. To catch those types of errors, content moderation would be required, which would also help prevent non-course related material from appearing. At Armstrong, the instructor of the course is required to moderate forum postings and content within their courses in the LMS. Students are provided with netiquette documents and other guidelines on what is appropriate to post in forums, so it is not expected that moderation would take much time.

An additional forum could be created that allows the instructor to post questions asked privately by students and allow other students to see those "official" answers. This would require more work on the instructor's part, but would provide a more definitive source of knowledge regarding course questions. However, the timing of responses could create an issue based on when students ask questions and when the instructor is available to answer them. Offsetting face-to-face hours would help provide more time to answer forum postings, but some kind of schedule would have to be set up so students would know when to expect answers.

Another issue that needs to be addressed in future versions of the class is the issue of check off problems. A system needs to be formulated to allow quicker grading and return of those problems before lab results are due. Previous students also had the added luxury of multiple submissions during lab time, making their grades much higher on check offs than during this semester. A viable alternative needs to be constructed for online versions of this lab without requiring additional instructor time.

A lot of typical online course options/actions were avoided because of the impending LMS switch at Armstrong. Instructors did not want to spend a lot of time learning the intricacies of Vista right before having to switch to Desire2Learn. Because of this, the instructors did not encourage as much online interaction via discussion board posts and video conferences as they might in future semesters. The idea of virtual office hours was seriously considered, including the purchase of equipment, only to be scrapped at the last minute because of the time commitment required in other areas of the course, as well as the system switch. They also did not use the grade book, which might have made some aspects of the course easier. Subsequent attempts at offering this course online will include more of a traditional online experience.

Students taking a class from the first author the following semester were asked during the third week "If you had a choice of taking a face-to-face or online lab for ENGR 2025, which would you choose?" 13/13 students attending class that day (one student was absent), all of whom had taken ENGR 2025 the previous semester with the online lab said they would take the face-to-face version of the lab.

Conversations with the students during and after class shed light on possible reasons for that response:

- Armstrong online course tuition is higher than in-state face-to-face tuition ($209 vs. $150.40/credit hour).
- The students are all full time on-campus students. Only two of them had taken any other online courses; one was taking one online course that semester and one had taken several before coming to Armstrong.
- The students have a poor view of the experience in online courses.
- Several students had the misconception that Georgia's Hope Scholarship would not pay for online courses (it will).

Even with the student conversations, it was surprising that all 13 students would choose the face-to-face lab. Of those 13 students, eight had come regularly for face-to-face lab help but five had not.

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