AC 2012-4382: FACTORS THAT AFFECT STUDENT FRUSTRATION LEVEL IN INTRODUCTORY LABORATORY EXPERIENCES

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Factors that affect student frustration level in introductory laboratory experiences

Abstract

Laboratory-based courses have long been an integral part of undergraduate curricula in both engineering and basic sciences, and much research has been devoted to gauging and improving their effectiveness[1,2]. However, particularly in introductory courses with students from different majors and academic backgrounds, conducting successful laboratory experiences continues to entail many challenges, including the mitigation of student frustration level. Studies have shown that frustration may impede progress towards learning goals[3], and various authors have studied frustration in different settings, such as web-based courses[4] and programming courses[5]. We build upon these ideas by investigating the impact on student frustration of various factors in laboratory-based courses. Our purpose is to identify qualities of successful introductory laboratory experiences which may help mitigate student frustration.

Our study focused on two introductory level laboratory courses (College Physics Laboratory I and College Physics Laboratory II) within the ABET-accredited general engineering curriculum at a small (less than 2,000) regional liberal arts college. Total enrollment in these courses was 34 students, primarily freshmen and sophomores (94%), including 17 men and 17 women (50% each). The courses spanned engineering majors (41%) of different concentrations (electrical, mechanical, computer, and industrial), as well as basic sciences majors (59%). Following several of the laboratory sessions, the students filled out a survey. The survey included questions about their frustration level during the experiment, their perception of the duration of the laboratory session, the primary causes of their frustration (equipment or troubleshooting issues, difficulty with theoretical concepts, lack of support from the instructor, confusing lab document, difficulty working with partner, or outside distractions), whether there were any pre-lab exercises and whether these were helpful, whether the instructor's introduction was too brief or too prolonged, as well as their confidence level regarding both the technical and theoretical aspects of the course. We then examined the relationship between the characteristics of their laboratory experience and their self-reported frustration level.

The factor that was most often cited as a cause of frustration was difficulties with equipment and troubleshooting, followed by difficulty with concepts from the theory, and confusing lab documents. In fact, in the two laboratory sessions where the average frustration level was rated as highest, 78% of the students cited equipment issues as a cause of frustration. Interestingly, for the experiment with the highest average frustration level, the second leading cause was confusing lab documents (61% of the students). This points towards the necessity to place particular emphasis on clear documents for introductory laboratory courses, as well as spending more time helping students with instrumentation and troubleshooting. The students generally felt that the 15-minute introduction by the instructor was appropriate and that, when assigned, pre-lab exercises were helpful. Students' confidence level about the technical aspects of the course correlated inversely with frustration level, but their confidence level about the theoretical aspects

of the course did not show a clear trend. These results can help craft introductory laboratory experiences with lower student frustration levels.

Introduction

Laboratory-based courses have long been an integral part of undergraduate curricula in both engineering and basic sciences, and much research has been devoted to gauging and improving their effectiveness[1,2]. However, particularly in introductory courses with students from different majors and academic backgrounds, conducting successful laboratory experiences continues to entail many challenges, including the mitigation of student frustration level.

Studies have shown that student frustration may impede progress towards learning goals[3], and various authors have studied frustration in different settings, such as web-based courses[4] and programming courses[5]. In these settings, the authors studied which are the leading causes of frustration amongst students, in hopes that, with that insight, instructors may devise ways to address these difficulties and improve student learning.

We build upon these ideas by investigating the impact on student frustration of various factors in laboratory-based courses. Our purpose is to identify qualities of successful introductory laboratory experiences which may help mitigate student frustration. We hope that this study may provide instructors with insight to help craft more effective introductory laboratory experiences.

Methods

Our study focused on two introductory level laboratory courses (College Physics Laboratory I and College Physics Laboratory II) within the ABET-accredited general engineering curriculum at a small (less than 2,000) regional liberal arts college. Total enrollment in these courses was 34 students, primarily freshmen and sophomores (94%). With respect to gender, the distribution was of 17 men and 17 women (50% each). The courses spanned engineering majors (41%) of different concentrations (electrical, mechanical, computer, and industrial), as well as basic sciences majors (59%).

Following several of the laboratory sessions, the students filled out a survey about their frustration level during the experiment. For each of the courses, laboratory sessions were held once a week, and each session was 1 hour and 50 minutes long. The survey included questions about the following topics:

- the student's frustration level during the experiment
- perception of the duration of the laboratory session
- primary causes of their frustration (equipment or troubleshooting issues, difficulty with theoretical concepts, lack of support from the instructor, confusing lab document, difficulty working with partner, or outside distractions)
- whether there were any pre-lab exercises, and whether these were helpful
- whether the instructor's introduction was too brief or too prolonged
- confidence level regarding both the technical and theoretical aspects of the course

The college's Institutional Review Board approved all data collection and protocols for protecting student's identities. All students gave their informed consent to participate in the study.

We then examined the relationship between the characteristics of their laboratory experience and their self-reported frustration level and identified the leading causes of student frustration.

Results and Discussion

The factor that was most often cited as a cause of frustration was difficulties with equipment and troubleshooting, followed by difficulty with concepts from the theory, and confusing lab documents. Table 1 shows the total number of instances in which each factor was listed as a cause of frustration, for all laboratory sessions surveyed.

	Equipment and troubleshooting	Concepts from theory	Confusing documents	Lack of support from instructor	Difficulty with partner	Outside distractions	Other
Total	55	25	22	1	6	9	2

Table 1. Results for the total number of instances each factor was listed as a cause of frustration.

In fact, in the two laboratory sessions where the average frustration level was rated as highest, 78% of the students cited equipment issues as a cause of frustration. Interestingly, for the experiment with the highest average frustration level, the second leading cause was confusing lab documents (61% of the students). (Table 2)

	Equipment and troubleshooting	Concepts from theory	Confusing documents	Lack of support from instructor	Difficulty with partner	Outside distractions	Other
Session 1	15	7	14	1	1	2	1
Session 2	21	12	3	0	2	2	1

Table 2. Number of instances each cause was listed as a cause of frustration, for the two lab sessions with highest average frustration level.

This points towards the necessity to place particular emphasis on clear documents for introductory laboratory courses, as well as spending more time helping students with instrumentation and troubleshooting.

Frustration level vs perception of duration, Session 1

Frustration level vs perception of duration, Session 2

y = 0.7868x + 1.8207
R² = 0.5555
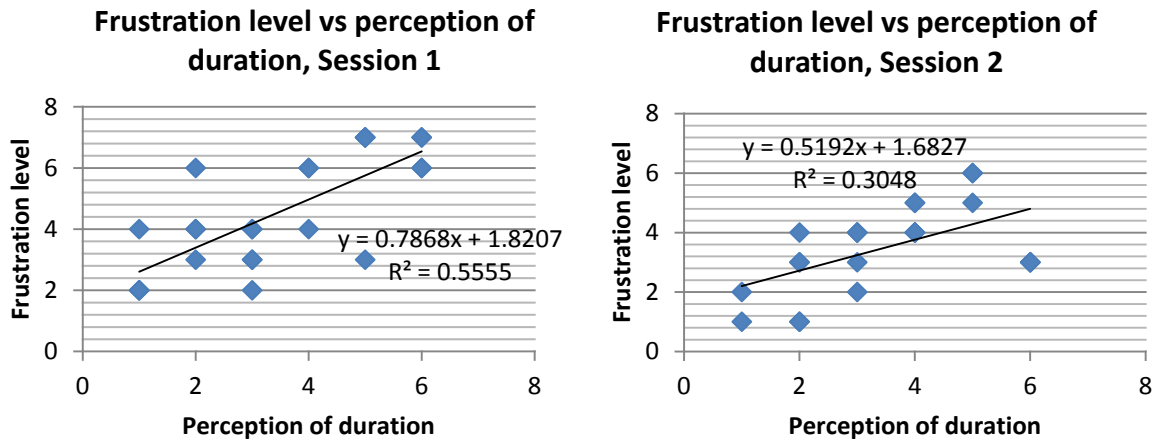
y = 0.5192x + 1.6827
R² = 0.3048

Figure 1. Positive correlation between frustration level and perceived duration of laboratory session, for the two sessions with highest average frustration level.

As we surmised, there was a positive correlation between student's frustration level and the way they perceived the duration of the session, in comparison to the expected duration. (Figure 1) It should be of note that some students reported the experiment took considerably longer than they expected, even though it did not take the full class period. We expect this may be because, upon reading a relatively short lab document, students may underestimate the actual time it may take them doing measurements. Particularly, in the cases where the equipment either needs to be calibrated or they have to spend time troubleshooting, students do not factor this into their initial estimate on how long the experiment will take, and thus become more frustrated.

Another aspect which the survey investigated was gauging the students' opinion on the duration of the instructor's introduction to the laboratory session. In the early sessions, the instructor's introduction usually lasted around 15 minutes. We were open to modifying the duration of time based on the feedback we received from the student throughout the course. However, the students generally felt that the 15-minute introduction by the instructor was appropriate.

Students' confidence level about the technical aspects of the course correlated inversely with frustration level, but their confidence level about the theoretical aspects of the course did not show a clear trend. (Figures 3 and 4) This was somewhat surprising, in that we expected that students with lower confidence in the theoretical level might find the laboratory sessions particularly frustrating. However, it may also be reassuring for instructors and students to know that, even if a student is having difficulty with the theoretical portion of a course, he or she may be engaged in the laboratory portion.

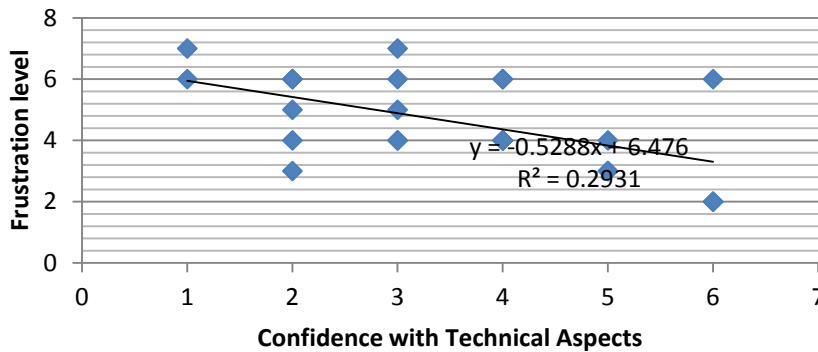## Frustration level vs Confidence with Technical Aspects

Figure 3. Inverse correlation between students' frustration level and their confidence in the technical aspects of the course.

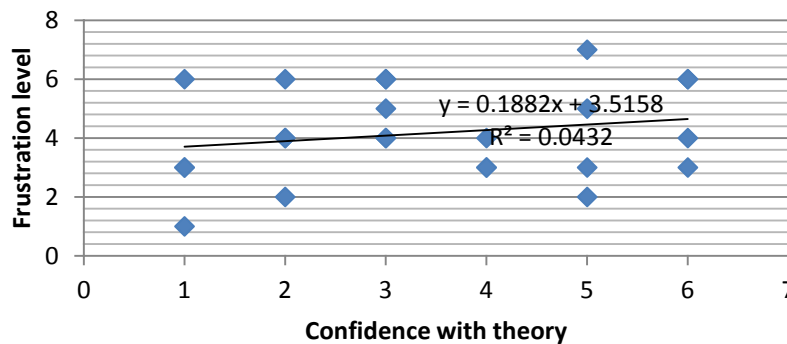## Frustration level vs confidence with theory

Figure 4. Frustration level was uncorrelated with students' confidence with the theoretical aspects of the course.

From the previous results, we as faculty members can learn valuable insight to incorporate into our laboratory courses for a more successful experience. We observed that the most significant source of student frustration are difficulties with equipment and troubleshooting. Based on this, the most immediate recommendation is for the instructor and any teaching assistants or technicians to spend additional time prior to the laboratory session making sure all the equipment is functioning correctly. However, we observed that there were multiple instances when the students became frustrated with the equipment even though it was functioning correctly. The reason for this was that the students did not fully understand the way the equipment functioned. One possible way to address this is to hold additional sessions at the beginning of the semester focusing simply on learning how to use the equipment and troubleshoot it.

We also observed that one of the leading causes for student frustration was lack of clarity in the lab documents. In many laboratory courses, instructors use documents or handouts from previous semesters without making any significant changes to them. Over time, however, these documents may become obsolete, particularly if there have been changes in the actual laboratory equipment that were not reflected in the original document. It may therefore be necessary to periodically revise these documents and make sure they are consistent with the most updated version of the experiment. Additionally, particularly in the case of introductory laboratory experiences , there are instances when the document may include all the necessary information, but students only skim the document prior to coming to lab. To address this, it may be necessary to either spend extra time reviewing the document with the students or to include a pre-lab exercise or quiz.

Students may also learn from our results and identify habits that may be conducive to getting the most from their lab experience. By spending enough time prior to the lab session studying the document and becoming familiar with the experiment, many of the causes of frustration may be allayed.

In spite of the insight we have gained from our results, there were limitations to our study. The primary limitation was that the number of students was relatively small, weakening our statistical power. However, trends are still apparent. Future studies could extend our approach to a larger cohort so that a more thorough statistical analysis may be applied.

Additionally, it would be of interest to test the effectiveness of the approaches to mitigating of student frustration level that we suggest here. Furthermore, if these approaches are indeed successful in mitigating frustration, it would also be of interest to determine whether, in turn, the lower levels of frustration do indeed result in higher student performance.

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