# In Depth Exploration of Added Course Expenses on Students of Various Socioeconomic Status

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***Abstract*—This research full paper explores the magnitude of added course fees and miscellaneous costs in an engineering program and how these fees impact lower socio-economic students. Previous work has examined the effects of added course fees and development boards on students from various socioeconomic backgrounds. While the study found that students of varying socioeconomic status did not agree that they felt "ostracized" as a result of added course expenses, the study did not examine whether students felt other, less severe feelings of exclusion or loss of identity in relation to engineering costs.**

**This paper provides an in-depth exploration of the effects of added course expenses on students' sense of inclusion in Electrical and Computer Engineering Programs. Specific emphasis is placed on how student experience varies by socio-economic status, and the experience of low-socio-economic status is treated with particular interest. "Added course expenses" includes any development boards, parts, and personal computing resources (laptops) necessary for student success but not directly charged by the school for enrollment in a course.**

***Index Terms*—course expenses, socio-economic status, inclusion**

## I. Introduction

Whether by requiring students to buy an Arduino for prototyping, "recommending" students purchase a USB-powered signal analyzer for out-of-classroom circuit analysis, or assigning "homework" that requires students to be able to run computationally intensive software like Matlab, many Electrical and Computer Engineering (ECE) are increasingly shifting the costs of offering lab and practice-based courses onto their students. Despite this trend, many programs do not keep track of how much of a financial burden these added course expenses present to their students. Further, to the authors' knowledge, not much previous work has explored how these costs affect perceptions of inclusion and academic success among students. Our work attempts to address this knowledge gap.

This work uses a custom survey instrument to assess whether and to what degree students feel a lack of identity or "otherized" in ECE programs due to affordability issues related to lab kits, development boards, and the laptops students require to use these components. The work finds that while most students are at least able to afford some working laptop computer that is sufficient to complete their work, a sizeable student population reports challenges in affording lab kits and other components. Further, a majority of these students report that affordability of class supplies and development boards negatively impacts their academic success in the program. Please note, however, that this data was collected in Fall 2019—before the COVID-19 epidemic—so student needs may have changed since.

The rest of this work is organized as follows. Section II provides an overview of previous work in the field of college affordability and the effects of added course expenses on students. Section III discusses how we designed our instrument to measure affordability issues for students. Section IV explores the results of our survey, and the paper concludes in Section V.

## II. Background

Significant research has identified cost as a barrier for access to higher education [1]–[3]. Some research has shown that even perceptions of college costs can disproportionately deter students from lower socioeconomic backgrounds from attending college [4], [5]. At the same time, many students who do attend are facing higher debt burdens [6], and fear of accumulating debt is creating another set of psychological barriers for students struggling to afford higher education [7].

As official college costs have increased, the advent of personal computing technology and low-cost development boards have left students in fields like Electrical and Computer Engineering facing a number of new "unofficial" or "optional" costs. Studies have shown that access to laptops and other computing devices is now ubiquitous, and that the vast majority of students view laptops as "very or extremely important" for their academic success [8]. As a result, students may face

strong social and academic pressures to purchase a laptop for classroom use [9].

As laptops have become more common, many instructors have started recommending or requiring students to buy mobile measurement equipment and development boards as part of the course curriculum, and encouraging students to incorporate purchased components into final projects. While it is unclear how much students spend on these supplies, some students report that this practice is both financially burdensome and that inability to afford course supplies can affect their sense of inclusion in computer and electrical engineering [10].

## III. Methodology

We developed a custom survey instrument to determine the effects of added expenses on inclusion in ECE. The survey is broken into two parts, the first part focuses on laptop ownership, and the second part focuses on costs associated with development boards, lab kits, and extra purchases.

The laptop section of the instrument asks students to describe their current laptop ownership status. Respondents may choose "I choose not to have a laptop", "I would like a laptop but cannot afford one", "I own a laptop, but it is broken and I cannot afford to fix it", "I own an older laptop that is slow and under-powered compared to typical lab computers", "I own a laptop that performs equally to typical lab computers", and "I own a laptop that performs better than typical lab computers". Based off of their response to this question, students with no laptops either by lack of affordability or by choice are sent to the questions shown in Tables I and II respectively. Students reporting ownership of under-powered laptops were asked slightly reworded versions of the questions in Table I. The questions are primarily asked on a five-point Likert scale [11], with some free response questions (indicated by a "*" prefix in the table) to assess whether a laptop is truly a priority for these students, or if they are facing more pressing needs.

TABLE I
QUESTIONS FOR STUDENTS WHO EITHER CANNOT AFFORD A LAPTOP OR CANNOT AFFORD TO FIX A BROKEN LAPTOP.

| **Questions for students who cannot afford to buy/fix a laptop** |
|---|
| Lack of laptop access does not affect my academic performance |
| Not having a laptop makes me feel like I don't belong |
| Not having a laptop adds to my sense of individuality in the program |
| Other students judge me negatively because I don't have a laptop |
| I judge myself negatively because I don't have a laptop |
| I feel insecure or sensitive when taking a class that requires or expects extensive use of a laptop |
| Affordability/financial constraints is the reason I do not have a functioning laptop |
| *If you were to win a cash prize, how much money would you need to win to consider purchasing a new laptop/repairing a broken laptop? |
| *If you were to win the amount you listed above and you could spend it on any personal need (food, housing, clothes, etc.) or educational need (textbooks, course fees, etc.) instead, what would you spend it on (or would you still spend it on getting a laptop)? |

In the second part of the instrument, all students were asked a common set of questions about added course expenses related to items like lab-kits, development boards, and sensors/parts for final course projects. These questions are shown in Table III. Respondents reporting that these costs constitute a financial burden were then directed to the set of questions shown in Table IV, which were designed to determine whether and to what extent lack of affordability impacts the respondent's sense of belonging and perceived academic performance. The questions in Tables III and IV are primarily Likert-based, with questions annotated with a "*" indicating a text response, and questions annotated with a "+" indicating a yes/no response.

TABLE II
QUESTIONS FOR STUDENTS WITH NO LAPTOP BY CHOICE.

| **Questions for students with no laptop by choice** |
|---|
| I prefer using another computing device, such as a tablet or smartphone to meet my mobile computing needs |
| I find laptops/mobile computing resources too distracting in the classroom |
| Lack of laptop access does not affect my academic performance |
| Not having a laptop makes me feel like I don't belong |
| Not having a laptop adds to my sense of individuality in the program |
| Other students judge me negatively because I don't have a laptop |
| I judge myself negatively because I don't have a laptop |
| I feel insecure or sensitive when taking a class that requires or expects extensive use of a laptop |
| Affordability/financial constraints is the reason I do not have a laptop |

TABLE III
QUESTIONS ABOUT LAB KITS AND OTHER EXPENSES.

| **Questions about lab kits and other expenses.** |
|---|
| I typically purchase most of the components in class projects |
| My group typically splits the cost of components |
| My group mates typically buy the the components for any class projects |
| I (or my group) typically build(s) a project without needing to purchase any additional components |
| *How much money per year do you estimate that you spend on additional parts/lab kits? This includes recommended development boards, recommended text books, lab kits, components for projects, and other expenses that aren't technically "required" for every student in the course. |
| *If you are eligible for financial aid, how much of your yearly expenses on parts/lab kits is covered by standard financial aid/grants/scholarships? |
| +Paying for lab kits, project components, development boards, and other miscellaneous course costs constitutes a financial burden for me or my family |

The survey concludes with several demographic questions to determine a respondent's race, ethnicity, and gender.

## IV. Results

The survey instrument was emailed to all ECE students at California Polytechnic State University during the Fall quarter 2019. Please note that is was before the COVID-19 epidemic, so student needs may have changed somewhat in the months since.

A total of $94$ students responded, with the race and gender breakdown show in Table V. $14\%$ of respondents identified their ethnicity as Hispanic or Latino, and $21\%$ of respondents identified as first generation college students.

TABLE IV
QUESTIONS ABOUT LAB KITS AND OTHER EXPENSES, ASKED OF STUDENTS WHO REPORTED THAT THESE COSTS CONSTITUTE A FINANCIAL BURDEN.

| **Questions about lab kits and other expenses.** |
|---|
| I feel insecure because I struggle to afford lab kits and components |
| My classmates have reacted negatively to me for depending on others to purchase lab kits and components |
| Lack of affordability of parts/lab kits negatively affects my academic performance |
| Struggling to afford parts, board, and kits makes me feel like an outsider in the department |
| Working through the curriculum despite affordability issues increases my sense of accomplishment as an engineer |
| *Are there components/development boards/lab kits that you are currently unable to use financial/scholarship money for? Please explain. |
| *Is there anything else about component affordability you would like us to know? |

TABLE V
NUMBER OF RESPONDENTS BY RACE AND GENDER.

| **Gender** | |
|---|---|
| Male | 67 |
| Female | 22 |
| Other | 2 |
| **Race** | |
| White | 48 |
| East Asian | 16 |
| South Asian | 10 |
| Multiracial | 10 |
| Black or African American | 1 |
| Native Hawaiian or API | 1 |
| Other or Unknown | 3 |
| Prefer not to answer | 2 |

### A. Laptop ownership

Only two out of ninety-four respondents reported having no working laptop: each reported that their laptop is broken and they cannot afford to fix it. While this is not a statistically significant population, both report that lack of a laptop hinders their academic success, and makes them feel like they do not belong. Both also agree or strongly agree that they feel insecure whenever taking a class that requires or expects extensive laptop use; and while both agree or strongly agree that lack of affordability is the reason that they do not have a laptop, both report that even if given enough money to buy a laptop they have other higher priorities that they would spend the money on: "Course fees and food are more important to pay than my laptop." While such a small population of non-laptop users would potentially be easy for departments to address through laptop lending programs [9], this data suggests that these students may have other, more pressing needs that need to be met to ensure their success.

While most respondents owned a working laptop, 48% indicate that they have a laptop that under-performs relative to lab computers. Of these, 64% either agree or strongly agree that financial constraints are the main reason that they do not upgrade. When posed with the hypothetical question of how they would use a cash prize large enough for them "to consider purchasing a new laptop/repairing a broken laptop," only 29% would use the money for a laptop, while 44% would use the money to pay for personal necessities—including food, housing, clothing, medical, and dental expenses—and 24% would use the funds for school expenses including tuition, textbooks, and lab supplies. The full breakdown of what students would spend money on is shown in Figure 1. Once again, it appears that many students with an under-performing laptop have more pressing financial needs than their personal computing resources.

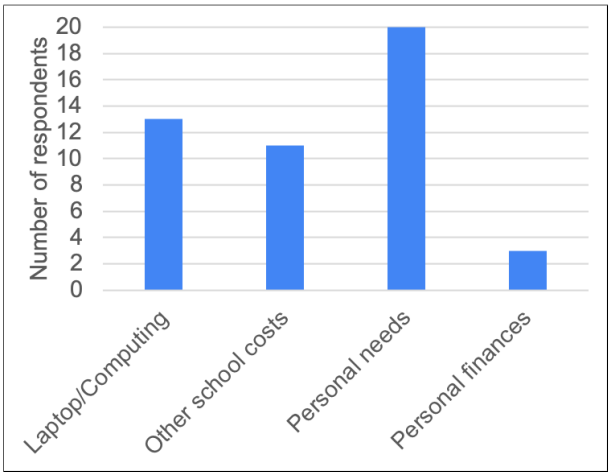


Fig. 1. *What students would actually spend money on, if given a cash prize big enough "to consider purchasing a new laptop/repairing a broken laptop".*

TABLE VI
AGREEMENT AND DISAGREEMENT RATES TO QUESTIONS ASKED OF STUDENTS WITH UNDER-PERFORMING LAPTOPS.

| **Questions for students with under-performing laptop** | **Agree/ Strongly agree (%)** | **Disagree/ Strongly disagree (%)** |
|---|---|---|
| *Use of an older/underperforming laptop does not affect my academic performance | 18 | 62 |
| Not having a faster laptop makes me feel like I don't belong | 24 | 47 |
| Not having a faster laptop adds to my sense of individuality in the program | 11 | 50 |
| Other students judge me negatively because I don't have a faster laptop | 16 | 57 |
| I judge myself negatively because I don't have a faster laptop | 27 | 52 |
| I feel insecure or sensitive when taking a class that requires or expects extensive use of a laptop | 36 | 52 |

Respondents with under-powered laptops expressed varying degrees of agreement and disagreement with the questions about their laptops' effects on their sense of inclusion and academic success. The results are summarized in Table VI.

The majority of respondents disagree that having an older/under-performing laptop does not affect their academic performance, while over a quarter of respondents report judging themselves negatively due to their laptop's performance. Additional, a substantial number of respondents report feeling insecure when taking a course that makes significant use of

a laptop. Taken together, this indicates that while a newer laptop may not be the most pressing financial need faced by students with an under-powered computer, having an under-powered computer does negatively affect students' perceptions of themselves and their confidence.

### *B. Added course expenses*

The survey instrument also asked students about their spending habits on lab kits, development boards, and extra hardware purchased for class. 70% of respondents report that they typically split these costs evenly with their group-mates, while only 7% of respondents report that they and their course partners tend to get through class projects and labs without the need to buy additional components.

Student reported spending on these costs, as well as how much of these costs students report using financial aid for are shown in Figure 2. Students not eligible for financial aid were asked not to report a financial aid number, resulting in different number of respondents for the two data series in the figures. Three outliers, reporting spending of $1000 or more, are omitted from the Figure. Excluding these outliers, financial aid eligible respondents who report that these costs constitute a financial burden for them spend a mean of $143 beyond what their financial aid covers per year on lab kits, parts, and development boards (median of $150 spent above what financial aid and scholarships cover).

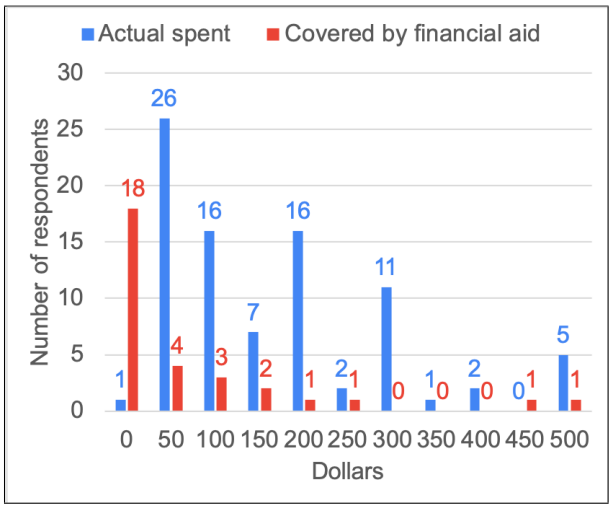


Fig. 2. *Student estimated annual expenditure on extra course hardware compared to student reported financial aid eligible to be spent on these expenses.*

Note that as part of this analysis, we did not ask students about other educational costs, such as textbooks and tuition. We reasoned that these costs are already well studied and are more likely to be addressed through standard financial aid. Additionally, anecdotal evidence suggests that students are able to somewhat control textbook costs by participating in large, second-hand markets, purchasing international editions, or other, potentially less legitimate, means.

The 25 students reporting that purchasing lab kits, boards, and components constituted a financial burden were asked an additional set of questions with responses summarized in Table VII. The responses indicate that these extra fees may have a significant impact on perceptions of inclusion and academic success faced by under-privileged students. While only 24% of these respondents report that they have faced negative reactions from classmates for depending on others to purchase components, 76% of these students report that a lack of affordable kits and components have negatively affected their academic performance. Additionally, roughly 50% of these respondents agree that affordability of lab kits and components make them feel insecure, and like an outsider in the department. Taken together, the data indicates that affordability of materials and supplies is a major issue for ECE students at California Polytechnic State University.

TABLE VII
RESPONSES ABOUT EXTRA COURSE COSTS FROM STUDENTS WHO REPORT THAT THESE COSTS CONSTITUTE A FINANCIAL BURDEN.

| **Questions to students reporting that added course expenses like lab kits, development boards, and components constitute a financial burden** | **Agree/ strongly agree (%)** | **Disagree/ strongly disagree (%)** |
|---|---|---|
| I feel insecure because I struggle to afford lab kits and components | 52 | 20 |
| My classmates have reacted negatively to me for depending on others to purchase lab kits and components | 24 | 36 |
| Lack of affordability of parts/lab kits negatively affects my academic performance | 76 | 0 |
| Struggling to afford parts, board, and kits makes me feel like an outsider in the department | 48 | 12 |
| Work through the curriculum despite affordability issues increases my sense of accomplishment as an engineer | 28 | 12 |

One reason for the impact of affordability on lab kits and components may be the short time window students have to acquire parts. Unlike text-books, component costs are not always advertised in advance of the quarter, making them, in the words of one respondent "an unexpected cost that my family and I have to figure out how to pay for in the span of 1 or 2 weeks." Another issue cited by several students is that parts and development boards can break, leading to unpredictable additional costs throughout the term: "many people I've talked to had to purchase kits with faulty parts which makes buying kits a hassle and a burden to purchase a part we already paid for." Finally, several students report fairness issues, with students unable to afford extra costs unable to produce work of the same quality as their peers: "When professors say that equipment is 'optional' it becomes very difficult to complete assignments and projects with the quality expected. The lab spaces aren't available enough to utilize the lab equipment, so these projects and assignments become rushed in order to complete them in time sacrificing the quality of the assignment." Unlike computers, which are available and equipped with required software throughout campus, development boards and specialized lab equipment is only available in a few heavily used class-rooms on campus,

giving students who can afford their own significantly more flexibility in completing assignments.

## V. Conclusions

This paper explored the impacts of personal computing resources and affordability of lab kits and other non-traditional course costs on ECE students. The results show that lack of access to a laptop computer, while problematic, is limited to a very small student population, small enough to potentially be served by laptop loaner-programs of the sort proposed in prior literature [9]. While students with older and under-powered laptops make up a sizeable population, it is not clear that these students perceive themselves to be at a significant disadvantage to their peers with more powerful computers. Indeed, many of these students reported that they were facing much more pressing financial concerns than lack of a new laptop.

The data shows that affordability of lab kits and other component costs is a significant issue for students who struggle to afford them. $76\%$ of these respondents either agree or strongly agree that lack of affordability of lab kits and components has hurt them academically. Roughly $50\%$ of these respondents also indicated that component affordability issues made them feel like outsiders in the department. While some of the same students reporting lab kit and component affordability issues also reported challenges in paying for rent, food, and other necessities, increasing access to components and supplies may be a relatively easy and affordable way to make under-privileged students at least feel more welcome in engineering programs, and more able to succeed at the rates of their wealthier peers.

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