Exploring the Impact of Added Course Expenses and Technology Fees on Students of Differing Social and Economic Status

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Abstract

The field of electronics has made immense advancements in affordability and portability that have transformed engineering education. Engineering course curricula have increasingly incorporated modern technology that has made a positive impact by creating more hands on activities and experiments. Specialized laboratory equipment and setups are being replaced with off the shelf devices and components. Customized printed circuit boards can be purchased cheaply and fabricated in days instead of weeks. Creating these hands on activities has many times corresponded with an increased expense that is passed on to the students in the form of a required parts kit or lab fee. At the same time laptops have become ubiquitous among students allowing universities to save money on computer labs and IT expenses by requiring students to provide their own laptop. Not all students are able to afford laptops, and even among those that can there is a disparity between the quality and capabilities of the laptops purchased. These increased expenses can add an inequitable burden on students of different social and economic status. This paper explores the impact of these expenses on students of different social and economic status. The impacts are measured using student survey data from a variety of computer and electrical engineering courses.

1 Introduction

This draft is for a full paper in the Research track and explores whether requiring students to purchase parts-kits and encouraging laptop ownership is creating a digital divide among Electrical and Computer Engineering students from different socio-economic backgrounds.

Commodification of many electronic components has largely been seen as a boon to engineering educators. Circuit analysis experiments that used to require expensive, specialized equipment can now be performed by any student with a sub-$\$200$ USB oscilloscope [1], and an entire Linux capable desktop computer for Linux development can be found for $\$35$ in the form of the Raspberry Pi [2]. Even complicated Matlab simulations that previously required desktop workstations can be run on any computer with a web-browser [3] and on most smartphones [4]. These advances have made it possible for many educators to assign new and advanced projects to students without the need for expensive new laboratories. At the same time, however, this trend has led to increasing materials costs for students.

As more classes adopt commoditized hardware and software for assignments, students are increasingly required to pay lab fees or purchase parts kits to participate in courses. Even for courses where development boards and software licenses are provided in the classroom in an effort to reduce barriers to entry, at Cal Poly San Luis Obispo we have observed that students of higher economic status are increasingly purchasing their own version of the lab setup, giving a potential advantage over students of lower economic status.

This work represents our attempt to determine whether, and to what extent students at a large, primarily undergraduate public university experience a "digital divide" as a result of these costs. We understand that the broader issues of economic equity in education are not new. Significant research has been conducted into issues of affordability in higher education [5, 6, 7], and the disparate effects of poverty on learning and academic achievement are well documented [8, 9]. We also do not suggest any solutions for the equity gap: as Computer and Electrical Engineering faculty at a public teaching-focused university, the authors are intimately aware that student purchases are often the only practical mechanism instructors have for introducing new, state of the art educational material into the classroom.

With this work, however, we hope to start a discussion about whether and how course design and technology adoption decisions by individual instructors and departments may be exacerbating inequality, and hope to spur more research and action on how faculty, departments, and colleges can better address some of these equity gaps among students.

The rest of the paper is organized as follows. In Section 2, we discuss the design of a survey instrument sent to all Computer and Electrical Engineering students to determine if there are practical and psychological impacts of these costs on students. In Section 3, we present the results of the survey. Final, we conclude with a discussion of the implications of added supply and computing costs for college students in Section 4.

2 Survey Design

In assessing the impacts of added parts, supply, and computing costs, we focused our measurements on three potential areas of interest: assessing overall student need, assessing the perceived impacts of costs and resource availability on student academic performance, and assessing the perceived social impacts of affordability issues. The survey questions broken down by category are shown in Table 1.

To measure student need, we ask students about what trade-offs they have had to make to afford the added expense of lab kits and computing resources. These trade-offs include forgoing groceries or giving up study time to take on an extra job.

For social issue impacts, our primary concern was that students of limited means would feel embarrassed or isloated if they have to rely on lab partners and others for access to necessary course equipment. Our questions related to social impact are designed to test the validity of this concern.

Finally, as instructors, we wanted to determine whether disparate access to computing resources has a significant effect on students' academic performance. Since there are so many factors that

Table 1: Survey questions and categories to ascertain impacts from cost of parts kits and computing resources on students. Note, some questions could be used to measure multiple categories of effects of affordability including academic performance and social impacts.

Question	**Category**
I prefer to use my own laptop instead of lab computers	Academic Factors, Social Impacts
I feel that not being able to own a laptop has negatively impacted my education	Academic Performance
I feel that not being able to own a newer high performance laptop has negatively impacted my education	Academic Performance
Using my own laptop instead of university provided lab computers has helped me take ownership of my work	Academic Performance
I feel ostracized because I cannot afford a newer laptop	Social Impact
I feel ostracized because I depend on group mates to purchase lab kits and components	Social Impact
I have had to sacrifice study time to work to pay bills	Student Need
I have had to make decisions between purchasing course materials and food consumption	Student Need
I am currently homeless because of education expenses	Student Need
Buying a laptop for school is or would be a financial burden to me or my family	Student Need
Purchasing components for class projects are a financial burden to me or my family	Student Need

Table 2: Questions about the demographic and need level of survey respondents.

Question
What gender do you identify as?
What is your race?
What is your ethnicity?
Are you the first person in your immediate family to attend college?

could impact performance, we largely rely on student attitude, rather than controlled quantitative data for these measurements.

All of the questions in Table 1 ask students to respond on a five-point Likert-scale [10] with values Strongly Disagree, Disagree, Neutral, Agree, and Strongly Agree.

We also included a number of demographic questions on the survey to determine which respondents fell into low-income categories, and how well our respondents represent the overall study body of the Computer and Electrical Engineering programs. These questions are listed in Table 2.

Table 3: Demographics of survey respondents. Results are reported in number of students per category

Category	**Options**	**Respondents (N)**
Gender	Male	87
	Female	24
	Gender-queer/Non-Gender-Conforming	2
	Prefer not to Answer	1
Race	East Asian	19
	South Asian	11
	Native Hawaiian or Other Pacific Islander	3
	White	51
	Multiracial	18
	Other or Unknown	2
	Prefer not to Answer	8
Ethnicity	Hispanic or Latino	24
	Not Hispanic or Latino	81
	Prefer not to Answer	5
	Unknown	3
First Generation College	Yes	27
	No	85
	Prefer not to Answer	2

These questions were assembled into an IRB-approved online survey that was sent to all Electrical and Computer Engineering students at Cal Poly San Luis Obispo. Section 3 discusses the responses to the survey.

3 Results

The survey was distributed via email to all Electrical and Computer Engineering students at Cal Poly San Luis Obispo during Winter quarter 2019. The survey elicited a total of 114 responses, representing a response rate of 9.6%.

The demographic breakdown of the respondents are shown in Table 3. An analysis of impact of course fees by gender, racial, or ethnic identity is beyond the scope of this work. The respondents roughly match the demographics of the overall programs.

While we did not directly ask students about their socio-economic status, we did ask a few questions to determine whether respondents were having trouble paying for food and housing. We also asked respondents whether they had to give up time to study to work to pay for their

expenses. The results of these questions are shown in Figure 1. From the data, 32% of respondents indicated that they had to trade study time for work time to afford course materials, while 15% traded food, and 2.7% indicate that they may be homeless due to education expenses. Overall, this data indicates that the costs of school materials and supplies are a major concern for a significant number of our students.

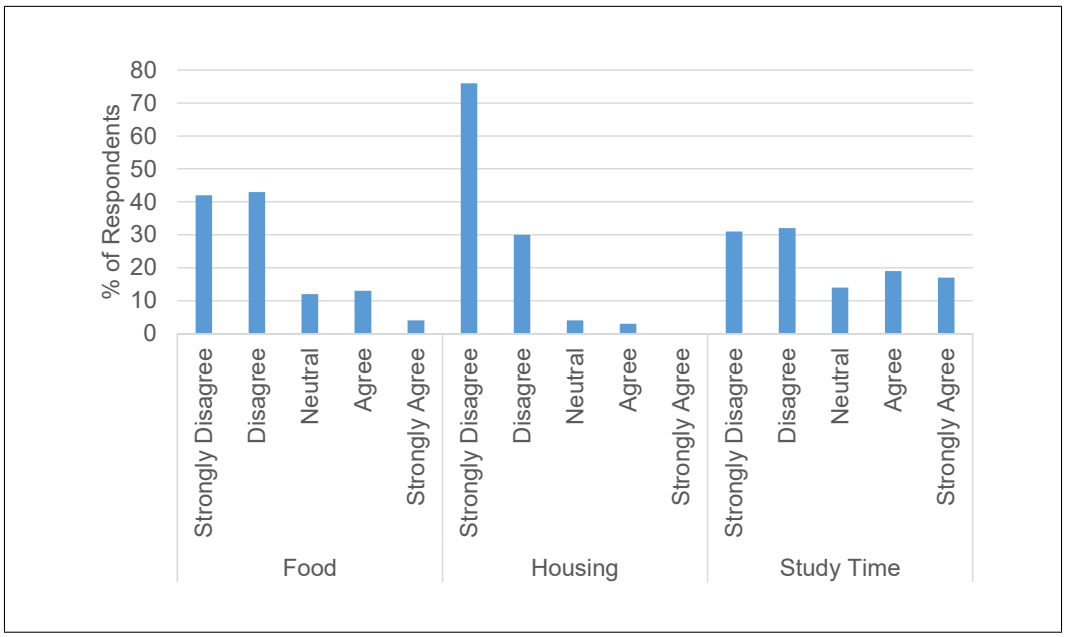

Figure 1: *Responses to questions about financial need, specifically "I have had to make decisions between purchasing course materials and food consumption", "I am currently homeless because of education expenses", "I have had to sacrifice study time to work to pay bills."*

To better understand what cost factors are attributing to the financial need shown in Figure 1, the rest of the analysis in this section is broken down into two categories: how access to computing resources (a laptop) affects students, and how the cost of lab supplies and parts kits affect students.

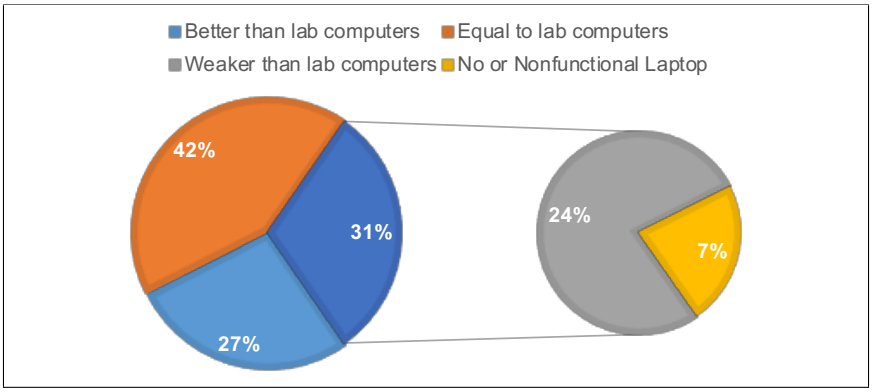

Figure 2: *Laptop ownership statistics. Students were asked whether they owned a functional laptop, and how their laptop compares to laboratory computers maintained by their departments.*

Baseline computer ownership among the students is shown in Figure 2. The data shows that 7% of respondents do not have access to a laptop computer for their schoolwork, while another 24% of respondents report that their laptops are slower/less capable than the lab computers maintained by the school. The specifications of the lab computers are documented in previous work [11].

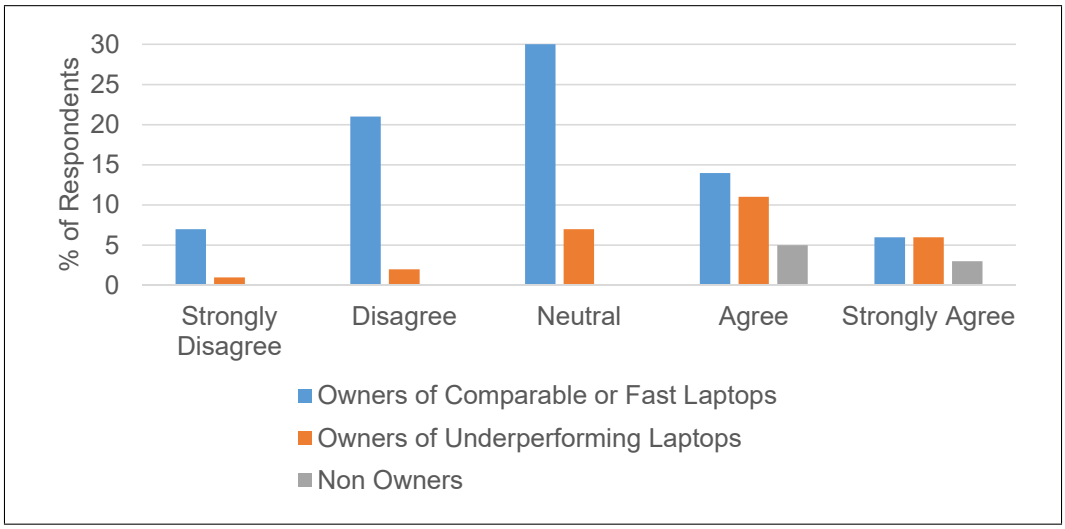

Figure 3: *Responses to the question "Buying a laptop for school is or would be a financial burden to me or my family" Respondents are broken out based on whether they do not have a laptop, have a laptop less powerful than a lab computer, or have a laptop comparable-to or better-than a lab computer.*

When asked, roughly 40% either agreed or strongly agreed with the statement that buying a laptop for school constitutes a financial burden for them or their families, as shown in Figure 3. It is important to note that 100% of the non-laptop owners either agreed or strongly agreed, suggesting that financial factors rather than personal preference is the reason these students do not have a laptop.

To determine whether laptop ownership had an impact on student academic performance, we asked students two questions: whether they felt completing assignments on their own laptops helped them take ownership of their work; and whether not being able to own a high performing laptop, or, in some cases, any laptop, has negatively impacted their education. The results of these questions are shown in Figures 4–6.

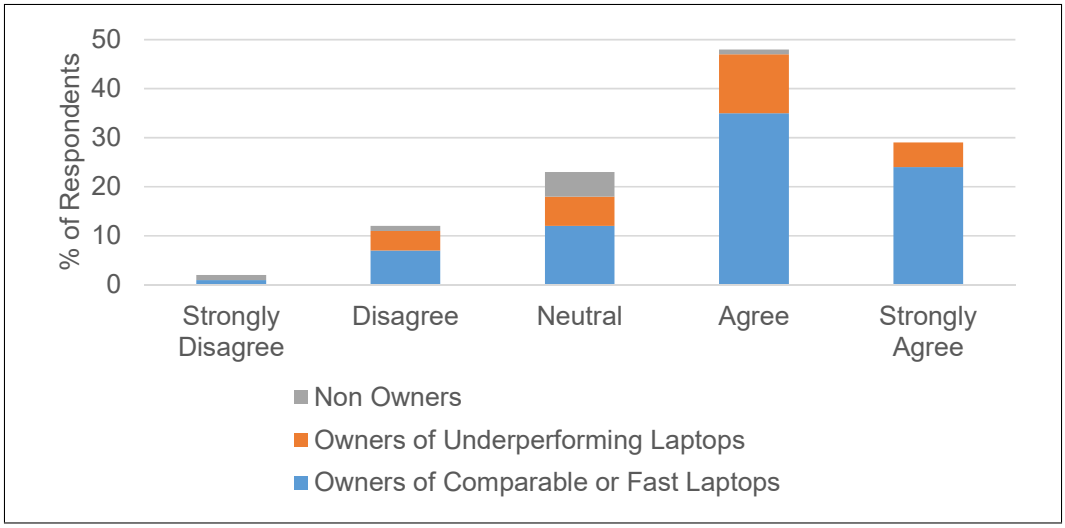

Figure 4: *Responses to the question "Using my own laptop instead of university provided lab computers has helped me take ownership of my work." Respondents are broken out based on whether they do not have a laptop, have a laptop less powerful than a lab computer, or have a laptop comparable-to or better-than a lab computer.*

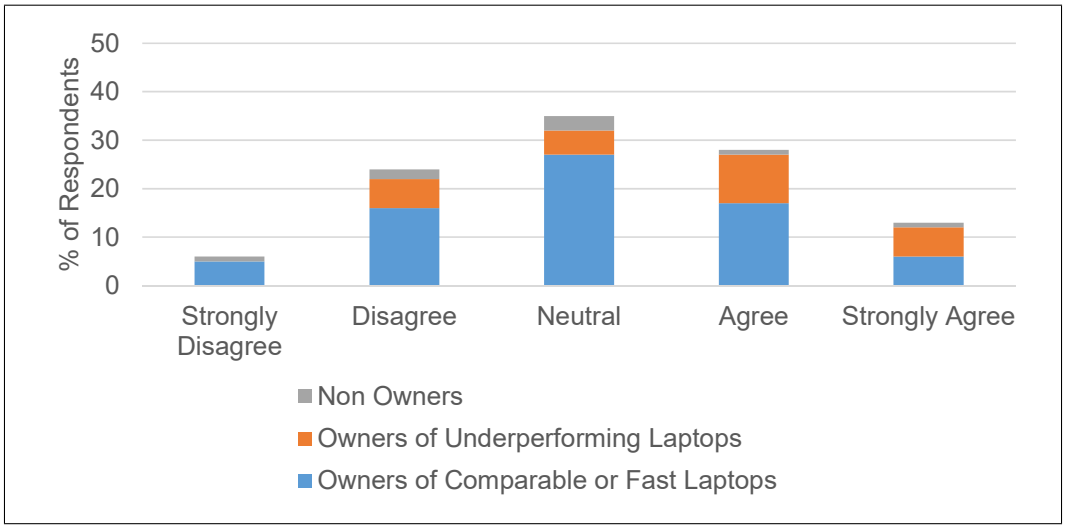

Figure 5: *Response to the question "I feel that not being able to own a newer high performance laptop has negatively impacted my education." Respondents are broken out based on whether they do not have a laptop, have a laptop less powerful than a lab computer, or have a laptop comparable-to or better-than a lab computer.*

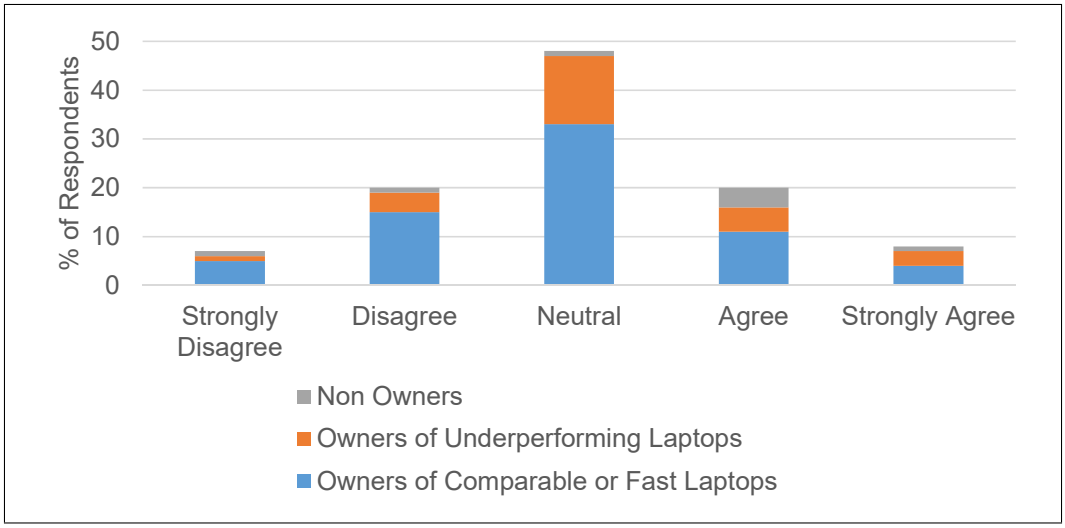

Figure 6: *Response to the question "I feel that not being able to own a laptop has negatively impacted my education." Respondents are broken out based on whether they do not have a laptop, have a laptop less powerful than a lab computer, or have a laptop comparable-to or better-than a lab computer.*

These results indicate that students who own a laptop largely believe that being able to use their own laptop does help them take more ownership of their work, with 67.5% of respondents either agreeing or strongly agreeing (Figure 4. While this could just be the result of bias in the part of laptop owning respondents ("I own a laptop, therefore it is important"), 62.5% of students without a working laptop indicate that not having a laptop has harmed them academically (Figure 6).

Results in Figure 5 indicate that the quality of laptop does not appear to be a major consideration for students without access to one. Only 25% of non-laptop owners agree or strongly agree that they have suffered academically specifically from not having access to a high-performance laptop versus the 62.5% who believe that no access to any laptop has harmed them. This may indicate that even providing these students with second-hand university surplus laptops could help mitigate some of the academic impacts of not being able to afford a laptop computer. Roughly 60% of students with an under-performing laptop agree or strongly agree that they have suffered academically from not having access to a higher-performance laptop, however, so more study is needed to tease out whether there is a trade-off between laptop performance and academic success, or if there are other factors at play.

Finally, we wished to check whether and to what extent laptop ownership affected a students' sense of inclusion among classmates. This aspect is particularly important for our program since many assignments and projects are designed to be completed in groups. Figure 7 shows the extent to which students report feeling ostracized based off of laptop ownership.

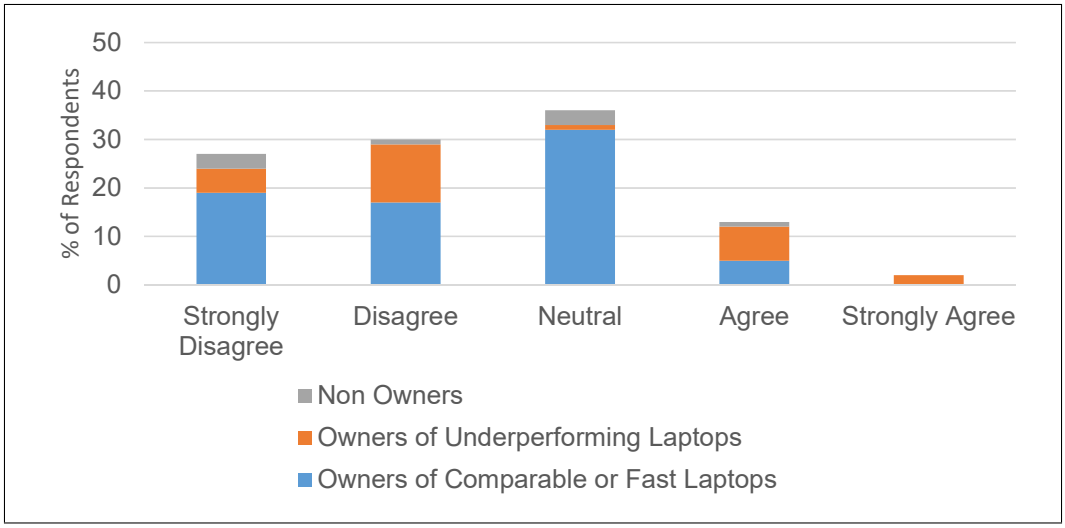

Figure 7: *Response to the question "I feel ostracized because I cannot afford a newer laptop." Respondents are broken out based on whether they do not have a laptop, have a laptop less powerful than a lab computer, or have a laptop comparable-to or better-than a lab computer.*

Only 7% of students with a laptop with comparable or better performance than a lab computer agree that they feel ostracized for not having a better laptop. Among students with a weaker laptop, a full third of students feel ostracized. Finally, only 12.5% of students without a working laptop report feeling ostracized for being unable to "afford a newer laptop."

On the face, these results may seem a little counter-intuitive since one might think that ostracism over laptop ownership would impact those without laptops the most significantly. There are several possible explanations for why more students with under-powered laptops feel ostracized than students with no laptops. First, only 8 respondents report having no laptop, which may cast doubt on the statistical significance of their responses as representative of a larger population. A second explanation comes from the question specifying ownership of a "newer laptop": students without laptops may specifically feel ostracized for having no laptop at all, rather than simply not having a "newer" one. The final possible explanation is that an individual's laptop ownership position predisposes them to different perceptions of ostracism: anecdotally, I have felt far more embarrassed and isolated in group settings when an older laptop belong to me exhibits issues than I have when facing issues on a newer computer or on a colleague's computer.

Analyzing these results as a whole, there is enough evidence to suggest that disparities in laptop ownership may have an impact on academic performance and sense of inclusion among students. More research is needed, however, to isolate and quantify these effects and determine whether low-cost solutions, like offering low-or-no cost surplussed university laptops and laptop repair services can ameliorate some of these problems.

While laptops and computing resources represent a large and obvious cost for engineering students, we were also interested in whether smaller, more regular expenses like parts kits and lab fees could have disparate effects on students from different socio-economic backgrounds. The answers to these questions are explored in Figures 8–9.

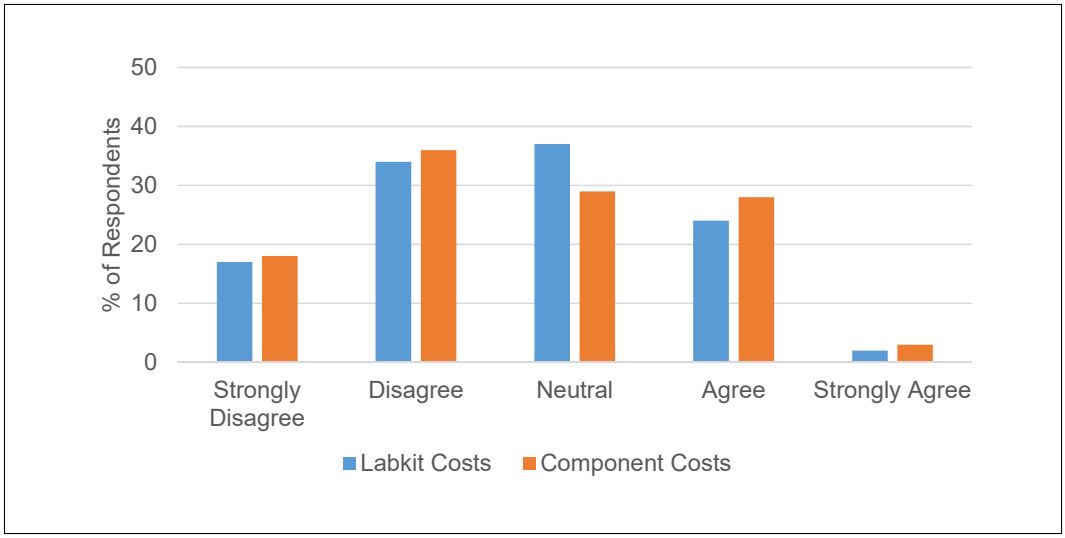

Figure 8: *Response to the questions "Purchasing components for class projects, lab kits is a financial burden to me or my family."*

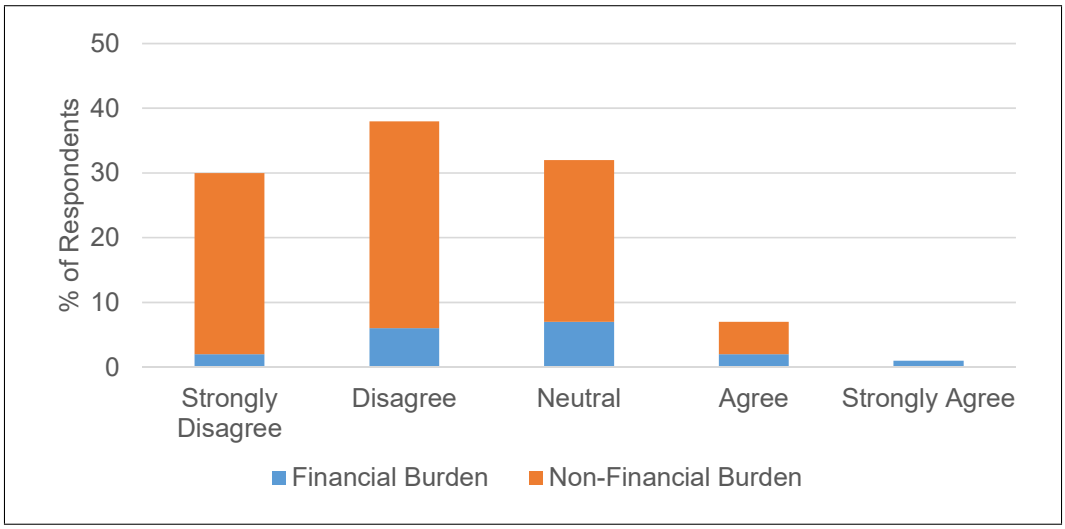

Figure 9: *Response to the question "I feel ostracized because I depend on group mates to purchase lab kits and components." Responses broken out between those reporting that both lab kits and components are a financial burden versus other respondents.*

When looking at lab kit and components cost, 23% and 27% of students respectively either agree or strongly agree that the associated costs are a financial burden for them or their family. While this is an improvement over the 40% of students who indicated that purchasing a laptop would be a financial burden, it is important to note that lab and component costs are not as readily avoidable as laptop costs are. This is because, while Cal Poly maintains many computer labs across campus where students without laptops can perform their work, we currently offer no equivalent "public" lab-kits or spare parts to be used in projects. When students require a kit for a

lab, they either need to scrounge up the money somewhere, find a lab partner who is willing to purchase supplies, or "out" themselves as financially distressed to the faculty in hopes of getting a free or discounted kit. Depending on a students' situation, each of these options may be very stressful to consider.

Figure 9 looks at whether students feel ostracized for relying on other students to purchase lab kits and other project components. Overall, only about 7.4% of respondents report feeling this way. For students who find that both lab kit and component purchases are a financial burden, this number increases to 16.7%. While still fairly low, this still indicates that there is some room for improvement in making students facing financial hurdles feel more included among their classmates.

4 Conclusion

This paper was designed to take a narrow look at cost and inequality in Engineering Education. Specifically, we hoped to determine whether direct added costs, such as lab kits and components for class projects, and indirect costs, such as the expectation among professors that students have a laptop, were affecting the ability of different students to feel socially included among their classmates and strive academically. To answer this question, we sent a survey to all Computer and Electrical Engineering students at Cal Poly San Luis Obispo asking about their experiences with these types of expenses. Ultimately the survey collected responses from 114 students across the economic spectrum, from students facing homelessness due to education costs, to those who do not face financial burdens or the need to work to support their education.

Overall some of the results of this paper were promising. Students of lower means largely do not report feeling ostracized from their peers based on laptop ownership or the need to rely on course partners to pay for components. At the same time, though, it is important that programs not forget about or write-off those students who do feel ostracized as a result of economic status, especially if our goal as educators is retention and inclusion.

More troubling, however, is the number of students who report that not having access to a laptop, or not having access to a powerful laptop has harmed them academically. The numbers may be exacerbated here since computers are used especially heavily in Computer Engineering and Electrical Engineering programs, but as computation becomes more important across all parts of engineering, programs will need to find solutions to ensure equitable access to computing resources among all of its students. As more computation moves to the cloud, greater equity could perhaps be achieved by making used surplus university laptops available for checkout, or by diverting some of the funds used to update and maintain fixed computer labs to create a pool of laptops that can be checked out to students in need.

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