MEMORANDUM

TO:
FROM:
SUBJECT: Proposal for PCB Printer
DATE: September 17, 2024

The purpose of this proposal is to request funding for a Printed Circuit Board (PCB) printer, which will significantly enhance hands-on learning opportunities for Colorado State University (CSU) students in the computer science (CS) and engineering departments. By purchasing this technology, CSU will help provide its students with the practical skills that will prepare them for a rapidly evolving and competitive job market.

Background and Rationale

A PCB printer has various applications, though it is chiefly concerned with quickly and efficiently prototyping and manufacturing custom PCBs. Traditional PCB prototyping and manufacturing is a time-consuming process and typically involves steps such as etching, drilling, and soldering (Chen & Rincon-Mora, 2010). With a PCB printer, however, students can design and prototype in real-time, using software to plan the layout before directly printing the board. A PCB printer will also allow students to print and assemble circuits, as well as test their designs, make suitable changes, and reprint in much less time.

As the PCB printer illustrates, technology has rapidly advanced, and thus it has become increasingly important for CS students to have access to such technology. At CSU, however, CS students currently have few opportunities to explore PCB design and prototyping. As a result, these students are likely to struggle against their counterparts at other universities where they have access to PCB printers and can use them to complete related work. Supporting this is the fact that the technology "allows students to gain hands-on experience with electronics manufacturing, fostering a deeper understanding of the principles and processes involved" (BotFactory, 2023, par. 3). Without the technology, CSU students are at a notable disadvantage, both in the classroom and once they graduate and enter the world of computer science. Students at MIT, Stanford, and other major universities already have access to PCB printers, and there is no reason that CSU students should not (Laing, 2022).

Department Benefits of PBC Printer

Aside from the actual students, the CS department may appear less competitive if it does not acquire a PCB printer. The reason, of course, is that the "adoption of 3D PCB printing in universities has significantly impacted both curriculums and research" (BotFactory, 2023), with universities like Cornell, Rice, and North Carolina State leading the way. At Cornell, for example, students have used the PCB printer to "print the wiring and encapsulation of the LIG sensor with conductive and dielectric inks (CI and DI)" (BotFactory, 2023, par. 8). At Rice and North Carolina State, students used the PCB printer to undertake similarly sophisticated projects (BotFactory, 2023). Unfortunately, CSU students are simply unable to follow in the academic footsteps of their peers at other universities.

Going further, the opportunities at other universities could motivate potential students to view the CSU CS department as less capable of preparing them with the hands-on experience that they

require, propelling them elsewhere. Given this, the CS department may see a decline in its overall quality, demanding that it move forward with this purchase. Finally, other than allowing the CS department to remain competitive, some of the other noteworthy benefits are as follows:

- **Research and Development** – Along with the students, the PCB printer will benefit faculty whose research is integral to computer science. As importantly, easy access to a PCB printer may help faculty develop partnerships and undertake more collaborative projects, further contributing to the department's reputation and enabling the university as a whole to tout the field to prospective students.
- **Industry Collaboration** – Opportunities for greater partnerships exist throughout the computer science industry, as students and faculty use the technology to advance their academic interests.
- **Interdisciplinary Innovation** – The PCB printer will enable greater collaboration between and among departments. Engineering, physics, and even art students can use the printer to explore the role of electronics in their disciplines, promoting the cross-pollination that leads to creative breakthroughs and innovation.

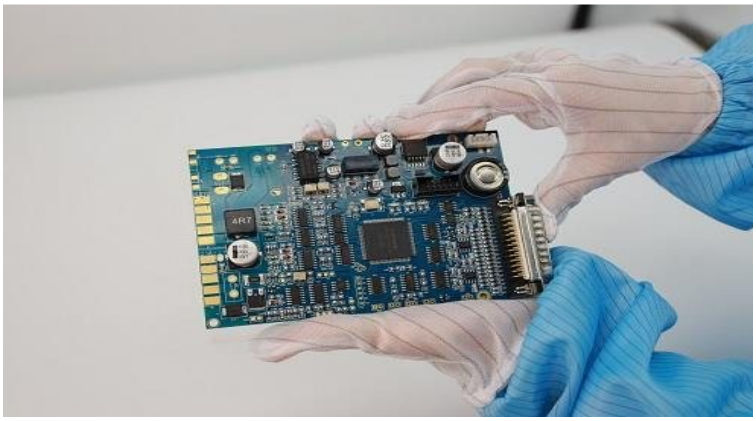

Image 1. A PCB printer would benefit the CS department, students, and the university.

There is no reason that CSU could not be like Cornell, Rice, North Carolina State, or any other university for that matter. Yet, for it to compete with these other universities, the CS department must purchase a PCB printer. Doing so will help both the university and department unlock these benefits, advantaging students so that they are equipped to succeed in the classroom and beyond.

Educational Impact

Though the CS department will benefit from a PCB printer, so will students, who can utilize the technology to fill their educational needs. Some of the positive impacts that the printer will have on student education are noted below:

- **Greater Learning Opportunities** – With a PCB printer, students will be able to engage in real-world PCB design, empowering them to put their theoretical knowledge into use. With the PCB printer, students will also gradually develop a deeper and broader understanding of circuit design and electronics (SGW, 2024).
- **Hands-On Experience** – Designing and fabricating PCBs is an indispensable part of any career in electronics and computer engineering. Though CSU is known for its experiential approach to education, with a PCB printer, it will solidify its reputation in this regard and have an outsized positive influence on student education.
- **Skill Development** – Using the PCB printer will help students develop skills in electronics, design software, troubleshooting, and more (Burhnam, 2023). With these

skills, students will be able to maximize their education and likely find it easier to succeed once they graduate and enter the workforce.

These positive impacts are not just broadly evident but are directly relevant to many of the courses that CS students take. In **CS 561: Hardware/Software Design of Embedded Systems**, for instance, a PCB printer could help students prototype circuit boards for the embedded systems that they are developing. In **CS 528: Embedded Systems and Machine Learning**, a PCB printer would help students better grasp the intricacies of the hardware that they encounter. As for **CS 470: Computer Architecture**, a PCB printer would help students create and test customized hardware designs, giving them greater knowledge of their various components. Clearly, the PCB printer is relevant and applicable to student learning, underscoring the immense value that it would provide. In short, an enriched learning experience will benefit students in the short- and long-terms as they embark on fruitful careers devoted to their field.

Associated Costs

While the benefits are clear, one must recognize that a PCB printer is costly. The V-One, as featured in Image 1, which allows one to prototype and assemble PCBs in less than an hour and receive immediate feedback, costs approximately **$5,199.98**. With more than 1,100 students, it goes without saying that the CS department would likely have to buy several PCB printers, significantly increasing the total cost, which will easily run into the tens of thousands of dollars.

Other related costs concern **training** students to effectively use the PCB printer, associated **maintenance**, and **potential future upgrades**. While it is difficult to estimate the precise cost of training, a design course that Udemy, the education technology company offers, costs $19.99. To help offset this cost, the university could require students to purchase this course on their own. Maintenance costs vary, but should be done approximately every 200 hours of printing time (Prusa, 2024). Potential upgrades are another variable expense, with the cost reflecting whatever improvements occur.

Despite the high costs, several grants can help the department secure them for less. The National Science Foundation (NSF), for instance, has issued grants in the past that help universities purchase otherwise expensive equipment (Wolf, 2023). Further, it is always possible to imagine the department partnering with a prominent technology corporation, which in turn helps fund some of its technological needs. In the past, corporations like Microsoft, Google, Apple, Intel, and Texas Instruments, and others have done just this, offering a pathway forward for the CSU computer science department to secure the technology it needs to prepare students for the twenty-first century.

Lastly, the CS department could engage alumni and local businesses to help offset the costs, or even reallocate the money that it receives from the university to purchasing a PCB printer. Likewise, the department may require students to pay an small additional fee to take courses where they would use the PCB printer, with the fee helping to cover maintenance and upgrades,

along with other expenses. As shown, there are many ways to ease the expense of a PCB printer, making it much more feasible for the CS department to purchase one.

Conclusion

Given the many benefits of purchasing a PCB printer, the CS department **must immediately prioritize** doing so. Waiting any longer would seriously disadvantage students, the CS department, and the university, as each risks falling behind educationally and technologically. The future is bright, but for CSU stakeholders to realize this future, a PCB printer is necessary.

References

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