GIFTS: A ”School Store” to Promote Sustainability and Product Iteration in a First-Year Engineering Design Course

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Introduction

In our first-year engineering design course, teams of students build an autonomous, rover-like vehicle from scratch. The project works well to teach students about the design process and working in teams; however, we were not satisfied with the waste and financial cost of having about 120 teams each semester building a vehicle with new parts, especially since the vehicle was typically discarded at the end of the course. To make the project more sustainable, we developed a "School Store" to allow teams to use credit they are allocated to "buy" recycled commercial-off-the-shelf parts for their vehicles.

Operation of the School Store

The stock for the School Store includes items previously purchased by the department and parts donated by students each semester to create a circular system. Items in the store include a variety of items needed for building autonomous vehicles, including wheels, microcontroller boards, motors, and sensors. We place the parts in bins labeled with the item and a barcode, and the bins are put inside a cart that only the teaching staff is allowed to access (Figure 1). Each team receives a fixed School Store budget at the beginning of the project (typically ~$50), and only this budget can be used to purchase items from the store. (No real money can be used to make purchases.) The parts are each assigned a price that factors in the cost to buy the item new and the amount of inventory in the store, with most items priced at $10 or less. Small, inexpensive items (e.g., bolts and wires) and safety-related items (e.g., battery connectors, battery storage bags) are not included in the School Store inventory, and teams have access to these components without using their store allowance. Purchases occur during class time or open lab time, and the cart is locked outside these times. Teams can return working items at any time to receive a refund and purchase different items.

Figure 1. Cart containing the School Store and labeled bins. Only teaching staff are allowed to go into the store, and the cart is locked outside of class and open lab times. (Photo source: https://sustainingprogress.umd.edu/celebrating-stories/engineering-reduced-waste-future-terrapin-works-and-enes100-sustainable-strides)

Although we initially used a simple Google form or online assignment to track the items each team purchased from the store, we recently developed a web-based platform to more easily track the spending of each team and the items being purchased. Undergraduate teaching fellows and instructors for the course have access to the platform and assist teams with their purchases,

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which take less than two minutes per purchase. The process involves opening the School Store website, identifying the appropriate team, and using a barcode scanner to scan the barcode (on the bin label) for the purchased (or returned) item(s). An undergraduate teaching fellow also maintains and updates the store website, keeps the bins labeled and organized, and restocks inventory in the School Store from the storage room, as needed.

At the end of the semester following the final presentations for the course, the teams are expected to return any items that remain functional to the school store and are encouraged to donate any non-School Store parts they purchased for the project. Students are asked to return or donate only functional, non-customized parts. The large number of students and large volume of parts led us to establish an assembly-line-style drop-off system for parts. Sets of bins for different items are placed in several stations in the lab space (Figure 2A), and teams deposit the items into the appropriate bin. As appropriate, (e.g., for motors), information sheets and/or bags are supplied to keep sets of items and/or their specifications together (Figure 2B).

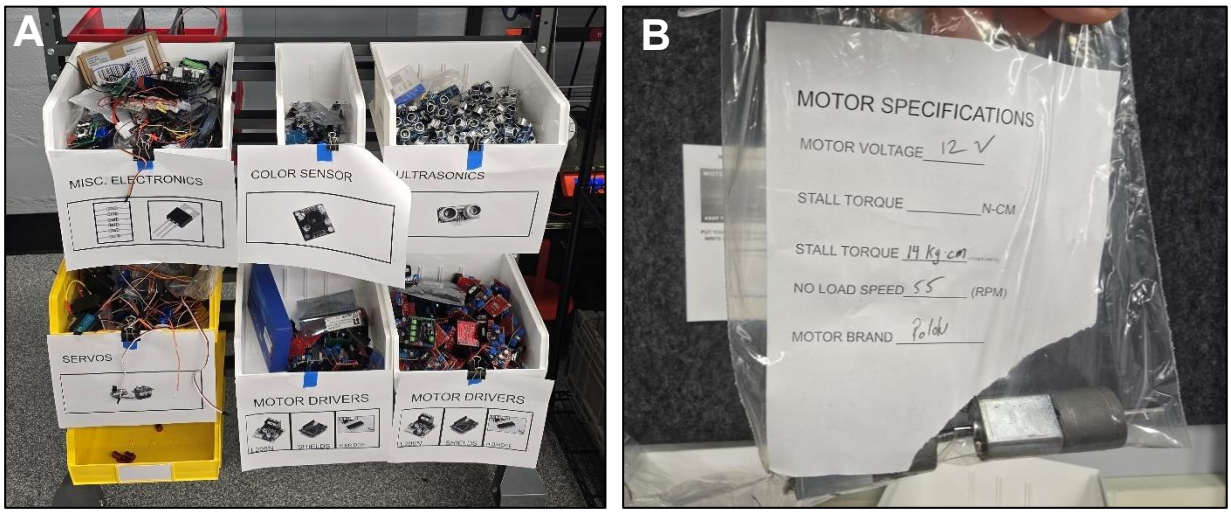

Figure 2. Return of items to the School Store. (A) Labeled bins are provided for teams to deposit their returned and donated parts. (B) Bags and information sheets keep sets of items together and identify part specifications.

Results and Discussion

The School Store has been successful in improving the sustainability of the design project. At the beginning of the Spring 2025 semester, the store contained over 2000 items and more than 75% of those items were "purchased" by teams for the project, reducing the financial burden on students in the course. At the end of the semester, teams returned or donated nearly 200 lbs of items from their vehicles, saving the items from the landfill and allowing future teams to re-use the parts and save over $17,000 compared to purchasing new parts. The School Store will eventually allow teams to build their vehicles with essentially no real financial cost and a greatly reduced environmental footprint.

The infrastructure and procedures we developed, such as the storage cart, part return protocols, and the web platform, continue to improve and make the store easier to use for students and course staff. We have made decisions in the School Store operation to minimize the effort of the course organization and teaching team. For example, the items returned or donated to the School

Store inventory are not checked by course staff for functionality; instead, teams are allowed to receive a replacement or refund for a purchased part that is not functional, as long as the issue is reported within the same class or open lab period. Additionally, the teaching staff does not check to ensure all items purchased from the store are returned at the end of the semester, which further reduces the workload of the store. Our observations indicate that most functional parts purchased from the School Store are returned, so we do not see a need to check in specific parts at this time.

We continue to improve the School Store to address challenges we have observed. Although checking functionality of purchased parts can be a valuable learning opportunity for students (e.g., diagnosing part issues and looking for errors in circuit design), we are developing tools for the teaching team to quickly check the functionality of common sensors and actuators to reduce the number of non-functional parts in the store. We have also noticed that some undergraduate teaching fellows and instructors begin to bypass the purchasing system over time, allowing students to take parts without using the purchasing system. Additionally, when the store cabinet is left unlocked, students may take parts without permission, especially as assignment deadlines approach. We are considering implementing dedicated store hours to improve oversight of these issues.

While sustainability was our main motivation, we have also seen learning benefits from the School Store. The ability to get parts immediately encourages teams to start physically building sooner and reduces delays when malfunctioning components need to be replaced. The store also allows teams to try different parts and configurations on their vehicle without committing real money, which improves the design iteration process. We expect these learning benefits to increase as the diversity and quantity of the items available in the store improves.

Our approach to building and using the School Store could be adapted to any design course where the project uses similar parts over multiple offerings of the course. The store can start with a relatively simple infrastructure and become more developed as inventory increases and the utility of the store is demonstrated.