ECE Class Kit Vending Machine  
Project Proposal

Nidhay Patel   
Department of Electrical and Computer Engineering  
*Tennessee Technological University*   
*Cookeville, United States of America*  
*npatel45@tntech.edu*

Austin Sigg  
Department of Electrical and Computer Engineering  
*Tennessee Technological University*   
*Cookeville, United States of America*  
*aesigg42@tntech.edu*Dillon Williams  
Department of Electrical and Computer Engineering  
*Tennessee Technological University*   
*Cookeville, United States of America*  
*dswilliams42@tntech.edu*

Ryan Reed  
Department of Electrical and Computer Engineering  
*Tennessee Technological University  
Cookeville, United States of America*  
*rcreed42@tntech.edu*Michel Turpeau  
Department of Electrical and Computer Engineering  
*Tennessee Technological University  
Cookeville, United States of America*  
*mmturpeau42@tntech.edu*

# Introduction

Every year hundreds of students require devices for their ECE classes. These specific devices are provided by the College of Engineering and are rented out to students through the ECE office. Typically, in the first month of a semester, a significant number of students attempt to check out devices from the office. This capstone project will focus on designing and implementing a vending machine that can check devices out to students while recording which students have checked out a device.

The finished product will be a vending machine that is able to vend devices to students. A student can enter their information and the machine will record who has checked out the device. The machine will include a clear front panel, which allows students to see and determine which board they need. A platform will lift to the desired device and vend it to the student.

The ECE office will benefit from having this machine because it will reduce traffic in the ECE office. It will also ease the process for the students because they will not have to fill out paperwork. Instead, the vending machine will allow the office to view the data submitted by the students. Because of this, the office associates will have to fill out paperwork on students less frequently, and the machine will remember the data students enter.

The first prototype will have the ability to prevent boards from getting stuck, have a touch interface for students to enter information on, have a locked door to enable associates to refill the machine, and have memory in the event of a fault or power loss to remember its functionality. The machine will also be fitted with a method of communication in order for the associates to pull student information from it. Security will be implemented in order to prevent boards from being stolen and to protect the database.

The objective of this capstone project is to make the process of checking out devices for ECE courses simpler by utilizing a vending machine, while also recording all information given by a student through a database.

# Formulating the Problem

This section will introduce the background information needed for the project. This includes the constraints and

specifications of the machine and the standards we will be bound to when working on the project. A survey of possible solutions to the problem will also be given so the project can be further improved in the future.

## Background

Much of the project relies on the background information of the systems in vending machines, and how they operate. The project will require knowledge in the areas of controls, programming, embedded, power, databases, and others.

Vending machines are used throughout many businesses and are a great source of convenience for the customers who use them. Maintenance on well-made vending machines is also low, saving time for the business as well [1]. A vending machine for the class kits in the ECE office would be of great convenience to students who can come by and pick up a device. It would eliminate the need to fill out paperwork in the office to obtain a board, as well as allow the office associates to do their own work without worrying about the students.

The project that is desired is difficult enough to allow for multiple people to assist in the creation of the machine. The machine requires its own control and power system to operate correctly. It must also have a computing system to control the platform and motors to dispense the board for the student. For the office to know who has retrieved a board, the machine must also have an onboard database system that is able to keep track of students and communicate with the office associates. The machine also requires some type of security to avoid student information being stolen, as well as physical security such as a lock to protect the devices. The reason we do not require a machine that is “off the shelf” is that all current vending machines drop the items to the bottom. The devices in the ECE office are sensitive and prone to breaking if dropped from a height. Also, most vending machines are paid services requiring the customer to buy the product whereas ours is for renting the product without a charge. Our team of engineers is in charge of the design of electrical and computer systems, and the mechanical team is in charge of the actual machine. Our part of the project cannot be bought and requires design.

The objective of the class kit vending machine is to have a machine that is capable of recording student and class information and using that information to know which device is required for the student. Then the machine can properly retrieve and distribute the device to the student and record that the student has the device for the department. In order for the machine to accomplish its given task, a power system, microcontroller, sensors, motors, student database, controls, interface, and possibly PLC systems.

The proposed power system for the machine would utilize a 120 W AC to DC converter as its source. The converters can range in output from 12 volts DC to 54 volts DC and need to be high efficiency to avoid overconsumption [2]. A benefit of a high-efficiency power supply is the machine remains cooler, increasing the machine’s lifetime [2]. Extra Fuses will be included to ensure the voltages of the devices are not exceeded as another protection layer. If needed, the team may also include a backup supply in case the system fails.



*Figure 1: 120W Power Supply*

The machine requires a microcontroller/computer to control the electronics inside and to hold a database that keeps track of each student who has obtained a board. The computer will also control the interface on the machine that the student needs to be able to take a device and possibly control a card reading device.

For vending the devices, the team has ideas on what type of motor to use. One option is to use normal vending machine parts such as the coils with stepper motors. Another is a belt and gate which moves only the device that has its gate opened. Either option will require the team to use a platform that can raise and lower to retrieve the device for the student.

## Specifications

The class kit vending machine must follow several specifications to achieve the customers’ desired objectives. First, the team must prevent the devices from getting stuck in the machine. However, normal machines are prone to having products become stuck, which results in people shaking and possibly damaging the machine [3]. The machine must be large enough to accommodate any device the department must put into the machine as well.

Secondly, the customer requires that the machine have some form of communication so the information can be retrieved from the machine. Most vending machines communicate through telemetry, which allows the machine to connect to the internet [4]. Some machines that are connected to the internet are vulnerable to hacking and can cause issues with other devices, which is why the team is considering alternate methods [5].

The vending machine must be able to keep track of a student’s Tech email, name, ID, and class according to the customer. In order to know what device is checked out, it must also know which board number is taken, which the student must enter after getting the device. An interface is required on the machine for the student to enter board numbers into the database as well after vending.

The machine requires a fault option if power is lost, and must remember what was entered before power loss. Security must also be applied to avoid any student stealing a board out of the machine after power loss, which will most likely be a type of lock. Lastly, the machine must be large enough to fit a decent number of devices before requiring the office associates to refill the machine.

## Constraints

The vending machine must follow certain constraints in order to be properly designed for the ECE office. The machine will be plugged into the wall, and must, therefore, follow the national electric code in order to be allowed to be used. The national electric code of the United States is the NFPA 70, which is the benchmark for the safe design and installation of electric devices [6].

The machine must not be as large as a normal vending machine because it must fit inside of the ECE office without obstructing the work environment. Also, for communication purposes, if Bluetooth is used, it can only operate on a 2.4 GHz frequency in order to avoid conflict with wireless networks [7].

The team must also adhere to student data privacy regulations from the school and apply measures to the machine in order to prevent any name or ID leaks.

## Standards

To ensure our team can successfully and safely implement our vending machine, we must understand the standards under which the machine will have to comply. These standards come from both IEEE and the government, and we must comply with both.

One of the most important standards we must hold to is the National Fire Protection Association 70 (NFPA 70), also known as the National Electric Code (NEC). This standard covers a large portion of our safety regulations; installations of connections, circuit protection, wiring, and general-purpose equipment such as cords, receptacles, and switches. This standard also covers the installation of electrical conductors and equipment “…used by the electric utility, such as office buildings…that are not an integral part of the generation plant…” [8]. These regulations are just the surface of the NFPA 70 standard. Our team must familiarize ourselves with this standard, above all, in order to successfully implement our vending machine.

Another standard similar to the NFPA 70 that we must comply with is the IEEE C2-2023 code. This code is similar to the NFPA 70, in that it involves standards related to those covered in the NFPA 70. IEEE C2-2023 is the National Electrical Safety Code(R) (NESC(R)) that “…includes the work rules for the operation of electric supply and communication lines and equipment,” [9]. This is a standard that covers more specific elements of working with the electrical communication and wiring rather than being an overall standard for all things electrical, like the NFPA 70.

Finally, one more standard we must comply with is IEEE Policy 7.8. This is the Code of Ethics that any electrical and computer engineer must comply with in order to conduct any professional work. This code of conduct requires that all engineers “uphold to the highest standard of integrity, responsible behavior, and ethical conduct in professional activities,” and “[To] treat all persons fairly and with respect, to avoid harassment or discrimination, and to avoid injuring others,” [10]. While IEEE Policy 7.8 does not cover anything involving electrical work specifically, it is a crucial standard we much adhere to. Without this policy, there is no guarantee that a project will be ethical or safe for the public. It also helps our team members keep each other accountable for upholding good ethics.

## Survey of Possible Solutions

Because the use of vending machines is such common practice, there are several possible solutions out in the market. One option is the smart vending machine. The smart vending machine would be a reasonable solution to our problem because of its convenience. A smart vending machine implements a touchscreen and digital transactions in order to become a more service-oriented machine [11]. This would help solve the issue of convenience for the ECE office and the student. In a non-smart vending machine, buttons can get jammed and lock up.

Another possible solution to our problem is an elevator vending machine. The general snack vending machines use a coil to keep its products on the shelves and when a product is requested, it will drop down into the collection bin. An elevator vending machine has a platform that raises to the desired level and the product is pushed onto it via a conveyor belt or a gate [12]. The product is then lowered down into the collection bin rather than being dropped. This is another possible solution to our problem because we cannot drop the devices used in the labs; these kits and devices can be very fragile and even a small fall could severely damage them.

One final solution that could be implemented is an array of lockboxes. The team we are collaborating with suggested using a series of lockboxes that could be refilled. When a student wants to check out a specific board, they would have that door unlocked and the staff would refill it. Our team believes that this solution could work, but it would have to be refilled more frequently than a regular vending machine. We also believe that a series of lockboxes would take up significantly more space than a vending machine.

## Summarizing the Problem

The existing solutions for our problem statement do not meet the specifications that we desire. At least, not on their own. The vending machine for the ECE office should have a customer-friendly interface, such as that of the smart vending machine. Our vending machine should also have a lift and conveyor to safely dispense the kits, such as that of the elevator vending machine. Given our background information, specifications, and constraints, our vending machine should be able to communicate through telemetry, safely and securely dispense the kits and boards, store and protect the information entered by each student, and reliably restart when there is a power outage. No lone vending machine that is available now can fill all of these specifications, and that is why our project is important to the ECE Department.

## Some Common Mistakes

* The word “data” is plural, not singular.
* The subscript for the permeability of vacuum **0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter “o”.
* In American English, commas, semicolons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)
* A graph within a graph is an “inset”, not an “insert”. The word alternatively is preferred to the word “alternately” (unless you really mean something that alternates).
* Do not use the word “essentially” to mean “approximately” or “effectively”.
* In your paper title, if the words “that uses” can accurately replace the word “using”, capitalize the “u”; if not, keep using lower-cased.
* Be aware of the different meanings of the homophones “affect” and “effect”, “complement” and “compliment”, “discreet” and “discrete”, “principal” and “principle”.
* Do not confuse “imply” and “infer”.
* The prefix “non” is not a word; it should be joined to the word it modifies, usually without a hyphen.
* There is no period after the “et” in the Latin abbreviation “et al.”.
* The abbreviation “i.e.” means “that is”, and the abbreviation “e.g.” means “for example”.

An excellent style manual for science writers is [7].

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The preferred spelling of the word “acknowledgment” in America is without an “e” after the “g”. Avoid the stilted expression “one of us (R. B. G.) thanks ...”. Instead, try “R. B. G. thanks...”. Put sponsor acknowledgments in the unnumbered footnote on the first page.

##### References

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