Class Kit Vending Machine  
Conceptual Design

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

Around fifty devices a day are needed by students each year for their ECE (Electrical and Computer Engineering) courses. The main emphasis of this capstone project is the design and implementation of a vending machine that can loan out devices to students while keeping track of which students have taken the devices. A student can enter their information into the machine, and it will keep track of who has borrowed each device(s). Students will be able to view and choose which gadget to remove with the help of an LED (Light Emitting Diode) equipped drawer system. Designing the entire system gives the machine the ability to meet all requirements of the customer. The machine shall comply with the following specifications of the customer.

The machine will be no taller than the average window height, which is around 2 to 3 feet, and no smaller than 2 feet in height. This allows for easy portability from the office to the student lounge at Brown Hall and vice versa. It should impact the customers and allow the office associates to be able to transport the machine where it is needed. Due to our ethical considerations, the machine will use ethernet to send data to our customers to avoid others from accessing the students’ information. We have also considered including either a hash or encryption on the data sent.

To allow proper function of the machine, an MCU (microcomputer unit) to manage the data acquisition system is needed. An SQL (structured query language) database will be programmed into the MCU to hold the student ID (identification) number, name, email, course, and which board has been rented, as required by the customer. The boxes the devices are held inside must be uniquely identifiable according to the department, so each box must be scanned into the database before a device is taken. This is to prevent the theft of a device by any student and allows the customer to know which is taken. For the same reason, the machine shall have a card reader to ID every student. This way no student can fake the number, even if other information was incorrect.

For the entire machine to function after a reset and to remember information for the customer, the machine is required to have a form of nonvolatile memory such as MicroSD or an actual separate drive. The machine must have a series of LED (light emitting diode) indicators so the student knows which drawer and compartment to access when retrieving the board. Solenoid Locks shall be installed into the drawers and compartments so no single person can easily break through to the devices when the machine is unsupervised. The current plan is for a drawer and compartment to hold for several minutes to allow enough time for a worker to notice the attempt.

The following subsections provide detail on each of the previous requirements and how each shall be completed according to the customer.

# Background

One of the most important subsections that will be mentioned is control for the vending machine. For controlling the physical aspects, a programmable logic controller (or PLC) will be used. A PLC is most commonly used in industry for controlling mechanical systems and applications. Some examples of systems typically controlled by PLCs are road traffic signals, automatic car washes, and automatic doors [1]. These applications tie into some of the applications in the vending machine such as the LED indication system, the process of selecting boards, and the locking of the doors and drawers. Because these systems need to have some sort of control software, a PLC is a likely candidate. In addition, because there are not a lot of systems that need to be controlled, a smaller, less power-intensive PLC will most likely be used.

Another subsection that needs to have clarification is the database. The database is where student information, such as T-Number, will be stored and sent to the ECE office. As stated in the introduction, an SQL database will be used. SQL is a query language that can facilitate communication to and from a database, as it can retrieve, insert, update, and delete information in a database. SQL can also create new databases and tables within a database [2]. The SQL language will be crucial to implementing the vending machine because of the need for a database.

Finally, as stated in the introduction, an MCU will be used in order to program the SQL database. An MCU is simply “an electronic device with a [microprocessor](https://www.britannica.com/technology/microprocessor) as its [central processing unit](https://www.britannica.com/technology/central-processing-unit) (CPU),” [3]. The microprocessor is what will perform the digital functioning of the MCU, as the microprocessor is what contains the circuitry of the MCU. In tandem with a PLC controlling the hardware, the MCU will control the software side of the vending machine. Both are needed in order for the vending machine to properly work.

# Ethical Considerations

During the process of designing this vending machine, every scenario that can occur must be taken into consideration. The vending machine will be plugged into the wall for its power supply. The supply voltage will be 120VAC before it’s sent through the AC/DC converter. It must be certain that the voltage is properly stepped down and converted to DC. The desired voltage is roughly 5V DC; given that “30 volts is generally considered to be a conservative threshold value for dangerous voltage,” a person could be severely injured in the event of incorrect conversion [4]. In order to counteract this, there will be a system in place to detect if there’s a spike in voltage or current in the AC/DC converter and trip the power supply. This system will most likely be a ground-fault circuit interrupter (GFCI). Having this within the power cord for the vending machine will comply with the National Electric Code (NEC) standard NEC 422.51, which requires vending machines that are powered by cord-and-plug to have a GFCI located near the wall plug [5].

In addition, security must be put in place to prevent student data from being compromised. One security measure is connecting the vending machine’s database to the ECE office’s computer by ethernet. This is because “An Ethernet connection is much more secure than a Wi-Fi connection. Data on an Ethernet network can only be accessed by physically attaching a device to the network, while data on a Wi-Fi network travel[s] through the air and can be more easily intercepted,” [6]. An Ethernet connection will make it more difficult to steal student information compared to a Wi-Fi connection since data can only be stolen by attaching a device to either the vending machine or the ECE office’s computers. In using Ethernet as a form of communication, the connection must follow the Institute of Electrical and Electronics Engineers (IEEE) standard IEEE 802.3-2018, which gives a selection of speeds at which an Ethernet connection must work [7].

To work with the Ethernet connection, a form of encryption will be used on the student information before it’s sent out. One option for this is using a cipher of some sort. A cipher is a phrase or string of words that information is shifted by in the alphabet. This will make the received information look jumbled, though it will be deciphered upon retrieval.

Finally, a scenario that must be considered is the stealing of a device from the vending machine. Given the chance that the faculty in the ECE office may step out of the office for a few minutes, there is a chance that someone could attempt to break into the vending machine to steal the devices within. To help prevent this, the vending machine will have locks on both the drawers and the lids of each device. There will also be a sensor system in place to detect if a box is in its compartment. While this will be mainly used for the SQL database, it can be given the purpose of detecting if a device is removed without approval.

# Block Diagram

## Raspberry Pi

To meet the requirement of an MCU to hold the data of the system, a Raspberry Pi will be included to support a database for student information and allow the transmission to the customer. Explain Inputs and Outputs

### 1) SQL Database

### a. Inventory

The database will be used to keep a record of the inventory inside the machine and will be able to tell the customer whether a device is loaded or unloaded from a sensor in the PLC system. If loaded, the system will check whether the box is scanned in by the barcode scanner. If unloaded, the system will check whether the box is not scanned. All information will then be recorded and saved in the inventory section of the database.

b. Student Information

The database will also be used to keep a record of the students who have rented devices for classes and will also be able to send the data to the customer through Ethernet. Under the student portion of the database, the T number will be recorded from the card reader connected to the MCU. The name and email of the student will be taken in by a user interface. A course section will then be chosen from a list of courses held by the database. Once a board is chosen, the barcode will be read by the scanner and logged for use by the customer.

*2) Ethernet*

*a. File Drop*

The ethernet cord shall be used to send and receive data to and from the customer. If the customer wants to see the database and who has taken items, they can request the file and it will be transmitted. The file will likely be a CSV from Excel that will feed from and to the database. Find numbers and references for In/Out

Input: Encoded message to the database

Output: Message signal to the connected device

*3) UI (User Interface)*

The user interface will be connected to the MCU and will allow the user to input their name, email, and which class(s) he or she needs a device for. The information is also relayed through the PLC system.

1. Explain Touchscreen, Inputs, Outputs

*4) Card Reader*

The card reader shall receive a signal from an ID card issued to the student by the college. When the signal is received, the device will send the data to the database through the MCU. The Reader will have an indicator light for a correctly scanned card to notify the student that he/she is good to proceed. Explain the input/output with numbers.

## PLC

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1. Control Locks

## Touch Screen

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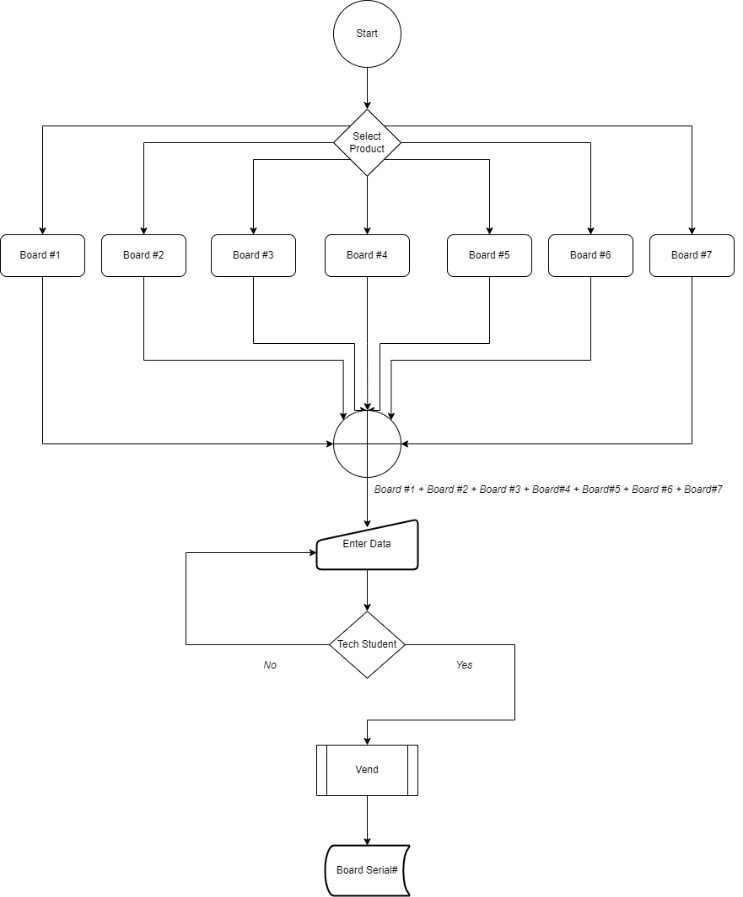
# Design And Implementation

The following design for a class kit vending machine is suggested in order to address the drawbacks of the current approach and to offer a solution that is both affordable and user-friendly. The project's primary components—the power supply, the card reader, the motor driver, and the LCD—are shown in Fig. 1 as being composed of five elements.



*Figure 1: Overall Design of Machine*

In order to understand the overall design the process must be acknowledged first. The process would be very simple. A student would walk into the office of Electrical and Computer Engineering and using the Eagle Card he/she would tap on the reader and after verifying the information the student then will choose the required board from the given set of choices on LCD and after doing so one of the drawers would pop open and with the help of LEDs the student would grab the needed board and close the drawer as shown in figure 2.



*Figure 2: Design Flow of Machine*

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*a**b* 

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* Do not confuse “imply” and “infer”.
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* 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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1. G. Eason, B. Noble, and I. N. Sneddon, “On certain integrals of Lipschitz-Hankel type involving products of Bessel functions,” Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955. *(references)*
2. J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.
3. I. S. Jacobs and C. P. Bean, “Fine particles, thin films and exchange anisotropy,” in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.
4. K. Elissa, “Title of paper if known,” unpublished.
5. R. Nicole, “Title of paper with only first word capitalized,” J. Name Stand. Abbrev., in press.
6. Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, “Electron spectroscopy studies on magneto-optical media and plastic substrate interface,” IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].
7. M. Young, The Technical Writer’s Handbook. Mill Valley, CA: University Science, 1989.

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