ECE Kit Project Proposal V2

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I. Introduction

In many instances, college students in electrical and computer engineering find themselves dropping out of school. In fact, between forty and fifty percent of first year students in ECE drop out [10]. Furthermore, some students claim that they go from learning nothing to learning everything [10]. With this being said, the goal of this project is to create a kit that will create a smoother transition from learning nothing or knowing nothing to learning the basic concepts of ECE. While there are many other kits on the market that serve a somewhat similar purpose, the objective of this project is quite different. This kit will be able to portray many concepts in ECE, simple or complex, to anyone who chooses to use it. Since the kit will be very user-friendly, it will allow people with no experience to learn from it.

The targeted audience and customer will consist of incoming college students or anyone who might be interested in the concepts of electrical and computer engineering. Allowing people to use this kit before going to school for engineering will allow them to have a preview of what they would be learning in school which would help them decide whether they want to pursue the degree. Furthermore, the kit will demonstrate some of the concepts from circuits, controls, signals, and computing. These are all very important core classes in the ECE curriculum but are also complex to learn. For instance, when setting up a circuit for a circuits course, the user can use different components to achieve different outcomes. The user must also use a variety of equipment which also takes a certain level of knowledge to use to measure and achieve certain goals. Also, there is a certain level of danger when manipulating these components when using different currents and voltages. This kit will allow the user to do the following without using special equipment and will not have to worry about safety issues.

Along with the design of this electrical engineering kit, there comes many questions and responsibilities. The following parts of this proposal will thoroughly explain more information about the project and the goals that the team has for it. Also, the difficulties such as specifications, constraints, and standards will be covered in depth. With any project, there is a customer which has been identified and there are also other kits that are available. The team's job is to identify the other available kits, and build a kit that is more sufficient and well rounded that can be easily used by the intended user. Lastly, the need for this solution will be covered in a sufficient way.

II. Formulating the Problem

Two main problems need to be highlighted. First, there is a need for an instructional tool that efficiently introduces users to the basics and principles of electricity, electronics, hardware/software in an interesting and thorough way. The instrument must go beyond the constraints of existing solutions by delivering a hands-on learning experience that demonstrates the physical uses of electrical components and circuits while maintaining safety and instructional value.

Second, as the main objective is to stimulate the interest of electrical/computer engineering at an early stage and increase the number of students choosing to pursue a career in STEM, the kit shall be reasonably priced and adaptable to be utilized by a diverse spectrum of students, without requiring substantial prior knowledge or additional equipment.

In order to resolve these problems, Team 6 suggests an electrical/computer engineering kit that will have a range of parts, including safe, low-voltage power sources and resistors, capacitors, LEDs, and motors. Users will be guided through experiments covering basic topics like circuits, controllers, signals, and computers by the kit's straightforward, step-by-step instructions. To improve learning engagement and retention, it will also include real-world applications. By tackling these problems, the project will close a present gap in electrical/computer engineering teaching resources and increase young learners' awareness of and interest in STEM subjects.

A. Background Information

Electrical and Computer Engineering (ECE) is crucial to the technical developments that define our modern world. However, the abstract nature of electrical principles is a considerable barrier for many eager students. Unlike disciplines with tangible learning aids, electricity's qualities provide distinct obstacles in educational contexts. Recognizing this, our team discovered a shortcoming in the present educational resources accessible to high school students and incoming freshmen interested in ECE.

The current teaching kits on the market, while valuable, sometimes fail to explain the fundamentals of electrical/computer engineering and electronics to users. For example, the Deluxe Digital/Analog Trainer aims more at the construction part of projects than teaching electronics fundamentals. Indeed, it offers plenty of features and training opportunities but it focuses on building rather than making the users understand the principles of electrical and computer engineering. Such a kit would not serve much to the Electrical and Computer Engineering department of Tennesse Tech. [1]

Another kit to look at is the Elenco MX907 200-in-1 Electronics Project Lab kit. It focuses on teaching about transistors, transformers, diodes, capacitors, oscillators, and schematic symbols. It exposes students to a wide range of materials and concepts but it lacks exposing the user to hands-on applications or integration of these concepts to a real-world scenario. [2]

Likewise, the Teenii STEM Electricity and Magnetism Kit is designed to help users explore concepts like series and parallel circuits, lighting bulbs, and other basic projects using an AA battery. However, it focuses on very basic introductory concepts and does not provide any real-world usage scenarios. [3]

These kits either oversimplify subjects, resulting in a lack of depth and breadth, or they are overly complicated, overwhelming the students. Our idea seeks to close this gap by creating a full electrical kit that makes learning about electricity enjoyable, straightforward, and safe.

B. *Specifications and Constraints*

The following specifications will be related to an educational electrical kit which is the main purpose of the project.

The kit shall operate at less than 50V, safe voltage level suitable for educational purposes [6].

The current used in the kit shall not go above 5mA [6]

The kit shall be designed with clear instructions, labeled components, and a user-friendly interface to facilitate learning.

The kit shall include a modular design that allows users to easily assemble and disassemble components, promoting a hands-on learning experience.

The kit shall be compatible with Arduino IDE.

The kit shall include resistors ranging for 10 ohms to 100k ohms.

The kit overall budget shall be within a 400 - 900 dollar range.

C. *Standards*

As is with any engineering design, there are certain rules and regulations that must be followed to ensure safe design, use, and repair of the product. Since the project calls for portable power solutions, several different types of batteries must be used. Some microcontrollers (like the Atmega 2560) can be connected directly to a 9V battery with no issue[2]. However, some microcontrollers and various other electrical components will need either less or more voltage. Thus, the use of step-down converters and small car batteries may be necessary to design parts of the project. As a result, standards like UL 2054 must be followed in order to safely use the batteries. It is wise to be mindful of recalls, too. Some batteries have been recalled due to safety concerns, and it is advisable to check on the company's website before using any of their products in the design.

Moreover, the signals aspect of the project needs to follow strict guidelines set forth by the ECFR. According to Section 15.205 of their guidelines, there are several frequencies listed that cannot be used by any intentional radiators[8]. If the project is to include any component that radiates radio signals, it cannot purposefully emit any radio signals within any of those ranges.

D. *Externalities*

The project has a positive impact on the education industry. If this kit is successful, it will attract a wide audience of potential ECE students. This in turn will drive up enrollment in STEM programs, especially in electrical, computer, and mechanical engineering. As far as the equipment is concerned, low voltage and low current circuits and electronics are being used so as to not risk the safety of any potential users. However, the design will incorporate some level of interactivity, so plugging something in incorrectly in terms of polarity or quantitative measurement must be considered.

E. *Survey of Solutions*

Research led to the discovery of multiple products that were already on the market. For example, The Teenii Stem Electricity and Magnetism kit (50 dollar kit) is designed for children of 8-16 years old [7]. In this kit students can experiment with making series and parallel circuits, using a multimeter, wiring a simple circuit to light bulbs, and other simple circuits [5]. The power supply used is an AA battery and comes with a battery holder with color coded polarity. A kit that was designed for students in 7th-11th grade is the EUDAX science lab learning circuit kit (20 dollars) [5]. Similar to the last kit, it also uses an AA battery as a power source. It includes the use of a hand crank electrical generator, wind powered car, light bulbs, and wires [4]. Both kits are intended for high school and middle school students, so following the guidelines from these manufacturers would assure the safety requirements of the ECE kit. Moreover, the kits have magnets and iron filings to introduce the students to magnetic effects. These two kits are great for experimenting with components but lack the ability to demonstrate the electrical property the student is experimenting with. For this, the experiment needs to incorporate an output that changes as the experiment's inputs change. For example, when building circuits with parallel or series resistors the kits the output can only be tested using a multimeter. This lacks the ability to physically show the difference between circuits with series or parallel components.

The ELENCO MX907 Electronics Kit (160 dollars) is designed to learn about transistors, transformers, diodes, capacitors, oscillators, basic electronic circuits, and schematic symbols [4]. This kit also uses AA batteries for a power supply and has the component's schematic on the board with the actual component. This gets the students familiar with schematic symbols while using the kit. This kit also introduces students to logic gates, seven segment LED digital display, and more [4]. This kit advertises a 200 in 1 electronic project kit with a wide array of components [4]. The Deluxe digital analog trainer (360 dollars and includes a case and tools) is a kit designed for school projects, so it is built on a single PCB for simplicity [3]. With this kit, students are able to practice soldering and building circuits. This kit is not manufactured to teach students about electronics, instead to have all the necessary components to be able to build, test, and develop electronic projects. It also includes 5 different power supplies, all of which are regulated and protected against shorts, and a function generator with sine, square, and triangular waves [9]. This is an advanced kit with tons of components and training opportunities, but it lacks the ability to show how the circuit operates in an approachable way for students who are new to the ECE program. While the kits listed have their respective advantages, the kit team 6 is designing will physically represent electrical properties. This will allow students to see the results of changing components in the circuit, and gives the user a different understanding of how components work in the circuit.

F. Summarizing the Solution

So why invest in a kit like this at all? As was laid out earlier, there are several already pre-made kits that demonstrate basic electric concepts well. One shortcoming that those kits have (and that this kit will not have) is taking those electrical concepts, and showing them in a way that anyone, even someone who has never learned Ohm's Law can easily understand. Put simply, the project is taking broad, abstract concepts like computing, resistance, voltage, current, and many more, and it is representing those ideals with more physical means. Why wonder what resistance does to a circuit when, with this design, a wheel would physically spin slower when connected in series with a higher resistance than before. This kit is treading on a well-worn path, but in a way that its users can follow behind it easier than ever.

III. Looking Down the Path Toward Solution

Looking forward, the team can put together a general solution to the problem assessed in the previous parts of the proposal. The following paragraphs will explain in more detail the parts of the project that will be used such as the electrical and mechanical components. Also, the team will discuss how these components plan to be used and how they will work. While explaining this, the team will keep in mind the standards, externalities, specifications, and constraints.

1) Electrical Components:: For the electrical side of the solution, the team plans to use many different components. These components will also be made simple to understand for users. The team will use rechargeable batteries as a DC power source, so they can be reused or replaced easily if needed. The team will come up with a way to convert DC to AC. Resistors of different values will also be used to see the effects of the resistance on different components. Also, leds will be used to show differences between alternate current and direct current. It will also be used to show the effects of low and high current. Capacitors will be used with leds to show how capacitors charge. Next, the mechanical components will be explained in more detail.

2) Mechanical Components:: Considering the mechanical side of the project, some basic components will be necessary. For one, simple dc motors would help demonstrate resistance in conjunction with a voltage source. These motors would be connected in series with varying resistor values in order to physically show the relationship between voltage, current, and resistance. Connected to these motors would be a plethora of other components. Fans would be connected to the motors to "feel" more wind coming off the blades depending on the resistance values picked. Lastly, gears will be connected to the motors in order to demonstrate simple logic gates, with 2 input gears and 1 output gear.

A. Unknowns/Obstacles, Implications, and Necessary Experiments

In developing a freshman-level Electrical and Computer Engineering kit, there are some unknowns and obstacles that may affect our kit.

1) Safety: Working with electrical components can be risky, and the team knows that when designing this kit there are going to be safety risks. Safety is important, so the team must go in and do safety checks to make sure of no safety risks. If the team overlooks anything, then this could lead to user's harm. The team will use a laboratory to do lab tests on all components and equipment being used in the kit to give the team a better understanding of any risks that remain. If the team does not remove these safety risk, then they cannot design this kit because it could harm users and that's not acceptable, so safety risk can lead to the team failing to complete the project if the team does not thoroughly work through and fix any safety risk that remain.

2) Compatibility: Another unknown that the team has is electrical component compatibility. When the team first begins collecting components for the kit the compatibility of each of these components is unknown. The problem with this is that the different components will have specific limitations or ratings and that could cause the circuit to fail or output unpredictable behavior. The team will need to do lab tests to determine the compatibility and how to make the components work together so that the circuit does not fail or output bad results. If the team does not test and figure out the best compatibility of these components and then tries to design a kit from scratch it will be a failure, this is a risk that the team faces when working with compatibility because if they do not have it correct, then the team could fail to complete the project.

3) Life cycle: The life cycle of the kit is currently unknown by the team, the team can not guarantee that the kit will have a lasting life cycle. This could lead to the project having to be frequently replaced causing cost increases. For the team to handle this problem they will need to lab test the components to make sure they are durable enough to last for a sufficient amount of time.

4) Time constraints: The team is uncertain right now how much time the full development of this Electrical and Computer Engineering kit will take. Time constraints limit the time the team has during development. This will lead to rushing the design causing it to fall short of the goals the team set, lead to a bad kit, or even be a risk that could hinder the design of the kit because of the time that we are limited to in order to design this project. The team will set deadlines for each assignment to avoid delays or getting off track to try and avoid running out of time. If the team does not set goals and deadlines and they get off track and start falling behind, then that can lead to the team running out of time failing to develop the kit. This risk is important because the team needs to make sure that they set these effective deadlines wisely to design the kit or else the kit will fail to be complete.

5) Kit instructions: As the team starts to develop the Electrical and Computer Engineering kit, good instructions are unknown. If the instructions are not very clear this will lead to bad learning experiences and defeat the purpose of the kit. The team will need to make a clear set of instructions during the development to make sure any user who uses the kit for the first time can follow the instructions for better learning experiences. The team will use the instructions that are put together to conduct a lab themselves and confirm that the instructions are clear enough.

6) Power delivery: Power that must be delivered is also a huge unknown and will have a big impact on the project as well. The team needs to figure out ratings for everything that will use power. The team will have to choose the source, its size and it's rating based on the equipment that must be powered. If the team just chooses a power source without taking everything into consideration, then this could lead back to safety risk, a nonfunctional kit, and unreasonable orders and cost to the project that is not needed. The power delivery source can be a big unknown since the team doesn't know yet exactly what they will need. If there are no power sources that will work for the components and equipment together based on their ratings, then this could lead to the project failing to be complete, so the team needs to carefully consider all these things when working with the power delivery so that they don't let it interrupt the completion of the project.

B. Measures of Success

For the project to be considered a success, the group must meet the expectations of the stakeholders and customers. The customer has given the team some degree of freedom in curating and designing the kits functionality. Moreover, the kit must show electrical theory, basic circuitry, is safe from electrical shock, and does not break due to a short from misplaced parts. To test if the kit would overwhelm an incoming freshman, the team will collaborate with currently enrolled highschoolers with an interest in engineering to gauge how approachable the kit must be. Another way is to compare it to the kit given during members of the groups' freshman year. Adding the opinions of younger students with the experience from the team gives the group a fair amount of feedback to determine if the kit is appropriate for incoming students. To test the kit's operating voltage, the team will use a voltmeter to ensure the kit does not go over the rated voltage for the safety constraint. The team will test the durability of electrical components by observing how the component holds against controlled testing. By controlling things like voltage, current, temperature, and operation time, the team will be able to gauge how reliable each component is for the kit. The tests will run in cycles of extended operating times to simulate lab time. By doing this, the team can gauge components life span and reliability.

C. Broader Implications, Ethics, and Responsibility as Engineers

With engineering comes many responsibilities. Engineers must think of broader implications and ethics in their careers and especially when participating in the design of a project. The design of the electrical engineering kit is expected to have a positive impact in the engineering community by increasing the opportunity of learning. Economically, this kit could be more expensive than other options already available which could impact universities or customers who are interested. With this being said, the kit will come with more opportunities and options for the user than other kits. To ensure that the kit is economical, the user will have the option to rent the kit from the ECE department rather than having to buy it for themselves. Furthermore, it is the engineers job to ensure that safety is crucial. The team will put measures in place to ensure safety throughout the process and allow for safe and convenient operation. Assuming that safety is a top priority and the customer uses the equipment correctly, the kit will only benefit the design team and the customer. If not used correctly and any safety measures are missed, there could be negative results. Also, while the opportunity of learning increases, so does the cost. Assuming that the university provided the kit for the student, the cost would be a less significant problem. But if the student is required to purchase the kit or someone who is interested in electrical engineering wants to use this product, cost may become a more significant issue.

IV. Resources

While a specific dollar amount for the project cannot be known at this time, a rough idea of what components are necessary to accomplish it can be listed along with their expected prices. These prices are researched through Amazon, although no specific components or prices will be listed, only aggregates[1]. Motion Sensors can be bought in bulk, but only one or two is necessary for this project, at an average of 10 dollars total for 3. A pack of 9 Volt batteries would be sufficient, not only for testing purposes, but also for the project's demonstration. A 4-pack of these runs about 10 dollars, so getting 5 packs of these would total 40 dollars. Next, some basic motors are necessary for various bits and pieces of the design and can be bought in a 10-pack for around 15 dollars. General soldering will be used greatly throughout this project, so setting aside 50 dollars for all of its equipment would be best. Various packs of circuit equipment (capacitors, inductors, resistors, etc.) will be purchased for around 20 dollars. However, high-wattage-rated resistors will be necessary for the project. A pack of assorted resistors rated at 5 Watts runs about 30 dollars. Lastly, tying all this together into a briefcase like apparatus will not only be safer for everyone, it would finalize the design into something a student could take with them to a lab. This particular resource might be free (thanks to the iMaker space), but if filament is necessary to purchase, then a pack of 8 with different colors totals around 50 dollars.

This is certainly not an exhaustive list of everything the ECE kit will need, but it is a good start. The team estimates a total cost for the project anywhere from 400 to 900 dollars for everything necessary for the completion of the Capstone Project.

A. Personnel

Each member of the team has strengths in certain areas while also knowing areas where improvement is needed. During team discussions, each member identified skills that are strong suits and weaknesses. These skills are listed below.

1) Abdoul Modi: This member possesses hard skills in PLC's and VHDL. His soft skills are event planning and teamwork. This member's weakness is communication.

2) Carson Ray: This member possesses hard skills in Python and analyzing circuits. The soft skills this team member has is accountability and dedication. This member's weakness is control systems.

3) Dave Placide: This member possesses hard skills in Powerpoint and C++. The soft skills consist of active listening and adaptability. This member's weakness is signals.

4) Jesse Griffey: This member possesses hard skills in control system design and Word. The soft skills consist of social skills and time management. This member's weakness is C coding.

5) Keston Robbins: This member possesses hard skills in C coding and filter design. The soft skills consist of work ethic and cooperation. This member's weakness is assembly code.

6) Slayde Simmons: This member possesses hard skills in assembly code and circuit diagrams. The soft skills consist of teamwork and time management. This member's weakness is c++ coding.

7) Troy Dunn: This member possesses hard skills in circuit design and power systems. The soft skills are work ethic and organization. This member's weakness is coding.

Using the above skills, the team will work together to provide a safe and reliable kit. While each team member possesses weaknesses, each member will work diligently with one another to ensure that everyone learns throughout the process. Each member is motivated to have a successful outcome, therefore, each person is determined to learn new skills which will be necessary for a successful outcome.

B. Timeline

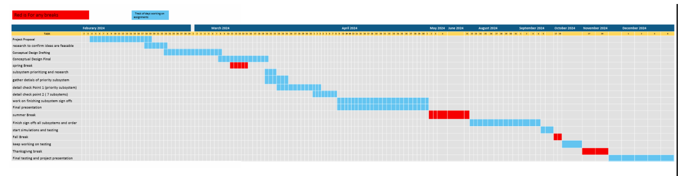

Figure 1. Timeline

The team is expected to have between nine and ten months to complete their capstone project. With this being said, the team has to carefully plan their tasks and assignments to complete the project on time. It is important to take into consideration when the team will and will not be able to work on the assignments and tasks given. In figure 1 above, the tasks deadlines, and breaks within the semesters are detailed. It is important for the group to have a timeline for the project to help with time management along with dates and goals for each task. Each team member will have access to the timeline, helping with day to day work towards accomplishments. While these assignments have dates, smaller responsibilities that are not planned out will be given to each team member. With the timeline in place, all team members will know when to start on these smaller responsibilities and when they will need to be finished. Eventually, changes will happen and details will need to be taken out or added. The team has decided to not work specifically on the project through the breaks, but are willing to work through them if necessary. Also, the team will meet with their supervisor and customer to receive feedback which will contribute to all ideas. With this happening, the timeline will continuously be revised and every team member will be aware of each change. This needs to be done so everyone's time management is up to date and new additions or details taken out are known. The timeline in figure 1 above will be a great tool for this process, ensuring efficiency towards our objective

V. Conclusion

In conclusion, the team will build this electrical and computer engineering kit in order to help with the beginning learning process for incoming freshmen students and anyone else who may have interest in the ECE curriculum. The kit will be designed and built in a safe and ethical manner. It will also possess many attributes which will be used in an ECE degree. It will include the subjects of circuits, signals, controls, and computing. Furthermore, the kit will have multiple options for learning and will be able to be used in several ways to show each concept.

Some may ask, how is the team qualified to complete this project? Throughout each teammate's academic career thus far, they have taken a multitude of courses which will contribute to the design of the project. Some of the main concepts needed to perform the project successfully include but are not limited to, circuit design, coding, and digital logic. The team meets these qualifications as seen in the personnel section. Also, the team is dedicated to overcome any obstacles faced, and are willing to learn any new material that may be needed for the success of the design.

Lastly, this project will solve the problem of finding a more efficient way to learn the basics of electrical and computer engineering. Using multiple electrical components or ideas and portraying them as mechanical or electric vehicle concepts will be extremely useful to anyone starting their academic career or getting more people interested in the subjects. The team has identified the general problem and solution for the project along with many other topics seen above. Combining the team's understanding of the project, the skills of each team member, the budget of the project, the methods that are intended to be used, and the timeline the team intends to follow, the project will be feasible and productive for the team itself, stakeholders, and the customer.

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