Project Proposal

Introduction

Among electrical engineering students, it is a common idea that there is an easier way to understand the concept of electricity. Many students struggle in the beginning of their college career in the electrical engineering field because they have not had the ability to use an electrical kit which is sufficient in teaching the subject. The basic knowledge of electrical engineering becomes imperative as a student furthers their education. The design of this new electrical engineering kit could change the way that many new students begin to learn about electrical engineering.

The objective of this project is to build an electrical engineering kit for high schoolers or incoming freshmen students to use in an introductory level ECE course. The kit could also be used by younger people who may be interested in electrical engineering. This would give them the ability to gain a better understanding of the subject they are interested in. The problem with electricity is that it is intangible, which means it is much more difficult to understand since it cannot be seen by the human eye unless using certain equipment. With this being said, it would be much more sufficient to use electrical components in order to portray them in a mechanical manner, allowing the user to see the effects of electricity without using specific equipment. The kit will include a variety of electrical and mechanical components, giving the user options while maintaining safety. Furthermore, these components will involve the subjects of circuits, controls, signals, and computing.

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.

Formulating the Problem

Two main problems need to be highlighted. First, there is a need for an instructional tool that efficiently introduces freshmen 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 consequences of electrical components and circuits while maintaining safety and instructional value.

Second, the tool should be reasonably priced and adaptable enough to be utilized by a diverse spectrum of students, from high schools to college freshman, without requiring substantial prior knowledge or additional equipment. The objective is to build a greater

knowledge and interest in electrical/computer engineering at an early stage and possibly increasing the number of students choosing STEM careers.

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 gamification and 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.

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 to entrance for many eager students. Unlike disciplines with tangible learning aids, electricity's ethereal qualities provide distinct obstacles in educational contexts. Recognizing this, our team discovered a crucial vacuum 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 freshmen. 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.

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Specifications

Electrical specifications are many, multifaceted, challenging, picky and put together by opinionated engineers hell bent on doing a good job because that is what engineers do. The following specifications will be more related to an educational electrical kit which is the main purpose of the project.

> The kit shall operate at safe voltage levels suitable for educational settings. Low-voltage circuits (e.g., 5V or 12V) are common for educational kits. We shall ensure that the current is limited to a safe range, typically within 500mA for educational purposes. We

shall include safety features such as overcurrent protection, short-circuit protection, and proper insulation to ensure the safety of users. The kit shall be designed with clear instructions, labeled components, and a user-friendly interface to facilitate learning. We shall create a modular design that allows users to easily assemble and disassemble components, promoting a hands-on learning experience. The kit shall provide comprehensive educational materials, including a curriculum, manuals, and experiment guides to help users understand fundamental electrical concepts. If applicable, the kit shall be compatible with online learning platforms or software that can enhance the educational experience. The kit shall be designed with durable components in mind to withstand repeated use in an educational environment.

Constraint

We shall balance the inclusion of features with cost considerations to make the kit affordable and accessible to educational institutions.we shall ensure that the kit is suitable for the target age group, with appropriate safety features and complexity level. We shall adhere to safety standards and regulations relevant to educational materials, especially those related to child safety. While allowing for learning progression, we shall avoid unnecessary complexity to ensure that the kit remains suitable for beginners. We shall choose readily available components to simplify production and replacement if needed. We shall consider feedback from educators and students to continuously improve the kit's educational effectiveness.

Standards

The first set of standards applies to any electrical engineering project. These standards are the IEEE code of ethics. These standards' main goal is to ensure that the engineering process is safe, effective, and informative for all involved parties. The code is broken up into 3 sections, each with its own individual subsections. The first section reads, "To uphold the highest standards of integrity, responsible behavior, and ethical conduct in professional activities"[1]. This is further broken down into smaller subsections, but suffice it to say that all engineers should act professionally when working on anything pertaining to their field. The second standard states, "To treat all persons fairly and with respect, to not engage in harassment or discrimination, and to avoid injuring others "[1]. This section outlines how engineers should treat their peers, that being with respect and common courtesy at all times. The last section says, "To strive to ensure this code is upheld by colleagues and co-workers" [1]. This section states that any engineer should ensure that his/her peers are also following this code of ethics.

In this project, it is also paramount that the various technical standards are upheld for each individual task to be accomplished both effectively and safely. The designs involving simple designs such as battery powered circuits (which would be governed by the Consumer

Product Safety Commission) don't have too many strenuous regulations. However, the signals aspect of the project needs to follow strict guidelines set forth by the FCC, the Federal Communications Commission. According to Section 15.3 of their guidelines, "An incidental radiator is an electrical device that is not designed to intentionally use, intentionally generate or intentionally emit radio frequency energy over 9 kHz" [2]. Put simply, anything concerning signals in the project must not exceed nine-kilohertz in frequency, or they run the risk of violating these guidelines.

Externalities

One positive externality of the project is on the education industry. If this kit is successful, it could attract a wider audience than traditional plug and play ECE kits. This could drive up the number of 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. As a result, all of the designs will have to be "foolproof", meaning that no matter what someone does (within some degree of reason), the product should not destroy itself, harm its users, or affect anything else negatively. Using rechargeable lithium-ion batteries so its power will be sustainable, and all of its moving parts will have their "pinch points" minimized or outright removed.

Survey of Solutions

While designing an ECE kit for incoming freshmen, research led to the discovery of multiple products that were already on the market. For example, The Teenii Stem Electricity & Magnetism kit ($50 kit) is designed for children of 8-16 years old [3]. 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 [3]. 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 7^{th}-11^{th} grade is the EUDAX science lab learning circuit kit ($20) [4]. 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.

The ELENCO MX907 Electronics Kit ($160) is designed to learn about transistors, transformers, diodes, capacitors, oscillators, basic electronic circuits, and schematic symbols [5]. 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 [5]. This kit advertises a 200 in 1 electronic project kit with a wide array of components [5].

The Deluxe digital analog trainer ($360 and includes a case and tools) is a kit designed for school projects, so it is built on a single PCB for simplicity [6]. 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 [6]. 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.

All of the kits listed above bring their own unique approach to learning and testing circuitry, so it is vital that the team designs a kit that would not overwhelm an incoming freshman and give the student a challenging yet instructive kit. With this in mind, it is also important that the team makes sure to present the necessary components for a student to have a solid base in their early career in ECE engineering.

Summarizing the Problem

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.

Unknowns/obstacles, implications, necessary experiments

- In developing a freshman-level Electrical and Computer Engineering kit, there are some unknowns and obstacles that may affect our kit.
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- \subsubsection{Safety}
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➢ Anything that has to do with electrical components is 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 can lead to student 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.

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➢ \subsubsection{Compatibility}

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➢ 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 may 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.

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➢ \subsubsection{Life cycle}

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➢ 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.

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➢ \subsubsection{Time constraints}

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➢ 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 could lead to rushing the design causing it to fall short of the goals the team set or lead to a bad kit. The team will set deadlines for each assignment to avoid delays.

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➢ As the team starts to develop the Electrical and Computer Engineering kit, good instructions are unknown. If the instructions are not very clear this could 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 freshman 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.

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The 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 short from misplaced parts. The learning kit shall give the student an applicable representation of electrical properties. The kit shall be operable for the duration of the student's freshman year.Apart from batteries, jumper wires, or resistors which are easily replaceable. 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. Parts that have a polarity should be color coded to eliminate any confusion. In doing this, it reduces the chance of a component being placed incorrectly in the circuit which can lead to electrical hazards.

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. 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.

Resources

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 their strong suit and ones that are their weaknesses. These skills are listed below.

- Slayde Simmons
  - This member has hard skills in Circuit diagram, LT Spice, and PowerPoint. So they are more skilled on the circuitry side. The soft skills consist of teamwork and time management. This member's weaknesses are filtering and c++ coding.
- Carson Ray
  - This member possesses hard skills in MATLAB, Python, C and C++, analyzing circuits, designing circuitry and lab measurements. This member is strong with programming, design and has a good background with electrical circuits. Their weaknesses are in control systems and signals. The soft skills the team member has are cooperation and time management.
- Troy Dunn
  - This member has hard skills in LTSpice, MATLAB, digital logic design, Word, Excel, circuit design, and circuit analysis. This member has most of his experience with design and analysis of circuits and is a little weaker on the programming side. The soft skills are work ethic, organization, and dedication.
- Jesse Griffey
  - This member possesses hard skills in Excel, LTSpice, Word, Digital Logic Design, Powerpoint, and hands on work. This member has most of his experience with data arrangement, digital design and hands on work. The soft skills consist of control systems, technical writing, and time management.
- Keston Robbins

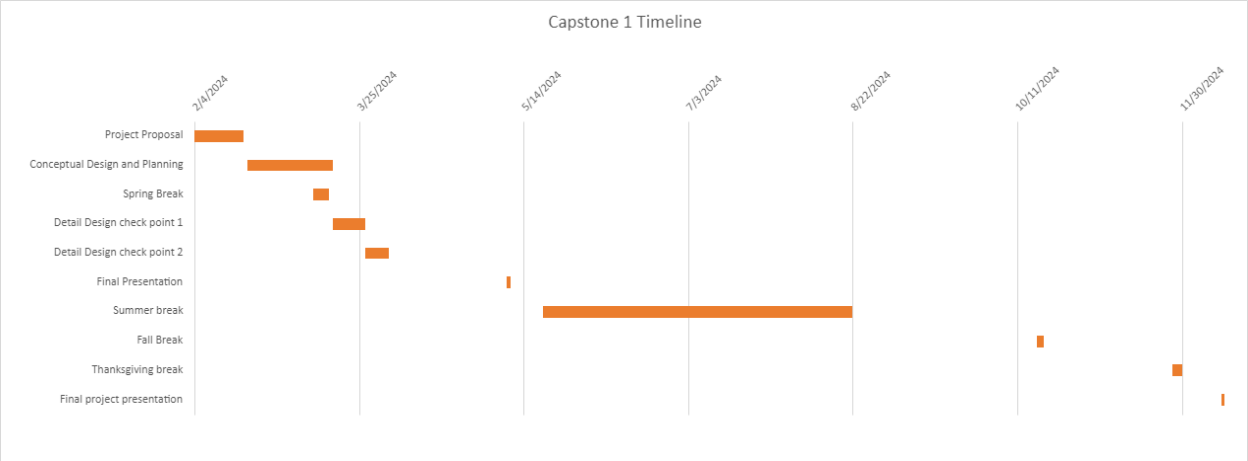
- This member possesses hard skills in LTSpice, C and C++, Filter Design. Programming being more of the strong suit along with circuit design. The soft skills consist of work ethic and cooperation

- Dave Placide
  - This member has hard skills in Word, Powerpoint, C++, Circuit Design. This member's strong suits consist of technical writing and design. The soft skills consist of being easy going and teamwork.
- Abdoul Modi
  - This member has hard skills in C and C++, Pascal, MATAB, Unix, R, Python, PLC, and VHDL. This member's specialty is programming, knowing lots of different languages. His soft skills are event planning, tutoring, mentoring, and teamwork.

Some members have strong programming skills. These skills will allow us to have high-quality outcomes. The different languages will help us take on challenges from multiple angles and come up with many solutions. Another one of our team's strengths lies in circuit design and analysis. Each member has experience with this category, some team members stronger than others in certain areas. One of our more frequent weaknesses is time management. It's important to plan ahead for each activity to ensure everything gets done on time.

Throughout the course of this project, team members will have many tasks that may not align with the strengths of every team member. Knowing each member's areas of expertise and improvement, they will collaborate so that those with a strength in a particular task can support and help team members who may find it challenging. Also, when faced with a task for which none of us possess the certain skills, members will stick together and work together to tackle and resolve the issue.

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, assignment deadlines and breaks within the semesters are detailed. While the main assignments have an exact date, it is yet to be determined when tasks and other responsibilities will be assigned to each team member. Since these tasks and responsibilities have not yet been decided on, the team will be responsible for assigning and completing them later on. In the beginning stages of the project, broad ideas will be talked about and decided on which will be found in the project proposal. Around half way through the semester, the project will become more detailed and in depth. These ideas will be found in the conceptual design. Finally, the final ideas and concepts will be designed and placed into the detailed design. Along the way, the team will meet with their supervisor and customer to receive feedback which will contribute to all ideas. The timeline for the second half of the project (capstone 2) is unknown as of now, but the breaks for the semester are also placed in figure 1.

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, digital logic, and much more. 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 solves the solution 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 and also skills of each team member, the project will be feasible and productive for the team itself, stakeholders, and the customer.

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