PHYSICS

Building Electronic Circuits to Help Our Community

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As technology continues to evolve and open new areas of research and academic disciplines, one must take into account the impact on society as a whole. In exploring ideas for the IMP project, I thought that the laboratory experiments in PHYS 243 (Circuit Analysis Laboratory) and the required final project for the lecture part (PHYS 242) offered splendid opportunities in engaging students to grow their spirit of solidarity, compassion and service, and that they can demonstrate this by implementing projects dedicated to help those in need in our local community.

Course Description and Goals (from Course Syllabus):

The Circuit Analysis course covers the fundamental concepts and laws of electric AC and DC circuits. Students will learn about Kirchhoff's laws, passive linear components including resistor, capacitor, and inductor, and circuit design. Analysis techniques such as: Nodal, mesh, superposition theorem, Thevenin's and Norton's theorems will be covered. Moreover, transient analysis of linear circuits, power and power transfer, impedances, ideal transformers, operational amplifiers, and filters will be covered as well. **A final project based on the covered material is required.** The goal of the course is to allow students to gain a conceptual understanding of the course material in a manner that fosters critical thinking and problem solving skills.

Course Objectives:

A- Obtain a comprehensive understanding of the fundamental concepts and laws of electric circuits.
B- Obtain analytical skills for solving problems in Electricity.
C- Obtain a complete knowledge of the analysis and design of AC and DC circuits in addition to basic filters.
D- **Build a circuit that meets a practical requirement through the course final project.**

It should be noted that the final project is implemented and presented within the laboratory part of the course (PHYS 243).

After brainstorming with my mentor, Dr. Minerva Catral, we agreed that the PHYS 243 (Circuit Analysis Laboratory) would be a perfect candidate to pilot such project. When discussing the final project requirements with my students I have asked them to use Fr. Graham's quote *"Xavier University is dedicated to engaging and forming students intellectually, morally and spiritually, with rigor and compassion, toward lives of solidarity, service and success."* as an inspiration when proposing their final projects (mid semester). In the final reports I have added the requirement of including a reflection paragraph in the conclusion section. Twelve students have participated in this project (working in pairs) which have resulted six different implemented projects. Five groups out of six have included a reflection section in their final reports which are summarized below.

Project 1: Bridge Circuit for Self-Regulating Heated Plate for 3D Printer

Problem Addressed: *The community problem addressed is that inner-city school systems typically do not have enough of money to invest in new Science, Technology, Engineering, and/or Mathematical (STEM) equipment to motivate students to go into such fields. A common problem that could be faced with inner-city schools is that when they do invest in STEM equipment, they cannot afford the most expensive and top of the line equipment. The self-regulating device will make heated plates for 3D printers DIY, and more importantly, affordable. In order to accomplish this task, a bridge circuit was used to generate a self-regulating heated plate. This would not only save money on purchasing a heated plate, but this would also save on energy expenditure. Since it is self-regulating, the heated plate would turn off when it does not need to be used. Since heating a plate requires a large energy expenditure, this project would not only impact students across the world with its affordability, it would also be eco-friendly.*

Reflection: *"I also really enjoyed the theme of the project. It motivated me to finish and make the project as good as possible because I knew that it could end up helping the greater community. Furthermore, this is a project that could influence more young people to enter STEM fields, which would further change the world. Between the life experience and the real world application of helping the community, especially potential STEM students, I think that this project was both insightful and successful".*

Project 2: Handicap Escalator

Problem Addressed: *For my project my main concern was people who are handicapped, and who have trouble climbing stairs. My plan was to build a circuit that turns a set of stair into an escalator. This solves two different problems: it will help those who are not able to climb stairs easily, and it will save money on escalators that run all of the time.*

Reflection: "*The project itself was a great experience. It not only forced us to build a circuit, but it also made us think of a way to help the community. I believe that my circuit is very practical for small distance escalators, and that it could be used in buildings. It will save on electricity, and help those who have trouble breathing".*

Project 3: Cost-Effective Alarm system

Problem Addressed: *Many communities in our country and countries across the world suffer from effects caused by poverty. One of the many unfortunate side effects of poverty is the increase in theft related incidents in the given area. This in turn causes the small businesses who get robbed to lose money, which inhibits them from purchasing better security systems. It may seem like an effective, cheap alarm system is an oxymoron, but it is only that way if you let it be. To solve the problem of poverty-related theft, I decided to come up with a simple alarm that has the ability to fit the user's needs and works well. This alarm can be customized by the user for light threshold, allowing it to be utilized in rooms of varying darkness. Along with light threshold, the interface used to engage the alarm can be varied from the RFID scanner (implemented in my specific design) to include a keypad, a Bluetooth chip, a Wi-Fi module, or even a fingerprint scanner. None of these options, other than the fingerprint scanner, would be more expensive than the RFID scanner, which is only around $5. The only other requirement would be some sort of computer system, whether it be a phone or computer does not matter, to receive the update that the alarm has been set off.*

Reflection: None.

Project 4: Elderly Care Alert System

Problem Addressed: *The purpose of this project was to test the knowledge of circuits I have gained this semester and implement it into a practical project that may be useful in helping or assisting a body of people. The group of people I chose to zone in on are generally older persons who are bedridden where they are patients of staff members or faculty of an organization or facility. This product will help assist those taking care of bedridden patients as they will not be under 24/7 vigilant watch. If any type of waste, specifically urine, is detected by means of change in temperature, then a signal will be sent to the faculty member under watch to let it be known that the patient is in need of assistance. This product is instituted to further the care of these patients by having swift action taken, not necessarily to eradicate a problem the currently persists.*

Reflection: "*I was able to meet the design criteria set for me at the start. I'm glad I hopefully am able to produce something that will directly benefit others as well as their family and loved ones because that is important. Everyone will become old and making life as easy and comfortable as possible for all walks of life is a goal I plan to pursue as long as I am able".*

Project 5: Power Saver

Problem Addressed: *Our circuit is designed to help control the temperature of an environment by using two different types of sensors. The circuit is supposed to turn on an electric heating element as the environment in which it is placed decreases its light intensity and as the temperature of the environment decreases. In order to achieve this result, we used a thermistor that directly correlates to temperature and a photosensor that correlates to a decrease in light intensity. As the resistance of these elements decreases, the heating element will warm and provide heat to the environment. This will help reduce power consumption for many people.*

Reflection: "*I believe that this circuit can be used for many applications not only in the community, but also in the world. The circuit could be implemented in desert like environments which are very warm during the day and significantly cooler at night. This circuit would allow the people in these types of areas not only to control the temperature in their homes, but also to reduce their energy consumption. Reducing energy is beneficial to everyone because that means that we are reducing the money required to be paid to energy companies, and we are reducing the amount of energy we need to use. The homeowners save some money, and planet earth reduces its greenhouse gases production. This circuit can also be used for humanitarian purposes as well. For example, after a disaster strikes a certain area, energy production is often very rare. Most humanitarian aid programs are required to bring their own generators and produce their own energy. If the aid workers were to implement this circuit, they could save energy of the limited supplies that they have. They may be able to extend the amount of time they have before they need more fuel".*

Project 6: Heated Bench for the Homeless

Problem Addressed: *The purpose of this project is to produce a functional circuit that can heat a bench when it is cold out, but only when someone is sitting on the bench, in order to help the cold and homeless, who struggle to stay warm in the winter. To create such a circuit, a bridge circuit will be designed, such that the voltage drop is enough to activate a relay, which connects a pressure sensor to a heating unit. A functional bridge circuit was created, as well as a*

functional relay system, but due to internal resistance, the bridge circuit would not activate the relay.

There are over 100,000 homeless people living in America right now, and with the winter months approaching, most of them will not have a way to stay warm. This circuit is designed to help aid in that problem, as anyone who is cold will be able to use the heated bench to warm up. The benefit of this design is not limited to the homeless, as it can help anyone who is cold.

The first step in creating this circuit is implementing a relay into a pre-configured heating unit. After examining the circuit logic inside of the heating unit, it was concluded that an AND integrated circuit allowed for the heater to turn on when two buttons were pressed. The two default inputs were removed, and were replaced with a pressure sensor and a relay. This means that the heater will activate when the pressure sensor is activated and the relay is closed.

Reflection: "*The theme of the final project was a great way to get students to think about how to use their knowledge for good, and if this circuit worked properly, would have fully fit into the theme*".

Conclusion:

By the end of the semester and aggregating the students' reflections I feel that this pilot project is successful and could be used as a model in future applicable courses where a need-serving practical project is required. I have identified potential courses where such projects can be implemented (i.e.: ENGR 350 Digital Systems, ENGR 354 Microprocessors, and Communication Systems ENGR 358). The students' reflections highlighted the importance of such activities to prepare them to be morally and spiritually aware, and be equipped with compassion and rigor towards building a world of solidarity. On a personal level, I feel that this project has enabled me to better understand the importance of utilizing hands-on project based courses to implement realistic, not only theoretical, practical applications which would enhance the educational experience of students.