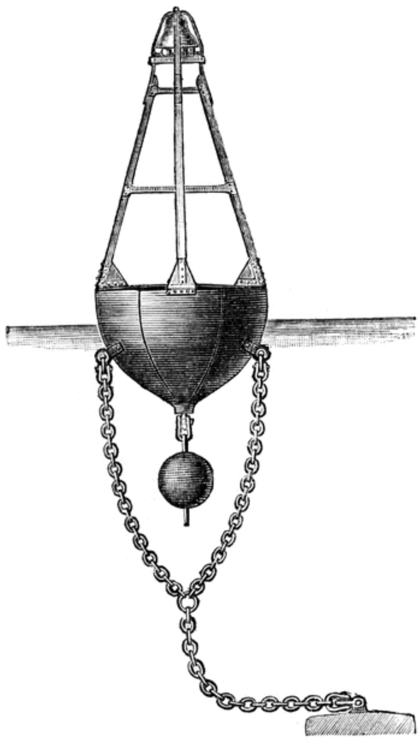

J.U.I.C.Y. Final Project Report

ELEC 4000

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Abstract

As a senior design project, a group of Auburn University students proposed a solution to drowning tragedies in the form of a pool alarm. The pool alarm, unlike any other on the market, will send push notifications to a WiFi-enabled device, such as a cell phone. The notifications will alert an adult the presence of a child or family pet in a pool. For the first phase of the project, the team focused on creating a fully-functional pool alarm. For the second phase of the project, the team wished to improve the existing design by introducing modifications such as a status indicator LED, an external ON/OFF switch, and any other viable ideas that would increase the attractiveness of the product. For the final design, the team settled on a cost effective pool alarm that met the primary constraints of the team's initial goals from phase 1. Multiple tests were performed to assure our device satisfied the expectations of being water-proof, stable, and sensitive enough to detect when a child has fallen into a pool from a remote distance.

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1 First Development Phase

1.1 Development Goals

This section provides a brief summary of the main goals set at the beginning of the first development phase. Later sections discuss how certain goals were met, as well as provide updated goals for the second development phase.

1.1.1 Casing

During Phase One the goal was to finalize the case design. We determined that the casing should have a watertight interior, be buoyant, and be stable but not too stable. The case must be water tight since the sensitive electronics inside the case need to remain dry. It is also critical that it is buoyant, otherwise it would not be able to detect waves. To enhance wave detection we determined that it should not be to stable though because that would prevent it from tilting with waves.

There were three case shapes considered for the design - namely a small base with large outriggers, an upside-down teardrop, and a circular shape. Early on 3D printed material was ruled out because it was porous and not very UV resistant thus not well suited for floating in a pool. The three outrigger design added to much complexity and was to stable for the design. Next considered was the circular design, this had to little room to store the electronics and the solar panel so it was ruled out. Finally the upside-down teardrop was examined, this design met all the requirements and was readily available in the form of a chlorine dispenser.

1.1.2 Microcontroller

Based on the product design, the microcontroller needed to reliably interact with the sensor module, perform meaningful computation on sensor data, and provide some sort of user interaction for configuration and notifications. These relatively broad goals make up the core functionality of the product - sensing and alarming.

To meet these goals, development needed to be done to setup communication interfaces between the Raspberry Pi and the sensor module, as well as on the software that uses data from it. A sensing algorithm had to be developed to detect motion events, and data and manual testing was needed to verify the accuracy efficacy of the approach. Research also needed to be done on various notification packages available in software, as well as the possible configuration management and user interface designs that could be used by the device. The actual progress made on each of these tasks is discussed in the accomplishments section later.

1.1.3 Notifications

Like any alarm system, there needed to be a way for the pool alarm to send distress calls when a pet/toddler has fallen into a pool. The original plan was to design an app that would be compatible with both iOS and Android devices. This would have allowed us to customize the app with a professional appearance and send notifications appropriately. The team team also needed to decide whether we wanted to send notifications via radio, WiFi, bluetooth, or any combination of the three.

1.1.4 Power

Because the pool alarm is an embedded device, charging is an important concern for correct operation. The four main components related to charging used in the design are the lithium polymer charger and battery, the Powerboost 500, and the solar panel.

The chosen charger has the charge current of 500 mA, but can be adjusted to anywhere in between 100 mA and 1000 mA by soldering a resistor. Charging is performed in three stages: first a preconditioning charge, then a constant-current fast charge, and finally a constant-voltage trickle charge to keep the battery fully charged. The connected battery has a capacity of 2500mAh for a total of about 10 Wh, and the output ranges from 4.2V to 3.7V when completely charged. One of the outlets of the charger connects to

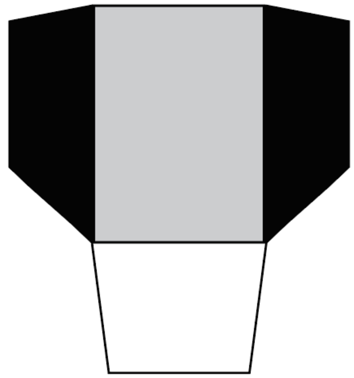


Figure 1: Outline of Casing design

the Powerboost 500 component. The DC/DC boost converter module can be powered by any 3.7V battery, and convert the battery output to 5.2V DC, which is sufficient for the Raspberry Pi.

1.1.5 Budget

At the beginning of the project, the J.U.I.C.Y. team researched the necessary components and created an initial estimated budget, as shown in Table 1. The original budget was based off the assumption that the team would be designing and 3D-printing the casing to house the electrical components.

Table 1: Proposed Budget

Quantity Needed	Item Description	Price (USD)
1	Solar Panel	$29.00
1	DC/Lithium-poly Charger	$17.50
1	Lithium-poly Battery	$14.95
1	Powerboost 500	$10.00
1	IMU	$15.00
1	WiFi-Enabled Raspberry Pi	$35.00
Unknown	3D-Printing Material	$15.00 – $60.00 per roll
	Total Estimated Cost	**$136.45 - $181.45**

1.2 Progress

This section summarizes the main work done during the first development phase. The section also describes the approaches taken to solve various problems and tasks not predicted in the original goal formulation at the beginning of the first phase.

1.2.1 Casing

The team finalized the design for the prototype case during the first development phase. The goal for the phase was to make the casing water tight and able to house all of the electronics. Figure 1 shows an outline of the shape of the casing. The grey area is were the electronics will be placed. The solar panel will eventually be secured to the top of the casing.

The bottom of the device was made water proof by securing an acrylic disk to the inside of the casing using some marine grade epoxy. During phase one the top was not made water proof yet because of complications of the design. That will be pushed into phase two of the project.

1.2.2 Microcontroller

Significant progress was made in using the sensor and microcontroller to perform remote sensing capabilities. A few different approaches were taken to perform wave detection, and the infrastructure to export sensor data for later analysis was added to provide finer tuning in the second development phase. A hardware setup was used to manually test the system, and the detection algorithm, as well as the notification and alarm response, were effectively tested.

1.2.3 Wave Detection

A few different approaches were taken to detect waves using the data available on the sensor module used in the design. The first approach sought to use the gyroscope in conjunction with the accelerometer to maintain an estimate of the orientation of the device with respect to its starting orientation. This way, the program could effectively cancel out the gravity component of the accelerometer reading, therefore only measuring disturbances from abrupt motions.

This was created with decent results, but the system was much more efficient and simple with the assumption that the sensor orientation will remain relatively constant. In other words, if the design assumed that the sensor's z-axis would always remain perpendicular to the ground, then gravity could simply be subtracted out of that axis of measurement. With a simple subtraction (instead of matrix multiplications for the orientation tracking approach), roughly the same task could be accomplished.

Because of the simplifying assumption made in the preceding paragraph, wave detections can in theory be made with simple thresholds on the accelerometer measurement magnitudes. Thresholds were discovered that performed well under manual testing (e.g. moving the sensor manually), but data exporting infrastructure was also added to allow for exporting data during in-pool testing. While these manual thresholds work well for current testing, the thresholds in the final product should correspond directly to data taken from simulated disturbances in a pool.

Notifications were tested in the same way as the detection method, and the testing setup is shown in Figure 2. The setup included a breadboard that, along with the sensor, included LED's that would light up when thresholds for the three different accelerometer axes would be met. At the same time, a call notification would be sent when one of these LEDs would go off, allowing verification of the response at the same time as the detection.

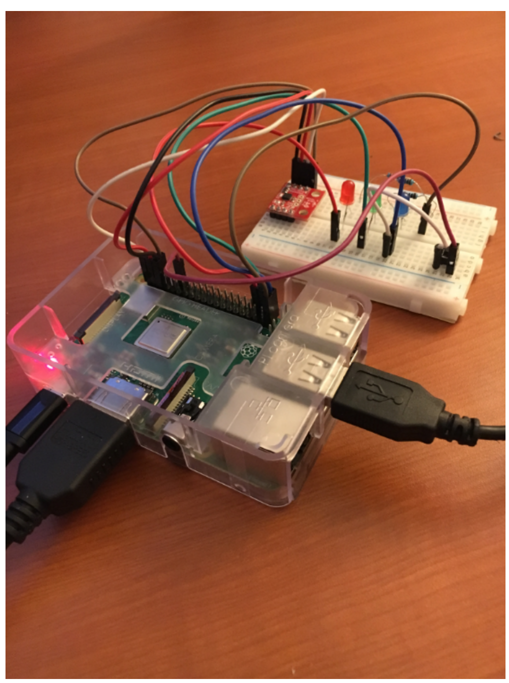


Figure 2: Testing setup used for the detection and notification capabilities of the Pi.

1.2.4 User Interaction

Similar to how data exporting infrastructure was added to the software design of the device, user configuration has the support for later integration. Currently configurations are managed in a manual, device-level interface (i.e. device terminal), but a simple web interface can be added to this to make it more viable. The end-goal for the configuration interface is to have something similar to a router configuration interface, where someone on the local network can configure the device how they want over a browser.

1.2.5 Notifications

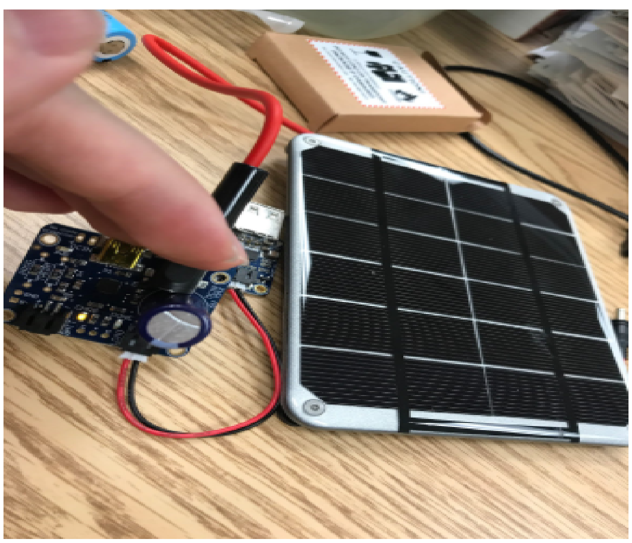
Our team was able to find two efficient ways to send real-time push notifications to desired devices. Designing an app seemed very time consuming, so instead, the team researched other methods of sending notifications from the Raspberry Pi to mobile devices. Two different applications were found - namely Twilio and Pushetta.

Twilio allows the Raspberry Pi to send API requests to the Twilio web server, in which the Twilio web server will then send a notifications via text or call. Twilio lacks in that creating these API requests costs money, which is an issue for exhaustive testing as well as any scaled product deployment.

The second alternative found was Pushetta. This application allows one to send free real-time notifications to any participant that has the app downloaded on their mobile device, and is subscribed to the channel in which the Raspberry Pi is notifying. The application is also available on both iOS and Android devices. Instead of picking one or the other, it would seem logical to have Pushetta first send notifications for a specific amount of time. If the alarm isn't reset by within a minute, the alarm system will begin to send text and calls to emergency contacts.

1.2.6 Power

All of the necessary hardware connections were made after the components were received. All the components were soldered in the PCB, but the plug of the solar panel did not fit the socket of the charger. The team found an adapted plug in the SPARC lab, which allowed the appropriate connection to be made. Figure 3a shows all components connected and Figure 3b shows the system charging a cell phone. The power system was tested with the Raspberry Pi as well.



(a) Power System

(b) Phone Charging

Figure 3: Powering a cell phone

1.2.7 Budget

After continued research on different types of 3D-printing plastics, the team decided a different approach could be better. Not only is 3D-printing expensive, but the team had difficulty finding a 3D printer that met the design needs. Also, many types of plastic 3D-printing materials are water-soluble or susceptible to damage from sun exposure, making them poor choices for the long term casing.

As a temporary solution, an off-the-shelf chlorine dispenser was modified to house the components. As shown in Table 2, the WiFi-enabled Raspberry Pi turned out to be more expensive than anticipated. This price increase can be attributed to an external casing for the Raspberry Pi. The team thought the casing was a reasonable expense, as the electrical components inside the casing need to eventually be stacked to fit. The case provides an additional level of protection to the microcontroller, hopefully preventing any loose connections or pin damage. Despite the previously mentioned minor changes, the actual budget is very similar to the original anticipated budget. The final cost of the first development phase falls within the desired boundaries of project costs, leaving the project right on track.

Table 2: Proposed Budget

Quantity Needed	Item Description	Price (USD)
1	Solar Panel	\$29.00
1	DC/Lithium-poly Charger	\$17.50
1	Lithium-poly Battery	\$14.95
1	Powerboost 500	\$9.95
1	Accelerometer	\$16.30
1	WiFi-Enabled Raspberry Pi	\$54.99
1	Chlorine Dispenser	\$9.00
N/A	Dispenser Modifications	\$0.00
N/A	Shipping Expenses	\$19.12
	Total Cost	**\$170.81**

2 Second Development Phase

2.1 Development Goals

This section describes the goals for the second stage of development. These include things like slightly revised or modified goals from the first stage, as well as newer goals meant to improve the quality and reliability of the final product.

2.1.1 Casing

For Phase two the goals of the team related to the casing are to waterproof the lid of the casing and to secure the solar panel to the top of the device. The current plan with the lid is to use some weather stripping to fill the void around the lid. This will allow the lid to still be removed while also not letting any water in. As for the solar panel, Velcro is being considered as it is not affected by water and will allow the lid to accessed under the solar panel if access to the inside compartment is needed. To test the water proofing of the case the team is buying some moister stickers to place inside the casing during testing to determine how much moisture is being let in. We will also need to find a way to allow a user to turn the device ON or OFF. LEDs will be visible to the user to indicate when the system is powered on and when it has started collecting data.

2.1.2 Testing

The majority of the testing process has been reserved for the second phase of the project. Up to this point, each component has only been tested separately. So far, the casing has been deemed buoyant and stable enough to support the electrical components without compromising the accelerometer's sensitivity. The solar panel is capable of powering the battery, which in turn produces enough energy to maintain the ON state of the Raspberry Pi, if it is already on prior to connecting the battery. The accelerometer can successfully detect manual disturbances generated by shaking the breadboard. For this initial testing phase, an LED lights up when a sufficient force has been detected in lieu of sending a notification to a cell phone. The Raspberry Pi can successfully send a text message or a phone call via Twilio, a cloud communications platform; it can also generate a push notification through Pushetta, a free service that pushes real-time notifications to a desired device or devices.

During the next phase, the device will be tested as a whole. The battery, microcontroller, and accelerometer will be safely stowed in the interior of the casing and the solar panel will be mounted on top of the casing to maximize its exposure to sunlight. Once access to an indoor pool is secured, tests similar to those conducted by the Consumer Product Safety Commission (CPSC) will be carried out. Two water-filled gallon water jugs will be tied together and used to simulate a drowning victim. The water jugs make an excellent model victim because not only are they of a similar weight to that of a toddler, but they are positively buoyant. Once dropped into the pool, the jugs will immediately sink to the bottom before slowly resurfacing, exactly as a human would. For the first test, the water jugs will be dropped into the pool within close proximity of J.U.I.C.Y. After producing the desired results, the distance between the device and the drop site will be increased, and the process repeated. Once a maximum distance between J.U.I.C.Y. and the drop site has been determined, the collected data will be examined and the sensitivity of the accelerometer will be adjusted based off of this worst case data.

2.1.3 Standards

ASTM International has produced a set of standards, ASTM F2208-08, for pool alarms. Although ASTM International lacks the ability to enforce its standards, separate organizations (i.e. governments, corporations, etc.) may declare certain standards mandatory. Alternatively, companies producing a product may voluntarily opt to comply with the latest standards either for moral or marketing reasons.

The specifications of this particular standard covers four types of pool alarms: surface, subsurface, pool perimeter, and personal immersion. J.U.I.C.Y. is different from any other pool alarm on the market today, and does not fully fall into any of the above categories. For this reason, it may be impossible for J.U.I.C.Y. to strictly adhere to the scope of the F2208-08 in its entirety.

The primary concern of the ASTM F2208-08 is the maximum volume of the alarm, as an alarm that is too quiet to be heard is not an alarm worth buying. The standard states that the pool alarm must produce an audible alert of a minimum of 85dB at up to a 10ft radius. However, in the original J.U.I.C.Y. design plan, the device itself was not intended to emit an alarm; it was to send a push notification to a cell phone, tablet, or other WiFi-enabled device, making it a less disruptive device to the surrounding community while still protecting those dearest to the consumer. With that being said, standards are in place for a reason, so the J.U.I.C.Y. team is considering adding an audible alarm to the device so that it will be ASTM standard compliant. In addition to ASTM International, several U.S. states have rules and regulations in place with the intent of preventing residential drownings. The state of Tennessee, for example, has the "Katie Beth" Law. The Katie Beth Law was put in place in 2011 after a state senator's great-granddaughter drowned in an above ground pool. This law requires all residential pools and spas greater than 36in deep be equipped with a pool alarm of 50dB that detects disturbances by objects greater than 15lbs. Other states have similar laws in place.

2.2 Accomplishments and Final Product

2.2.1 Final Casing

Accomplishments during phase two exceeded expectations set forth by the goals. The lid of a cookie jar was used as a waterproof seal around the lid that was easily removable. Velcro was used to attach the solar panel to the device on this lid. To get the power line to the insides a small hole was drilled. This hole did not cause any issues with the water proofing.

There was one minor issue with the device having a whole in the bottom acrylic sealing but was simple to patch.

The LED and button excluded from the final design. The off the shelf pool float was to cumbersome to work with in that context. The exclusion of the button required the reset functionality to be implemented in software. It uses the accelarometer to look for very large shaking before entering the reset state. During testing we found that our reset threshold was large enough to not trigger during normal use.

Figure 4: Casing for the final product.

2.2.2 Data Acquisition

One of the most important steps in the final testing period was the collection of data for determining thresholds for detection. MathWork's product ThingSpeak was chosen for the data collection, since it could be done wirelessly through simple API requests. The x, y, and z components of the accelerometer were logged separately, and Figure 5 shows the y and z components.

Not shown is the website's ability to mass export data. The plots shown in Figure 5 only show perhaps twenty or so data points per plot, while data was being collected around 960 times per second. Luckily, the API offered by the ThingSpeak platform allowed for all data ever sent to the channel to be exported as one large CSV (Comma-Separated Value) file. The exported file was used to plot the data in MATLAB and manually determine the thresholds used in the final product.

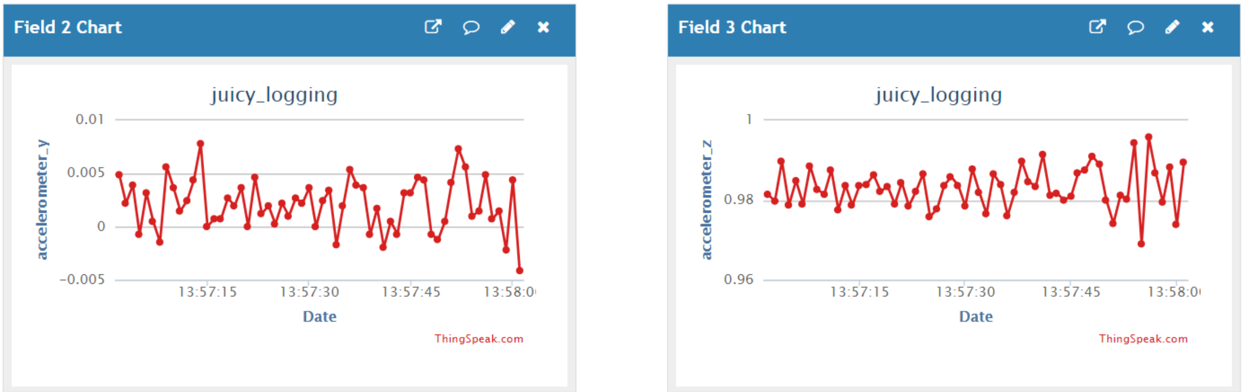


Figure 5: Image showing the y and z components of the accelerometer being logged to ThingSpeak.

2.2.3 Testing and Calibration

The data collected using ThingSpeak (discussed in the previous section) was used to determine the thresholds for the detection algorithm for the final product. As a simplifying assumption, the waves are assumed to cause primarily vertical motion in the accelerometer (z axis), so only the z-axis measurements are used for detection. MathWork's MATLAB was used to plot the data, as Microsoft Excel would crash when trying to plot around 30,000 data points, while MATLAB had no issue with several hundred thousands of data points.

Figure 6 shows a zoomed-in portion of the data captured during testing, the procedure for which is outlined in earlier sections. This is zoomed in near the beginning of the test, and the first spike in amplitude corresponds to the first water jugs being dropped into the pool from several feet away. To basically ignore the noisy measurements, only the maximum value over a window of data measurements are used to compare with the threshold. Figure 7 shows the current maximum measurement of the data in 6, while the orange line in both shows the chosen threshold. This threshold was chosen since it is essentially the half-way point between the low and high values of Figure 7. This in turn reduces the chance of false alarms while still capturing relatively low-magnitude disturbances (perhaps like a child gently falling into the water).

Based on these thresholds, a program was created for demonstration and testing purposes that used these thresholds to detect disturbances and send alarms as a response. The basic idea of the algorithm is shown in Figure 8, where the system basically keeps track of the data comparison value (which was chosen to be the maximum acceleration over a window) and constantly compares it to the determined threshold. If the comparison value meets or exceeds this threshold, then an alarm is sent out and the system waits to be reset. The reset sequence is currently a vigorous shaking of the unit, as this was deemed both effective and satisfying by the team. After this shaking, the unit waits for fifteen seconds to be placed back in the water to avoid an instant triggering of the alarm again. Once the unit is placed in the water, the algorithm begins again as though it was starting for the first time.

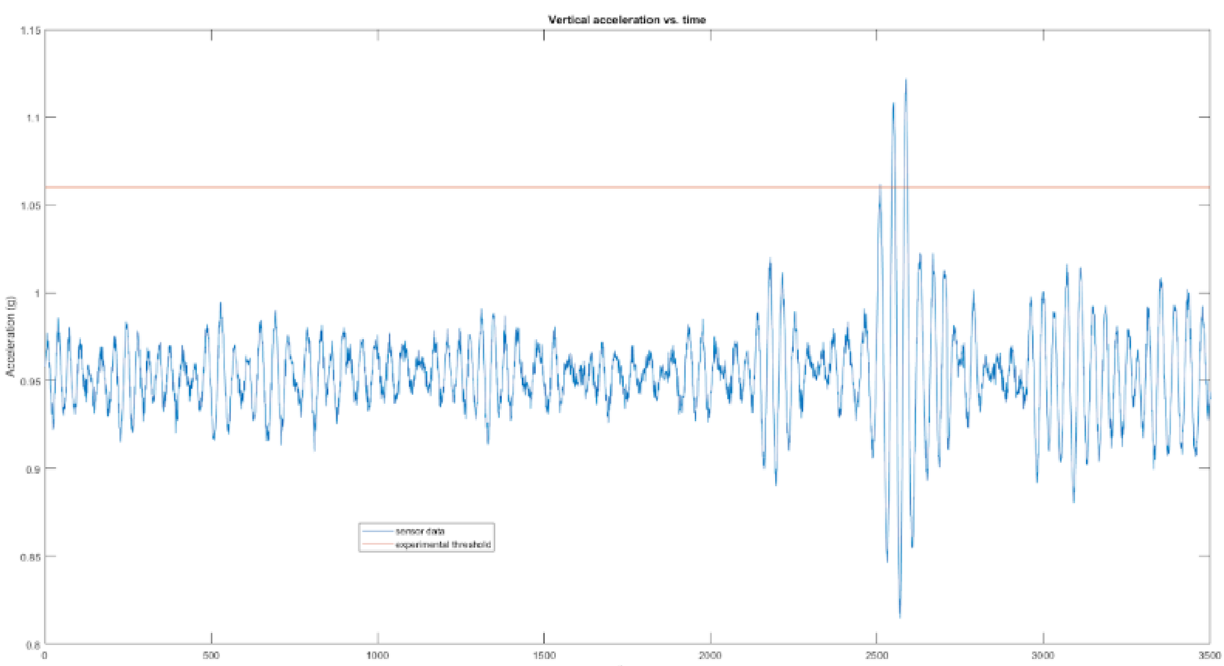


Figure 6: Vertical acceleration data captured using ThingSpeak. Data is shown in blue, and the chosen threshold is shown in orange.

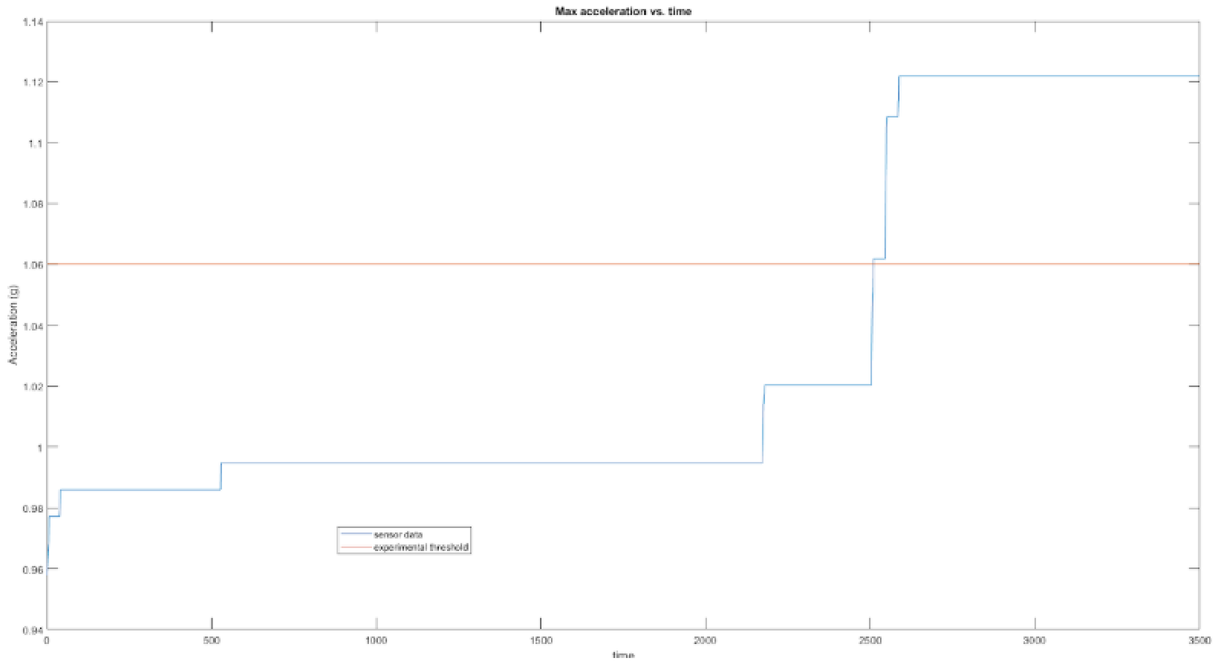


Figure 7: Plot showing the max of the vertical acceleration data, which is compared with the threshold in orange. Data is shown in blue, and the chosen threshold is shown in orange.

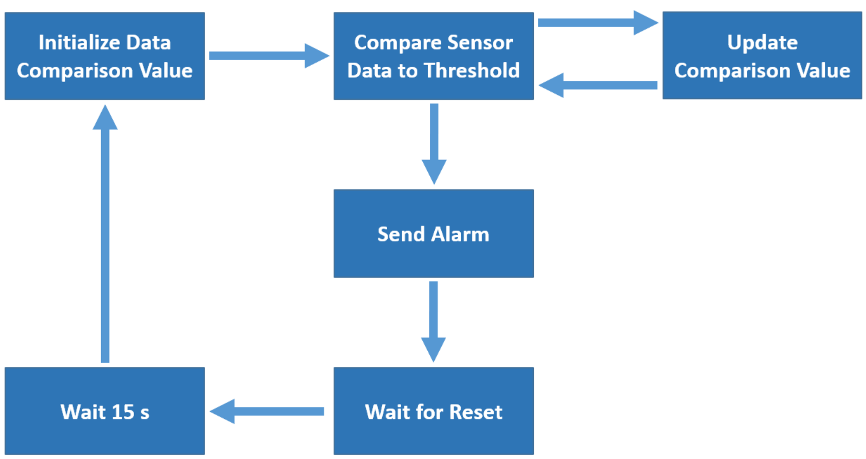


Figure 8: Flowchart showing the main points of the testing and demonstration algorithm, which would be included in the final product.

2.3 Final Cost

Overall, our team was satisfied with the final cost of our project. Figure 3 shows every component/modification required to produce to our pool alarm. If this device were to become intended for product sale, the manufacturing costs could be lowered by finding a more cost effective approach for the casing. A 3D printed case could be an alternative, based off the printing materials used.

Table 3: Total Project Cost

Quantity Needed	Item Description	Price (USD)
1	Solar Panel	$29.00
1	DC/Lithium-poly Charger	$17.50
1	Lithium-poly Battery	$14.95
1	Powerboost 500	$9.95
1	IMU	$16.30
1	WiFi-Enabled Raspberry Pi 3 B+	$35.00
1	Chlorine Dispenser	$9.00
	Chlorine Dispenser Modifications	$35.00
	Shipping Costs	$19.12
	Total Cost	**$205.81**

3 Conclusion

This project allowed each team member in our group to gain experience working in a team environment. The J.U.I.C.Y. project began by determining what role each team member would have to finish our project in a timely manner. Some members focused primarily on the casing of our device, some focused on supplying power to our electronic components, and some focused on configuring hardware components with the software application running our program. Although we finished our project by our deadline, it took a fair amount of time to piece together all of our ideas. Once we finalized how we were going to produce our device, we proceeded by ordering each component required and began to work on our assigned tasks based off what each member felt comfortable doing. We split our team into sub-teams to complete each task required, and as the semester went by, each sub-team would continue to work on their designated task and inform the other sub-teams once their task has been completed. Once each sub-team was finished, we began the testing phase. As a group, our team met at a pool, ideal to a pool that the device would be placed in, and ran multiple tests to assure the intended functionality of our device. Once we had all of the data needed from testing, we made the appropriate adjustments to our software program and later returned to the same pool and confirmed that our pool alarm was complete. Majority of our success came from having an organized way of completing each assignment throughout the semester. Aside from our actual device, our team utilized collaborative software applications such as Google Docs, GitHub, and LaTex to complete assignments such as presentations and reports. Using GitHub allowed us to maintain all of our research findings relative to our project and allowed each team member to remain updated throughout the semester to carry out our tasks effectively.

A ABET Addendums

ABET Addendum to ELEC 4000 Final Report Requirements:

As part of our ABET assessment process, each student must address outcomes (2) (4-j) and (7) in the appendix for your team's final report. The department's ABET outcome rubrics are provided. Note that each outcome has a series of performance indicators, and these are assessed using a rubric for the outcome.

Appendix A: ABET Issues – Marco A. Zuniga

(2) Apply Design: demonstrate an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

a. Use knowledge, methods, processes and tools to create a design that meets stated requirements

In designing a pool alarm, our team acknowledged that the hardware in our system needed to be protected from water damage, remain stable when placed in a pool, and assured the device was sensitive enough to detect long distance disturbances. We assured that the housing used for our electronics was completely waterproof, we created hazardous waves to assure the device would remain stable in those conditions, and we tested our device from ten feet away to assure it could detect our disturbance.

b. Evaluate if a design meets desired needs

By running multiple tests, and recreating different scenarios, and we were able to confirm that our device met all our constraints.

c. Consider realistic constraints in the design

All our constraints were followed to assure that our device met realistic requirements for what the device was meant for. It was waterproof and able to detect long distance disturbances.

d. Consider public health, safety, and welfare in the design

The purpose of our device was to assure the safety of children but could be calibrated using our testing method by analyzing the disturbance caused by people of other weights, or even family pets.

e. Consider global, cultural, social, environmental, and economic factors in the design

We designed our device to be used in a personal home. Our goal was to make the device as cost effective as possible, but also assure that the mean time to failure was reasonable by choosing high quality components.

f. Testing of the final design

We tested our device by running multiple tests. We used two gallons of water to mimic a 16 lbs. toddler and assured our device can detect when the gallons of water were thrown into a pool from up to ten feet away.

(4-j) Judgement: demonstrate an ability to make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

a. Make informed judgement

Before ordering all our components, we needed to assure that they would meet our system constraints. Each component we ordered was used for the final design and we made sure each component would deliver what it needed to for the purpose of our pool alarm.

b. judgement considers impact of solution in global context

Our device is flexible and can be used in any home pool no matter the region.

c. judgement considers impact of solution in economic context

We assured that our device would not require much to build, but also use high quality components.

d. judgement considers impact of solution in environmental context

Our device was intended for home environments. There’s nothing wrong with having extra security in one’s home, especially if a fatal accident can occur.

e. judgement considers impact of solution in societal context

The social setting shouldn’t have an affect on our device for what is was intended for. The device is intended for use when everyone in a household is inside of their home and someone has accidently fallen into the pool.

(7) Acquire Knowledge: demonstrate an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

a. Recognize the need to find information

When the semester first started, a lot of us never dealt with raspberry pis nor accelerometers. We had to look up the details of both components to contribute to both the software and hardware sides of the project. Others looked up details regarding how to power our device, and others researched what we would place our components in and whether 3D printing was necessary.

b. Acquire and organize outside information

Our team made a GitHub account to organize all relevant information for our project. This included both hardware and software documentations.

c. Assimilate and apply information

We applied all information from both the hardware and software side to make an effective device. Although it is fairly simple, we were able to have a working final project, and met all of our constraints.

ABET Issues – **Joe Driscoll**

(2) Apply Design: demonstrate an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

a. Use knowledge, methods, processes and tools to create a design that meets stated requirements

The software team combined knowledge of software development, embedded development, and sensor use to combine one of the primary components of the project – the detection and notification sending. Likewise, the casing and power teams respectively used their knowledge of materials, aesthetic design, and power electronics to design the case, its waterproofing, and the power electronics to connect the solar panel and battery to the microcontroller. All of these things combined to create the final product, so the team certainly did each of these things effectively.

b. Evaluate if a design meets desired needs

Care was taken to verify that the product met existing, established standards on what such a device should do. In addition to this, the progress of the device at any time was constantly scrutinized for how well it met the team prescribed needs and design goals.

c. Consider realistic constraints in the design

Various realistic design constraints were taken into consideration in the development of the product. Extensive care was taken to waterproof the case to account for possibly bad weather and rough water conditions that could compromise an otherwise mediocre waterproofed case. Sustainability and longevity of the product was also taken into consideration, leading the inclusion of a solar panel for long-term use and sustainable charging. Price was a major factor considered too, and this led the team to repurpose cheaper materials (like the lid of a cookie jar and a chlorine dispenser) for the case, as well as use the least expensive devices possible, leading to the choice of microcontroller and sensor.

d. Consider public health, safety, and welfare in the design

All of these things were considered in the design, as the product was created specifically to address public welfare, safety, and health. The product was created to save children, pets, or other things that can fall into a pool and be subject to danger. Because of the purpose of the project itself, all of these things were considered and certainly met in the design.

e. Consider global, cultural, social, environmental, and economic factors in the design

Global factors were somewhat considered, since pools are relatively common throughout the world, and with pools comes unwanted mortality risks like children or pets falling into the pool. Cultural and social factors were considered in that this problem is somewhat common in the United States, making the product more specifically suited for the social and cultural climate of the country. Environmental factors were considered in the inclusion of a solar panel, since sustainable power makes the product long-term and cleanly powered. Economic factors were also considered, as discussed early, because cost was considered by the team in the development of the project. This consideration, as well as the desire to only drive down its price for consumers and production, make the cost of the product a major consideration of the team.

f. Testing of the final design

Extensive testing of the design was done for fine-tuning the thresholding parameters of the detection algorithm. Several tests were done, and the results of these tests exactly met the team's expectations for the final product. To attest to the efficacy of the project and the testing done to verify it, videos of the testing procedure were shown and well-received by an audience, who agreed that the product worked as designed.

(4-j) Judgement: demonstrate an ability to make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

a. Make informed judgement

Informed judgements were made in the design of the product, as well as team decisions regarding the design of various, specific components of the product. Much of this can be seen in the testing and detection performance goals, since extensive research was done on pool alarms and the standards for the evaluating the performance of such devices. Care was taken to constantly modify the design to meet these standards, and many parts of the design demanded difficult compromise to do so.

b. judgement considers impact of solution in global context

The purpose of the product and verifying that it meets constraints addresses a global context, since the product is meant to be used in any pool around the world. The verification that it

works ensures that it can be used in a global context, and the development of a pool alarm is in and of itself a global consideration, since it addresses an essentially global issue not restricted to only the United States.

c. judgement considers impact of solution in economic context

Nearly every aspect of the design took into account an economic judgement, as the team only had their own money to use. Various, cheaper parts were purchased and repurposed to save money, and the least expensive components for each part, such as the microcontroller and sensor, were used instead of better-performing, more costly parts to save money.

d. judgement considers impact of solution in environmental context

The waterproofing and inclusion of a solar panel both address environmental concerns. The waterproofing ensures that the product performs well in harsh environmental conditions, such as inclement weather. The solar panel ensures sustainability and the ability for the product to acquire power in a clear way that leaves no carbon footprint.

e. judgement considers impact of solution in societal context

Again, the product itself is meant to have a societal impact in that it is meant to alleviate the serious dangers that come from having a pool. Infant and pet mortality is certainly a social issue, since both of these entities heavily contribute to the fabric of society. Because the product attempts to prevent these issues, it directly seeks to impact society.

(7) Acquire Knowledge: demonstrate an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

a. Recognize the need to find information

The team certainly recognized what information was known and what information was not known. Even for topics that the team had extensive experience in, the need to research the best way to do it (rather than settle for the easy, already-known way) was heavily taken into consideration by each team member. For the information not known, such as good waterproofing approaches and techniques, extensive time was taken to learn the common methods and techniques and apply them in a meaningful way. Overall, the team effectively

analyzed the information needed for the product, and care was taken to acquire the best information for each part.

b. Acquire and organize outside information

Extensive research was done on basically all parts of the project, and nearly all of the design and reference manuals were included in a large wiki page, hosted on the team's GitHub repository. This wiki-style reference site allowed information to be incrementally acquired and organized in one place, allowing ease of access and retrieval of information. This also allowed individual teams and team members to contribute to the front of information, since version control allows independent changes to the wiki itself. This organization allowed extensive research to be done and analyzed for the project.

c. Assimilate and apply information

Various standards for pool alarms were researched and gathered to steer the direction of testing and design constraints. Also, the various hardware components and their interconnections were researched to ensure the correct interoperation between them, as well as their fast, power-efficient operation. On the software side, many detection methods and tools were researched to include in the product, such as various techniques for sending wireless notifications and how to best use sensor data. The casing team had to find brand-new information in the realm of waterproofing a case, since all of the case team were computer engineers who had to acquire this information with no prior knowledge of it. In all, the large amounts of information that were collected for the project were collected for a reason, and each piece of information was in turn used somewhere in the final product.

Appendix A: ABET Issues – William Graviett

(2) Apply Design: demonstrate an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

a. Use knowledge, methods, processes and tools to create a design that meets stated requirements

Throughout the semester we used many things in order to get a working device at the end of the semester. We had to make very strict criteria to ensure every team member was on the same page and to ensure when we got to the end of the semester we would have clear proof that either the device worked or not. Lots of research was done when deciding what the criteria would be for this project. We had to figure out what type of devices where out there and why they were not being used in order to safe the life's of the 3000 kids that were drowning every year.

b. Evaluate if a design meets desired needs

The design meets all the needs specified at the beginning of the semester and almost all qualifications for the CPSC but does not have the audio alarm that is required. We tested our device in a pool using the testing standards for similar devices, which proved our device worked as intended.

c. Consider realistic constraints in the design

There are a lot of constraints in the design and mostly because of choices that the group made at the beginning of the semester. One constraint was the constraint of buying a premade case instead of the original idea which was to design and print a case using a 3D-printer. Another one is the size of the solar panel: including the voltage and amps it provides. This would have been more important if we would have added an audio alarm on the device.

d. Consider public health, safety, and welfare in the design

The device is designed to detect when a child falls into a pool. Since this is a growing issue in the US because of the increase of home pools, devices like this are even more important.

e. Consider global, cultural, social, environmental, and economic factors in the design

Our device is very environmentally friend because of the solar panel that is used to power the device. Because of this solar panel it requires no outside power source which makes the device self-sustaining. It also has a huge social impact because of the purpose of the device as described above.

f. Testing of the final design

To test the final design the device was taken to a teammates pool and put through a variety of tests to insure correct functionality. We used two one-gallon water containers to simulate a toddler around the size of 16 pounds. Then we threw them in about 10 feet away from the device and looked to see if a phone that was connected to the device got a notification. We also tested the device by just setting the containers into the water to simulating a toddler crawling into the pool.

(4-j) Judgement: demonstrate an ability to make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

a. Make informed judgement

Every decision that was made in the making of the device was for the improvement of not just the product but for everyone and everything that would be affect by the making of this product. The biggest example of this was the decision to install a solar panel to the top of the device.

b. judgement considers impact of solution in global context

This device was made to impact the world in a positive way. We as a group saw that there was way too many children dying in preventable pool drowning and we hope we made a device that would help decrease this.

c. judgement considers impact of solution in economic context

We tried to make the device as economical as possible, and if this was a device that we decided to make a product based on there would be many places that we could save money to make sure anyone who wanted the device would have it so that it could safe more and more life's.

d. judgement considers impact of solution in environmental context

The solar panel is the biggest example of the positive impact this device has on the environment. Though if we had more time we could also have made the decision to make a case with recyclable material so that it would be even more friendly to the environment.

e. judgement considers impact of solution in societal context

This product was originally designed to fix a societal problem we thought could easily be fixed. After the final testing I know that if we made this into an actual product it would safe life's and give pool owners peace of mind.

(7) Acquire Knowledge: demonstrate an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

a. Recognize the need to find information

In planning to make this device all group members had to do a lot of research on their part of the product and then bring their findings to the group for discussion. This was a crucial to making the device the best it could be in all aspects.

b. Acquire and organize outside information

Throughout the making of the device research had to be done in order to ensure that changing one thing, like how we had to change the idea of how to make the case, didn't affect any other part of the design.

c. Assimilate and apply information

Doing research throughout the making of the device was crucial in the end product working so well. If that would not have happened there is a good chance that when we got to testing something would not have worked correctly.

ABET Addendum to ELEC 4000 Final Report Requirements:

As part of our ABET assessment process, each student must address outcomes (2) (4-j) and (7) in the appendix for your team's final report. The department's ABET outcome rubrics are provided. Note that each outcome has a series of performance indicators, and these are assessed using a rubric for the outcome.

Use the following format (without the italicized comments):

Appendix A: ABET Issues – Matthew Cather

(2) Apply Design: demonstrate an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

a. Use knowledge, methods, processes and tools to create a design that meets stated requirements

Without prior experience from classes it would have posed a large challenge to determining a solution to the problem. It also took complete cooperation of the team to keep on task and finish goals on time.

b. Evaluate if a design meets desired needs

Postmortem, the design does not meet all the requirements set forth in the original project plan but did provide a suitable experience in managing people and staying on a time schedule.

c. Consider realistic constraints in the design

The design in it current form is limited to pools with suitable wifi connections. It also requires that someone will check their phone when the alarm goes off whether they are able to respond or not.

d. Consider public health, safety, and welfare in the design

I believe that more work on devices like this one would improve public safety. It has a large application to both private and public pools.

e. Consider global, cultural, social, environmental, and economic factors in the design

I believe that the design on a global scale would only apply to places with an easily available wifi signal. bu would have a positive social impact on those regions.

f. Testing of the final design

Testing of the final design focused primarily around functionality of the device. Does it float? Does it detect waves? etc. This was does using methods similar to the national standards mentioned in the report.

(4-j) Judgement: demonstrate an ability to make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

a. Make informed judgement

The system being constrained by the case required an informed designion on the size of electronics inside the container.

b. judgement considers impact of solution in global context

The decision to use wifi was because of the ubiquitousness of the connection. Other forms on wireless transfers were considered but were not a ubiquitous.

c. judgement considers impact of solution in economic context

The cost of the device was a consideration because other solutions found during the research phase were very expensive and we determined that a lower cost safety device would benefit everyone.

d. judgement considers impact of solution in environmental context

Other than the effects of the environment on the device, the environment was not considered during most of the process. We were more concerned with the design surviving the elements that the designs effects on the environment.

e. judgement considers impact of solution in societal context

The design was chosen because the device would be a benefit to society.

(7) Acquire Knowledge: demonstrate an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

a. Recognize the need to find information

The project started with the need to identify if and what the standards for a pool alarm would be. Once identified those were applied to the design to help give goals to the project.

b. Acquire and organize outside information

Several different standards were found during the research phase. Theses were combined into a single list of goals to meet.

c. Assimilate and apply information

Taking the national standards for pool alarms, the tests were designed to emulate their testing procedures. Then comparing the the expected outcome of the national stands to results would help identify how the design would compare to the real world.

Appendix A: ABET Issues – LaShae Timmerman

(2) Apply Design: demonstrate an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

a. Use knowledge, methods, processes and tools to create a design that meets stated requirements

At the beginning of the semester, certain criteria were decided upon by the team as a whole. Every effort was made throughout the course of the project to adhere to these criteria.

Research was done at each stage of the project to ensure that the necessary knowledge was available to the team. The team regularly followed the proven methods of the scientific process to produce consistent results during each testing phase. Tools were handled carefully and responsibly so that no injuries occurred to the team members, nor any damage to the product.

b. Evaluate if a design meets desired needs

Thorough testing at the final stage of the project proved that the design met the desired needs outlined at the beginning of the project.

c. Consider realistic constraints in the design

Certain constraints were created during the initial design phase of the project, as well as needed at certain subsequent stages throughout the course of the project.

Testing constraints included:

- using an indoor pool to eliminate the need for weatherproofing the design
- narrowing the project focus to young toddlers to eliminate the need to test with multiple weights
- purchasing an off-the-shelf case to remove the steps required to design and produce the case

d. Consider public health, safety, and welfare in the design

The device was created with the intention of reducing or eliminating the number of injuries and deaths per year in residential pools. Every caution was taken to prevent harm to those using the device. A reliable alarm system was used to alert a caretaker to the potential presence of their charge in a body of water. All components were thoroughly researched to make certain that they were safe for immersion.

e. Consider global, cultural, social, environmental, and economic factors in the design

Thanks to the attached solar panel, the device is self-sustaining. It requires no outside power source, nor does it produce any form of pollutant. The device is globally applicable, as there are thousands of water-related deaths and injuries around the world each year.

f. Testing of the final design

The final design was tested at a local pool under multiple conditions. Data produced from the testing was recorded and carefully analyzed to determine whether or not the device met the standards set forth by the team. After analyzing the data, any necessary adjustments to the design were completed before retesting.

(4-j) Judgement: demonstrate an ability to make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

a. Make informed judgement

Every decision throughout the course of the project was made with the betterment of society in mind. This product was created to help families make their pools a safer place, and that goal was kept in mind at all times.

b. judgement considers impact of solution in global context

This product is a simple concept that can be utilized anywhere a WiFi connection is available. Although WiFi is not yet available in every household around the world, it is readily available in many communities, with more gaining Wifi connectivity every day.

c. judgement considers impact of solution in economic context

Every effort was made to keep this device as cost-efficient as possible. If the device were ever mass-produced, the price would, of course, drop even further.

d. judgement considers impact of solution in environmental context

The product is very environmentally friendly. No harmful plastics were used in the design, so water contamination is not a concern. The solar panel that charges the internal battery allows the device to be self-sustaining, as well as eliminates the need for harmful, and often more expensive, methods of powering the device.

e. judgement considers impact of solution in societal context

This device’s ability to prevent death or injury around private pools makes it very societally-friendly.

(7) Acquire Knowledge: demonstrate an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

a. Recognize the need to find information

This project required the team members to use several materials and tools that had previously never used. It was necessary to do adequate research to learn how to safely handle all necessary tools and materials.

b. Acquire and organize outside information

Research was done throughout the course of the project to make certain that all aspects of the product were functioning as well as they possibly could. Several factors were considered for each component, including cost, durability, and accuracy.

c. Assimilate and apply information

Information gleaned from the research and design phase of the project was applied wherever necessary at every stage of the project.

ABET Addendum to ELEC-4000 Final Report

Kaidi Ding

kzd0028

(2) Apply Design:

a. Use knowledge, methods, processes and tools to create a design that meets stated requirements:

Our team's objective is to create a motion alarm device which can send an alarm signal when child has fallen into a swimming pool. This pool alarm device that can recognize a specific change in movement (acceleration) and send an alarm signal to a synchronized device.

b. Evaluate if a design meets desired needs

In our tests, our pool alarm can accurately detect disturbances from up to 10 ft away, also can successfully transmit notifications to multiple devices.

c. Consider realistic constraints in the design

1. The case of our equipment was not specifically designed for the alarm system, so lasting waterproofing cannot be guaranteed in practical applications.
2. In real life, there could be more noise that could interfere with our alarm system. For example, a splash of water from an adult swimming freestyle may alarm our system.

d. Consider public health, safety, and welfare in the design

From the statistic we can know, drowning is the leading cause of death in children under age 5. There are approximately 350 deaths per year, and 2,200 children treated annually for submersion accidents. The alarm system can warn the children when they fall into the water, thus reducing the death rate of drowning babies.

e. Consider global, cultural, social, environmental, and economic factors in the design

Our device can also help the government to early alarm the sea disaster, such as Tsunami. If our alarm system is accurate and collects enough data, we can use it to detect special fluctuations in the sea level to give early warning of a tsunami. Our alarm must be placed in strategic locations, such as seismic belt. It is important that the devices are near enough to earthquake epicenters. When earthquake occurs, our devices can immediately warn the department.

f. Testing of the final design

We test our device by running multiple tests. We used two gallons of water to simulate a 16-pound weight and dropped it into the water at 10 feet. Through experiments, we concluded that our device could detect when heavy objects fell into the pool and successfully send notifications to mobile devices.

(4-j) Judgement:

a. Make informed judgement

Before we were ready to start our design, we had already divided up the different parts. Everyone has his or her own special job. We put together the idea of each person being responsible for their own part, then carried out a feasibility study, and finally came up with our design idea.

b. judgement considers impact of solution in global context

Our device can be used in any public or personal pool.

c. judgement considers impact of solution in economic context

Our design does not contain very expensive parts, so the cost is not very high. The function can reduce the drowning rate, so our products are cost-effective.

d. judgement considers impact of solution in environmental context

Our equipment is mainly purchased for the family, which is why his cost and price are not too high.

e. judgement considers impact of solution in societal context

Protecting children from drowning increases societal happiness, which in turn makes families more stable.

(7) Acquire Knowledge:

a. Recognize the need to find information

During the semester we realized that being able to achieve complete waterproofing will be an important factor in the success of our design. We consulted the professor and inquired about some of the information on the Internet before we got the current design.

b. Acquire and organize outside information

Our team organize all information through GitHub.

c. Assimilate and apply information

It is the first time, I tried a product that I was responsible for, from design to production, which I learned a lot from professors and the Internet.

ABET Addendum to ELEC 4000 Final Report Requirements:

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Use the following format (without the italicized comments):

Appendix A: ABET Issues – Viraj Patel

(2) Apply Design: demonstrate an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

- The design project me and my team came up with was a "J.U.I.C.Y: Pool Safety Alarm". On conducting our research, we found that there are significant amounts of death that happen each year due to drowning in a swimming pool. One of our most important goal for our project was to detect if a child/toddler of around 16 pounds' weight is detected, if he/she falls into the pool. Few of the constraints we ran into were:

  - How would weather affect stability of our device.

  - How would we make the device waterproof, with all the electronics installed inside.

  - How would we power the device.

  - How would we communicate with the device once left in the water.

All of the above mentioned constraints were effectively considered while designing the device. We also made sure that our device is safe for the people to use, and will in no case harm the environment. We our device was also powered by solar energy which is a renewable source of energy, which makes it cost effective and self-sufficient. We tested our final protocol for its stability, water resistance, power and communication by exposing it to all kinds of different situations in a medium sized swimming pool.

(4-j) Judgement: demonstrate an ability to make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

- During the course of the project, it was often, that we had to make judgements with respect to designing the device, and at the same time, we also had to make sure that our judgements don't impact the community, and economy in a negative manner. Due to rising importance of using renewable energy, we planned to make our device solar powered. Our device is small, simple and easy to use and set up, it sends notification directly to your phone in case of emergency, which most people would prefer to have. In no case our solutions to various constraints of the device will have negative effect on the society or environment.

(7) Acquire Knowledge: demonstrate an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

- Our entire project was based upon researching and implementing the research to get the desired output. Today all of the information is readily available on the internet, so when researching it is very important to identify the source of the information, and check if the source is valid and appropriate. Our research mainly included scholarly articles, which are valid sources. Once all the research was done, we organized it based on design, software and hardware, which made it easier for us to implement it, without creating much chaos and confusion.