## **Purdue ECE Senior Design Semester Report**

## **(Team Section)**

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| **Course Number and Title** | ECE 47700 *Digital Systems Senior Design Project* |
| **Semester / Year** | Fall 2021 |
| **Advisors** | Mithuna Thottethodi and Phil Walter |
| **Team Number** | 8 |
| **Project Title** | Sink or be Sunk |

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| Senior Design Students – Team Composition | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Mitchell Arndt | EE | Server Software / PCB | Fall 2021 |
| Mary Arito | CompE | PCB Hardware | May 2022 |
| Joseph Mislansky | CompE | System Integration | May 2022 |
| Garrett Brillhart | CompE | Embedded Software | Fall 2022 |

**Project Description:** Provide a brief (2-3 page) technical description of the design project, as outlined below:

1. Provide a general description of the product to be delivered by this design project.

## Sink or be Sunk is a modern take on the old-school game of Battleship. Inspired by the lack of in-person connections allowed during the pandemic, Sink or be Sunk is designed to be played by anyone, anywhere. Using Wi-Fi, users connect to the internet to be able to play online against their friends on a physical board.

## This board also includes audio and visual enhancements to the original Battleship with light-emitting diodes (LEDs), a speaker, and a rumble motor. The user interacts with the game through a keypad and liquid crystal display (LCD) as well as physical boards that are placed on the board. The LEDs replace the hit and miss pegs that are in the classic version of the game and the keypad are how the user enters the attack locations. The game also includes an online version so that a user could play with someone else that does not have a board.

1. What is the purpose of this product? For whom is it intended?

## The purpose of this project is to improve and modernize the existing game of Battleship for the 21st century. During the peak of the COVID-19 pandemic, isolation was a big part of life so any solutions that allowed people to connect from a distance were important. Building off the desire to make a game, Battleship was chosen as a fun game to add distance capabilities as well as other enhancements.

## This product is intended for anybody and everybody. It is designed so that children can play it as it is durable and has a simple, easy-to-use design. Younger audiences may need help creating an account (especially with laws for online account creations for those under 13) and connection to games, but they can easily play the game on their own. The game even improves upon the original Battleship in this as there are no pegs and small boats that pose a potential choking hazard.

1. Describe how the engineering design process used to create your product was utilized in this project. Include how you were able to develop and conduct appropriate experiments, analyze and interpret data, and use engineering judgment to draw conclusions related to the development of your product.

## Throughout the entire project, the engineering design process was used to create the product. We began over the summer and at the beginning of the semester by doing individual and group brainstorming sessions to pick out a project idea and narrow down our PSSCs. Then as the semester went on, we continually iterated through different design ideas for specific components of our project. For example, we began with the idea of creating our keypad for entering coordinates to attack but then realized through idea evaluation techniques that this method would require a lot more work, time, and money than using an existing keypad that we had. While we had to be more creative about how to use the 16 buttons that we had instead of making as many buttons as we needed, this turned out to be a much simpler solution than our original idea.

1. Describe the design constraints, and resulting specifications, incorporated into your product (list a minimum of 3).

## One of our design constraints was time. This project was only a semester-long so it was known that the idea could not be too complex, while still needing to be sufficient for a senior design project. Creating a board game based on an already existing game cut down on game development time and let the focus be on hardware and software design. This was also incorporated through the physical implementation. The PCB for the grid was the same for the top and bottom even though the top did not need the boat insertion components. Creating the same PCB cut down on design time and eventually production time as the soldering process was the same.

## Another design constraint was portability. One of the major components of the game was the necessitation to be able to play it anywhere. This was incorporated into the product in multiple ways. The first and most obvious was through the ESP32. This enabled the device to be able to be used anywhere that there was an internet connection. Another way this constraint was incorporated was through its casing. It comes in a briefcase styled package so that it can be easily transported, and it also has a low weight.

## A final design constraint was cost. As a game designed for anyone to be able to play, it was important that the product would be affordable. While this project was a prototype and not a final mass-produced product, a low cost was still very desirable. The budget provided by the ECE department was $425. One way this was incorporated was through the LEDs. The original idea was to take existing LED strips from the market and cut them up to use in the design. However, when the cost was realized, it was too high to keep total costs low. Alternatives were explored and SMD LEDs were chosen with the same capabilities, but lower costs and power needs.

1. Describe how each of the following factors influenced your design specifications and constraints.

## **Public Health, Safety, and Welfare:** There were no major reasons that these factors influence the design specifications. However, as a game that can be played by younger children, the pieces were fabricated so that they were large enough to not be choking hazards. This product was also an improvement over the existing Battleship because it does not have the small pegs.

## **Global Factors:** Although our design was primarily driven by other factors, we took into account global regulations, specifically the CE (Conformité Européenne), whilst determining our target market. This way, our product can be more widely produced and available to the public. Additionally, due to the differing restrictions from the COVID-19 pandemic, it was critical for our design to be able to adhere to all social distancing policies around the world, hence why our design uses WiFi instead of something with a smaller range, such as Bluetooth, for connectivity.

## **Cultural Factors:** Our team strived to make our game as universal as possible by avoiding usage of culturally dependent identifiers. For instance, not naming the boats specifically after a historical or culturally known ship. We decided to use English for our website and LCD display, however once the game is actually started, the gameplay does not depend heavily on reading since the LEDs identify hits and misses. In this way, players with different language backgrounds and levels of understanding are still able to play competitively.

## **Social Factors:** By including a website option, even players without a board are able to those with a board, thus making it more affordable and available for a variety of users. Additionally, it was critical for our design to include the aspects of finding, adding, playing, and inviting other players. This ultimately helps to accommodate distant friends and family, and thus maintain distance relationships in a new, invigorating way.

## **Environmental Factors:** Cognizant choices were made during design to ensure that the product would be environmentally safe. Lead-free solder and PCB were used, and the product was designed to use low power while still ensuring all functionality exists.

## **Economic Factors:** The design was made with low costs in mind so that if the product was ever mass-produced, it could be an affordable game that anyone could purchase. Additionally, players have a reduced-cost option of buying just one board and their opponent using their personal computer.

1. Describe the appropriate engineering standards incorporated into the creation of your product.  
     
   The project utilizes components and equipment that have been verified by IEEE, FCC, and other regulatory bodies. The ESP32 transmits in the 2.4 GHz band, following Bluetooth Low Energy and WiFi standards. Using the MILSPEC for Reliability Prediction of Electronic Equipment, we have determined that the product is unlikely to have components fail, using the prediction formulas to determine a low rate of failure. The consequences are also low, with no risk to the user besides in the unlikely event the power adapter and battery catastrophically fail and cause a fire. Our PCB boards are also lead free and are safe to use with no risk of the user being shocked or being hit with dangerous substances.
2. Describe the final status of your product.

The final project is a briefcase that includes a fully functional Sink or be Sunk game board. This game board connects to the internet where the user can create an account to add friends and start new games. There is also an online version of the game that can be played with the physical product.

1. Describe the makeup of your project team and how you were organized to establish goals, plan tasks, and meet the objectives of this project.

## The team is made up of four individuals all in the school of ECE. Three students are computer engineering students and the fourth is an electrical engineering student. Loosely defined roles were put in place at the beginning of the semester concerning hardware, software, and systems, however, these roles evolved. The team met multiple times over the summer to set goals for the project and continued to do so in lab sessions as well as outside of class.

1. Did your project require the production of any written documentation other than this document (i.e., manuals, educational materials, etc.)? If so, describe the types, composition, and nature of the audiences for whom these materials were intended.

## Throughout the project, many different papers were created to document the design process and decisions made. These documents were written professionally to provide an archive of the work done as well as present to course staff the progress being made so that they could ensure the project was manageable and on track for completion.

1. Describe the types, composition, and nature of the audiences in attendance for the final oral design review. Discuss how you prepared for this audience.

## The nature of the audience for our final oral design will include professors of the ECE department and course staff, including the graduate teaching assistants and possibly some peers in ECE 477 as well. The audience will be well versed in Computer and Electrical Engineering, and should be able to understand technical concepts well. The nature of the presentation is formal and as an overview of our full project.

## **Purdue ECE Senior Design Semester Report**

## **(Individual Reflections Section)**

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| **Course Number and Title** | ECE 47700 Digital *Systems Senior Design Project* |
| **Semester / Year** | Fall 2021 |
| **Advisors** | Mithuna Thottethodi and Phil Walter |
| **Team Number** | 8 |
| **Project Title** | Sink or be Sunk |

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| Senior Design Student Completing This Section | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Mitchell Arndt | EE | Server Software / PCB | Fall 2021 |

**Individual Reflection:** Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

1. Describe your personal contributions to the project.

## For this project I was primarily in charge of the development of the high-level server code; however, I also worked on embedded software and PCB design. On the server-side of the project, I wrote all the TypeScript code to create the server. The server’s leading role is to handle incoming requests from the game console (ESP32). These requests range from a player’s request to attack a certain location on the game board to a player's request to get their friend list from the server database. This hints at the server’s role in storing and handling user accounts that link to a certain game board. The user account is handled through a webpage that is hosted on the cloud at the following URL (<http://sink-or-be-sunk.herokuapp.com>).

## In addition to the server, I also worked with Garrett to develop our embedded software. I created abstracted classes in C++ which had various roles in the project. For example, I created an LED Manager class which is responsible for configuring the GPIO for the required timing for our LED ICs, generating an RTOS task for the LEDs to run, and various function calls for starting/stopping the LED light show sequence.

## The next area that I contributed to this project was the PCB design. I worked closely with Molly on the schematic design and the place and routing of the two board designs. While developing the embedded software, I prototyped out the circuits that I then added to our KiCAD PCB. This allowed me to have great confidence that the design would work after fabrication as we already had a working prototype.

1. Describe how your contributions to this project built on the knowledge and skills you acquired in earlier coursework.

## This project truly challenged me to integrate all the knowledge that I have gained at Purdue through coursework and extracurriculars. The most notable course that I drew knowledge from was ECE 362. Other than the obvious draw from the experience of programming a microcontroller, the skill of reading datasheets was far more beneficial. When developing the PCB, it was crucial to understand how to approach the datasheets that provide an avalanche of information. Additionally, ECE 362 set the foundational building blocks of problem-solving with complicated circuits. I learned to develop a methodology for debugging circuits where I had no idea of the core issue. These skills were immediately useful when debugging our PCB when it just would not work. I was able to take a step back and work through the various subcomponents of the design to eventually catch the issue and fix it.

1. Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

## When developing the server, I was able to draw on some experience in programming in JavaScript; however, this task provided the unique challenge of doing something that I had never done before. I find that the best way for me to learn new topics is through immersion. I spent most of my time working on the server code not writing the code but learning how. To do this, I watched many YouTube videos and spent time pouring over online forums where novice programmers were solving the same issues that I was having. The best learning strategy for me was simple perseverance and determination to succeed.

1. Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

## Throughout both the hardware and software design for this project, I came across many resources and libraries that held useful knowledge that could directly be used in our design. In many instances, these resources held open-source licenses which meant that ethically I could take this code/hardware design and directly use it by giving credit to the designer. This was not true for all designs. I came upon some code where licensing was ambiguous, and I made sure to steer away from these for the express purpose of keeping our project fundamentally ours and keeping our ethical records as a team clean.

1. Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgment as to your product’s impact in each of these four contexts?

## This project is a straightforward consumer electronic recreational device. It would fall in the same category as any gaming console such as an Xbox or PlayStation. Because of this, should the team decide to bring this product to market, we would directly be competing in a giant industry with large and powerful players. This could have interesting economic effects should the venture be a success. If a small startup company can challenge billion-dollar electronic corporations, this would open the door for similar companies to follow and change the landscape of a vast industry. Furthermore, this project can have a more focused impact on how people interact on the internet. The game board provides a physical, tangible connection to an online environment. In the era of Covid, this allows for safe play with friends; however, the ramifications of this go far beyond. One only needs to look at Tech giant Facebook (Meta) with its recent announcement of the Metaverse which is a different approach to this same issue of merging the virtual world with the physical. With this project, there is an opportunity for creating new ways for people to interact in an ever-expanding global community.

## **Purdue ECE Senior Design Semester Report**

## **(Individual Reflections Section)**

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| **Semester / Year** | Fall 2021 |
| **Advisors** | Mithuna Thottethodi and Phil Walter |
| **Team Number** | 8 |
| **Project Title** | Sink or be Sunk |

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| Senior Design Student Completing This Section | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Mary Arito | CmpE | PCB and Hardware | May 2022 |

**Individual Reflection:** Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

1. Describe your personal contributions to the project.

## In developing Sink or be Sunk I contributed to multiple aspects, in multiple ways; initial PCB development, component ordering and assurance, 3D printing, and soldering. For the initial PCB development, I helped create and verify some of the schematics for our subsystems, and organize them on our PCB layout. Mitch was critical to our PCB design and helped me familiarize myself with KiCad, as well as the necessary steps for PCB design (such as reviewing component inputs/output values, determining trace widths, and heat considerations). On top of this, I did calculations to verify which traces had the most current and made estimations regarding their trace widths. During this time, I was also ordering components and managing our team’s budget; since I work in the ECE shop I was able to identify components already available to us and reduce some of our spending.

## Throughout this semester I was also responsible for the creation and design of the boats themselves, which I 3D printed with a semi-clear filament for luminating effects. In creating the boats, I used a design from an open-source website and modified it with OnShape to best fit our game. From there, I created the boat pegs themselves and began securing them in the boats. The boat printing process took many iterations to ensure the proper spacing of the peg holes beneath, side thickness for stability, and sizes for general aesthetics. Creating the boat pegs is a very lengthy process involving cutting and sanding protoboards to fit within the boat then soldering 4 male headers into them creating a short across all pins.

## Once our PCBs arrived, I was responsible for a large portion of soldering both the main boards as well as the grid boards. The main boards were all hand-soldered whereas the grid boards I was able to use a stencil and place into the oven. Further, I helped teach a couple teammates how to use the solder stencils. Once the grid boards were fully implemented, I retouched many of the solder joints and debugged a few of the boards. As for the main boards, Mitch and I worked closely in the debugging and last-minute problem solving: rearranging the pins on the ESP32 for the keypad, motor, and LCD subsystems, creating a fly-wired bypass of the USB to Serial chip subsystem.

1. Describe how your contributions to this project built on the knowledge and skills you acquired in earlier coursework.

## Something I thoroughly enjoyed about this project was the opportunity to combine a lot of the knowledge I have acquired throughout the past few years. For instance, I had learned how to solder primarily because of my working in the ECE Shop, however to be able to solder and test a project of my own was exciting. On top of this, from courses such as ECE 20007, ECE 270, and ECE 362, I have done a fair share of circuitry, but not to this scale of creating circuits based off of recommended schematics, having flexibility in component selection, and debugging. With that being said, I enjoyed the free-range aspects of designing and implementing Sink or be Sunk. On top of this, ECE 362 and ECE 40862 helped me understand more of the embedded systems background, and more of what is happening behind the scenes. With that being said, when it came to readjusting the pins we were using on the ESP32, I felt more prepared to make decisions about which pins to employ based on their GPIO and SPI capabilities.

1. Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

## Throughout the semester I relied heavily on datasheets for component selection and recommended circuitry during the PCB development stages. Additionally, the lab engineer, Joe, was extremely helpful in recommending components. When I started soldering the boards, I had some prior experience but Joe provided many soldering tricks and tips such as using hot glue, scratching the solder mask to make easily accessible connections for pull-up or pull-down resistors and fly-wiring, and using Chip-Quik for facilitated de-soldering. Moreover, his expertise was critical while our team was working to debug some of the issues on our main PCB. As for designing the PCB, this was my first time working with KiCad to develop a PCB. I utilized many video tutorials I found on the internet as well as a fellow teammate with much more experience. Through this, I was able to familiarize myself with the KiCad software as well as the PCB design process. In addition to learning about KiCad, I learned a substantial amount about CAD software and 3D printing. This was my first experience with OnShape and 3D printing, thus I ran into many issues; I asked some of my co-workers with 3D printing experience for their recommendations, about measurement and sizing, and general questions regarding how to use the tools in OnShape. On top of this, one of my co-workers allowed me to use their 3D printer, which was extremely generous of them. Throughout this semester, I faced many challenges that required determination and patience; when I reach a problem or had a question, I always attempted it with my best effort first, whether that was gathering more measurements, reading similar issues people ran into online, or watching YouTube videos, then asked for help from those with more experience. Moreover, I made sure to verify my work thoroughly before passing on to another teammate or stage in the project.

1. Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

## While developing the physical Sink or be Sunk game, something I was extremely conscious about was the amount of waste my team was creating. Even as small as how much tape we were using during stenciling, separating completed, tested, and working boards. With that being said, I ensured our team was reusing as many components and resources as possible; we reused devices from our previous labs, only cut a certain amount of tape and reused it for as long as possible, cut wires to exactly as long as we needed, and tried to use as few protoboards and headers for the ships as possible. Additionally, as previously mentioned, the original boat design came from an open-sourced website (Thingiverse), however our team is still providing credit for the original designs ([Scott Clausnitzer](https://www.thingiverse.com/maximumdude/designs)). In terms of professional responsibilities, I tried to facilitate communication amongst teammates and include all parties in important discussions regarding design adjustments. When helping teammates with soldering, I ensured they were using safe techniques and properly cleaning the station, tools, and hands.

1. Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgment as to your product’s impact in each of these four contexts?

## In an economic context, by balancing between a traditional style gameboard and video games, our enhanced version of a nostalgic game is entering an ever-growing market, focused around future generations. Previously, board games have introduced electrical aspects for facilitating gameplay, however our unique product is focused on using electronics to provide long-distance play, sensory elements, and score-keeping, all while maintaining the tactile element of a traditional board game. Moreover, by standing apart from the games currently available, we believe our product to be highly marketable. Environmentally, our design would have the largest impact depending on how it is being mass-produced: if it is produced with led-based products, amount of waste from shortened headers and sockets, etc. To ensure it is environmentally friendly, our team would need to further investigate how it is being produced and where the components are being manufactured. In a societal context, Sink or be Sunk is a unique way to incorporate screen-like captivation with board game engagement; it will reinvigorate the game for younger players whilst keeping the nostalgic elements for long-time players. In this way, this game is capable of bringing together a variety of age groups. Finally, in a global sense, it is capable of uniting players from around the world thanks to its wireless connection and server-based gameplay, however some regulations regarding WiFi devices and bandwidth/ranges in households in other countries need to be considered.

## **Purdue ECE Senior Design Semester Report**

## **(Individual Reflections Section)**

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| **Team Number** | 8 |
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| Senior Design Student Completing This Section | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Garrett Brillhart | CmpE | Embedded Software | Dec 2022 |

**Individual Reflection:** Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

1. Describe your personal contributions to the project.

## For our Sink or be Sunk project, I focused primarily on developing embedded software functionality and prototyping. I first focused on developing a rudimentary keypad scanner, able to simply detect keypresses to both build base code (that Mitch later improved on) and to facilitate understanding of how the hardware should interact with it. I then developed the SPI communication to the LED, able to send commands and write data to the screen. This allowed our game to have a much more enjoyable user experience, with game information and direction easily displayed for the user. As a PSSC, detecting boat placement was important to have tactile game pieces and again to improve the user experience. I prototyped the hardware we had brainstormed in theory, of a “row” multiplexer directing scanning of 8 “column” multiplexers to look for a high voltage when a boat was input. The boat would connect the pull-down resistor to the high voltage by shorting the connection. The embedded software had to determine the exact placement of the voltage (from the select lines of the multiplexers), look for the other end of the boat, and then determine all the slots in between the physical boat lay, but was not plugged into. I then developed C structures to store all this information, to both ensure that the ESP32 would record the positions of the boats to send to the server and to ensure that the same boat was never counted twice. Other contributions include creating a rudimentary sound system, with basic sine waves and frequencies. Once all the software was done, I then focused on aiding in the packaging and physical parts of the PCBs, with soldering, assembling the grids of PCBs, and creating connectors.

1. Describe how your contributions to this project built on the knowledge and skills you acquired in earlier coursework.

## Much of the contributions I made in this project was built off of ECE 270, Intro to Digital Logic, and ECE 362, Microprocessor Systems and Interfacing. Prototyping the keypad and SPI was skills acquired in ECE 362, through understanding how a keypad and SPI communication operates. The keypad was fairly straightforward due to this, and built off my knowledge through learning the basics of ESP-IDF input and output through GPIO pins. Knowing how SPI communication worked prior to starting was an enormous time-saver, by utilizing the 10-bit system of 2 command bits followed by a byte of data to write to screen. Utilizing this, I learned how to use the ESP-IDF framework of SPI communication and structures and adapted it to the specifics of our LCD screen. The boat detection built off of ECE 270 digital logic skills, by understanding how multiplexers and pull-down resistors worked. I built off the basics by building a complex web of multiplexers that allowed me to prototype and successfully develop the boat detection software. Overall, the skills I developed in earlier coursework allowed me to develop the embedded software through my experience with STM32 and learning the new syntax and tools at my disposal with the ESP32.

1. Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

## I acquired new knowledge primarily from the internet, utilizing the ESP-IDF and ESP32 documentation widely available. The documentation could be obtuse at times, and not clear on what a certain tool or structure actually did/meant. I learned to do incremental embedded development, starting simple and experimenting with what I could do from the explanations given in the documentation. For the keypad, I made sure I could blink an LED as desired and read in simple inputs, ensuring I had a full grasp of how the GPIO pins worked before working on the inputs of a keypad. I applied what I had learned online of how to control the GPIO pins from the ESP-IDF framework. SPI wise, I used an AD2 Oscilloscope to slowly build my command signals and data signals, starting with ensuring I had the correct command bits sent before beginning to attempt sending bytes of data. I applied the structures explained in the ESP-IDF documentation and experimented with the different fields to achieve the desired results. The main learning strategies I used for boat detection and other embedded software I developed consisted of understanding the capabilities and functions of the ESP32 and ESP-IDF development software, and experimenting and incrementally building until I had a finished functionality.

1. Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

## My ethical and professional responsibilities mainly relied on respecting intellectual property of code online and ensuring that I stayed within the realm of tools allowed (i.e., not using Arduino software).

1. Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgment as to your product’s impact in each of these four contexts?

## As an economic impact, the product could be placed as a commercial board game, with electronic versions of board games becoming more common. It would add to a growing pool of electronic board game versions, but with much more capability and set a new standard for what these products can do. It would also be competing with other entertainment sources, such as video game consoles, regular board games, and so forth. Environmentally, this product would add more E-Waste to the world once its lifetime run out and utilize batteries, so the Lithium mining impact should also be considered. Societal, the retro style of our project invites the idea of playing board games and time with family and friends through friendly competition. It would also connect long-distance contacts with the ability to connect and play with each other. Globally, the ability and concept of our project to be played over WiFi promotes safe habits of social distancing during this time of the Covid-19 global pandemic.

## **Purdue ECE Senior Design Semester Report**

## **(Individual Reflections Section)**

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| Senior Design Student Completing This Section | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Joseph Mislansky | CmpE | System Integration | May 2022 |

**Individual Reflection:** Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

1. Describe your personal contributions to the project.

## I worked on this project in a variety of ways. I created the online version of Sink or be Sunk through JavaScript so that users could play the game online. This was difficult as the game had a lot of constraints and implementing it in JavaScript was hard at first. I also created the CAD model for the team to get a better visualization of our implementation as well as use it in presentations for the team. After learning processes for using the solder oven, I helped instantiate over 20 of the grid PCBs with LEDs and other components. While not a difficult process, it was very time-consuming as we wanted to avoid having to fix errors after the fact. Overall, I helped out the team in any way I could through designing, implementation, testing, and installation on the physical realized product.

1. Describe how your contributions to this project built on the knowledge and skills you acquired in earlier coursework.

## In ECE 49595 I had learned many HTML and JS skills that I had not needed to apply in a class before, so it was enjoyable to be able to use and build on those skills in this project. I did some basic HTML redesign for the team page that I have not implemented yet but would like to when we turn in the final archive. I had also not used my CAD skills in a very long time, but once I practiced with it a little, I was able to get back into the swing of things.

1. Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

## This semester I had to learn a lot of new things to work on the senior design project because I had not done a lot of electrical hardware work in the past other than a couple of courses over my time at Purdue. While I did not end up using the skills, I spent time learning how to use KiCad for circuit design. I learned this through guides online and tutorial videos. I also learned how to solder from my teammates and again through videos online. My two biggest learning strategies were talking with others who had done it before and doing research online.

1. Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

## Some of my responsibilities included making sure the work the team was doing was safe. For example, when soldering was done I had to make sure we were safely using the equipment, keeping our workspace clean, and making sure the boards were cleaned off so they could be safely tested and used. Ethically, I had to make sure to give credit to the code I modeled my own code from that I found online.

1. Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgment as to your product’s impact in each of these four contexts?

## Economically, this product could theoretically come to market if we developed it more. We would have to work on bringing the price down and finding cheaper products if we truly wanted to sell Sink or be Sunk as a game. Environmentally, we made sure that products we used had no toxic materials (or at least in a small and safe amount) so that when the project was disposed of, we would not be damaging any environment. Societally, we realized that this was a game made for people to play. This could have a social impact in that many people could be using the product, so we had to ensure that it functioned correctly and safely for people to use. Lastly, in a global context, if we ever mass produced the game, we would have to consider other languages for the instructions and website so that anyone could play the game.