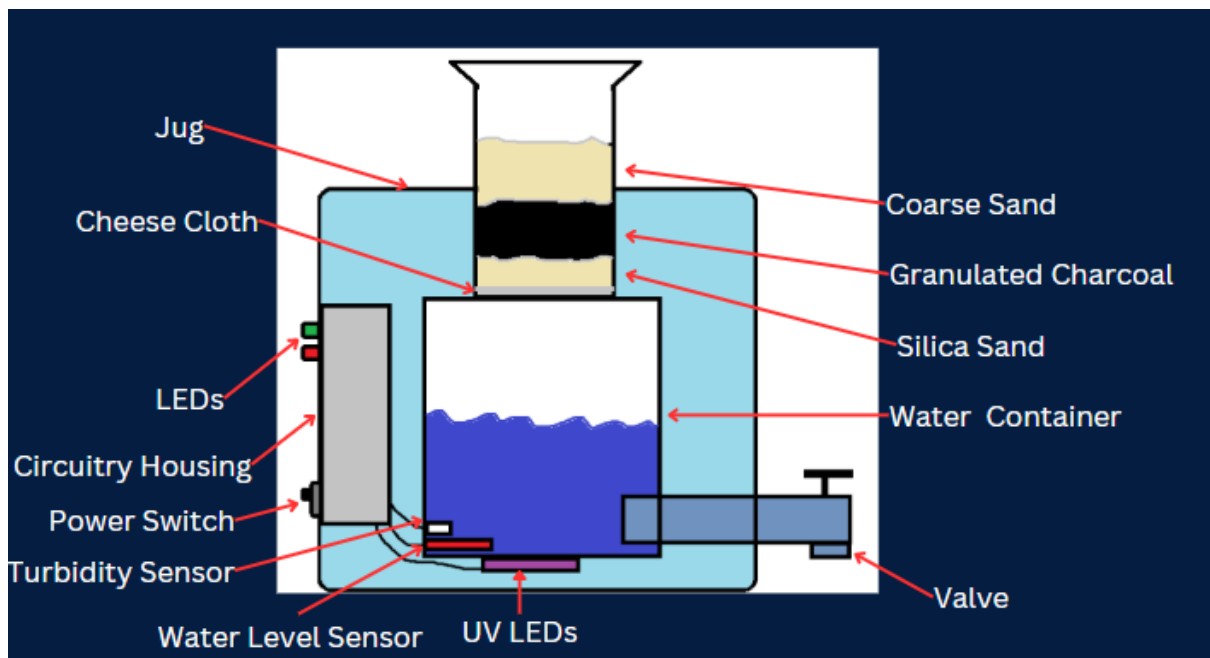




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Water filter purifier project



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HND in electrical and electronic engineering

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Group Project and Research Methods

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I would also like to thank Rhys Watts for he's support and contribution in the printing and milling of components within the project.

Introduction

This report will follow the interim report and cover the final stages of the group water purifier project. During these stages, the group began building their prototype and final product, which was then shown off during a promotional event within the college HE section. This report will also cover an evaluation of the project, looking at what went well and what could to be improved upon if the project were to be done again.

Planning

One of the first things the group did after choosing the project idea was to make a plan and set out targets to complete within allotted times. This was done to make sure that different sections of the project would be completed on time. To do this, the group made a Gantt chart to easily visualise deadlines. A Gantt chart was chosen because it helps greatly with projects that have multiple tasks and deadlines, allowing for resources to be allocated properly (MEARDON, n.d.).

Due to a number of factors, the original Gantt chart (Figure 1) was not stuck to as there were quite a few delays during the making process. One of the large contributors to this was the group not evaluating the effect that college half-terms would have on the project as the group struggled to make progress from home. These struggles were due to a lack of communication and not having access to resources like the project or equipment.

Figure 2 shows the updated Gantt chart for the project. As well as the half-terms effecting the project, there were also delays due to the group not accurately predicting the time certain aspects would take. This was generally due to a lack of experience with time management within the group and an overestimation of the simplicity of tasks. The two main targets that took longer were the Arduino programming and the prototype testing.

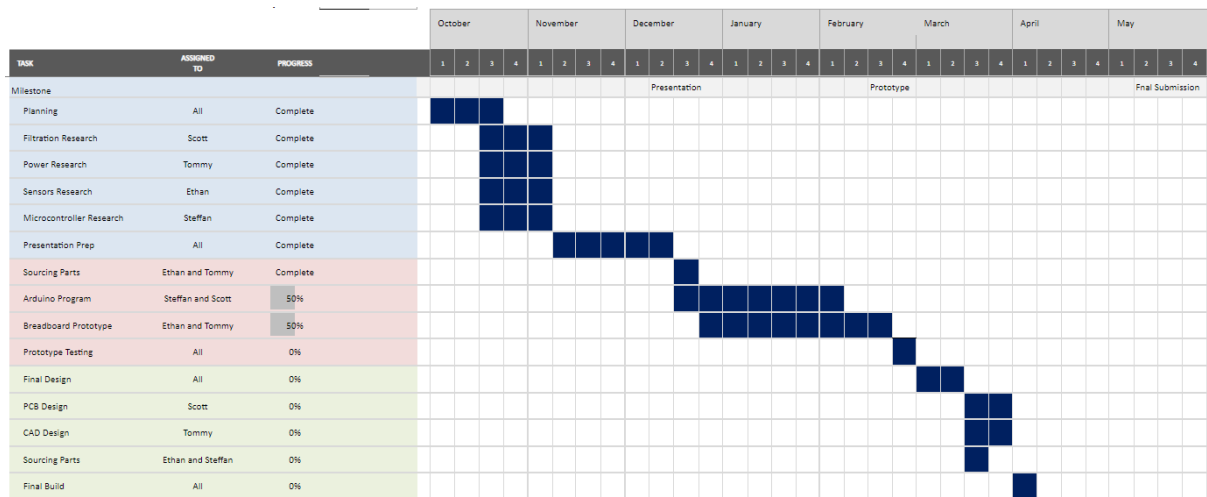


Figure 1

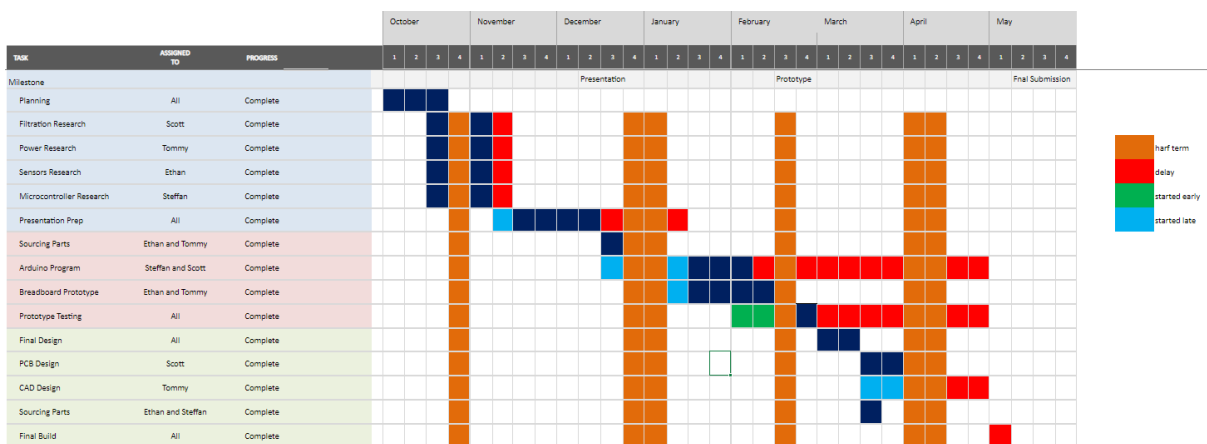


Figure 2

Sourcing Parts

One of the first tasks that needed to be completed was sourcing parts. This entailed looking at the group's research and initial design in order to source the parts needed for the project. By looking at the Gantt chart (see Figure 1), this was originally intended to be overseen by Tommy and Ethan however, due to Scott's previous experience with the order form format from being a technician with the college, he took over the position. Figure 3 shows that parts ready to be used in the project.



Figure 3

Despite this, the process was mainly a group effort, as different members had all researched different aspects of the project. This meant that there was a collaboration to determine what parts would be needed for the project to proceed. It was then the job of Scott to find sources that the college could use in its order forms, such as RS online.

Overall, the team worked well for sourcing parts and managed to get the task done within the time set out however, as seen in the original Gantt chart, the group did not anticipate the time that would be needed for parts to arrive. This meant that there would have been a large delay to the project starting if it were not for the half-term that had already created a delay. In order to improve, the group should allow more time for parts to arrive and do research into possible shipping times for parts.

Arduino programming

One of the largest sections of the project was the Arduino code, as this would work as the brain of the project and control the processes of the system. Due to the group's background in electronics and not coding, some members of the group had little experience with Arduino. Steffan however, had some extra experience through doing a robotics competition while in college and so he was chosen to oversee it.

This area of the project suffered the largest delay as the group did not correctly anticipate the time it would take to resolve issues arising in the code. This led to Ethan assisting Steffan with the coding in order to get it done. Having a second person helping with the code allowed for different perspectives on solutions, aiding with problem solving.

The main section that posed an issue was the turbidity sensor, as it was very different from anything the group had coded before. This led to struggles with understanding the analogue values it would produce, which created difficulty when making other areas of the code work of 'if statements' using the sensor. Additionally, there were added delays to the code due to its reliance on other aspects, like parts arriving and needing to be put together, as the code could not be properly tested without having a breadboard prototype built.

An improvement that would have helped with the coding would be if Ethan had sooner started helping Steffan, as they could have both built the code from the ground up together rather than Ethan helping to troubleshoot Steffan's code. This would have saved time, as it can prove to be a struggle when understanding someone else's code.

There were also some communication issues that occurred later in the project, as some of the pins that Scott had linked when creating the PCB were not the same as those assigned. This issue was quickly resolved with some reassigning in the code.

A large improvement that could be made would be the layout of the code. Due to the lack of experience with coding, the formatting of the final code ended up being quite unorganised and complex to read. This led to more difficulty when troubleshooting problems, leading to delays. So having a neat layout of code from the start would have increased productivity drastically.

Bread-boarding

The bread-boarding of the project was a key part in testing whether the group's ideas would work and was an opportunity to fine-tune the circuit easily before committing to a built PCB (Bishop, 2001). Figure 4 shows the breadboard of the circuit.

Ethan was the individual put in charge of the bread-boarding and worked well to adapt to unforeseen problems. One of these problems was the difficulty faced when trying to attach the UVC LED to the circuit. The group had already realised that they needed to solder wires to the underside of the LED (see Figure 5) as it was surface mount and could not directly plug into the breadboard; however, they did not accurately predict how difficult it would be to do so. This was because the LED was far smaller than the group thought, so not bridging the cathode and anode would be quite tricky. In order to address this, Scott soldered the LED, as he had the most experience in soldering from his role in competitions.

Ethan proposed to use a normal LED as a representation so that the coding progress would not be halted by this issue. To do this, the resistor had to be changed from 10Ω to 220Ω , as the forward voltage of the UVC LED was 6.5V, whereas the yellow LED that was used to represent it had a voltage of 2V. This can be seen in Figure 6.

The main area that could have been improved is if the group had found an alternative LED with an easier footprint to solder to, as having a larger LED would not have affected the original project idea. Despite this, the issue was resolved and did not stop the group from completing the job within the set time.

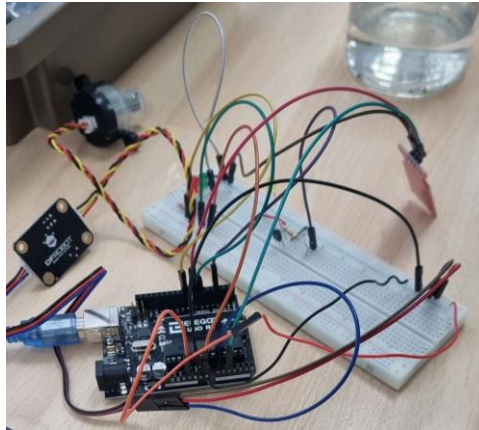


Figure 4



Figure 5

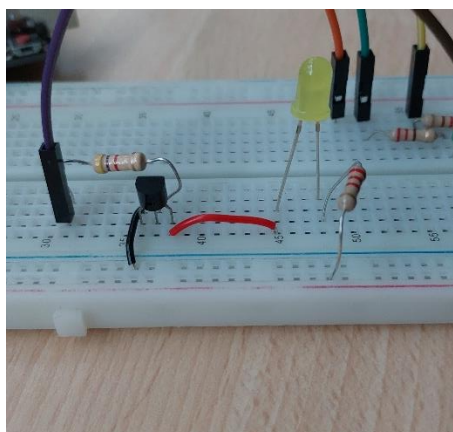


Figure 6

Prototype testing.

Initially, the group set out for the project to have its first prototype testing take only one session (see Figure 1). However, this ended up not being what took place. Instead of a singular prototype test, the group tested different parts of the project over a number of weeks. This was largely due to the number of delays that had occurred with areas like the coding and the CAD design. Because of this, the project's final prototype testing ended up being very close to the final submission. This meant there was not a large amount of adjustment that could be made compared to the final product. Figure 7 shows prototype testing of the breadboard version of the project.

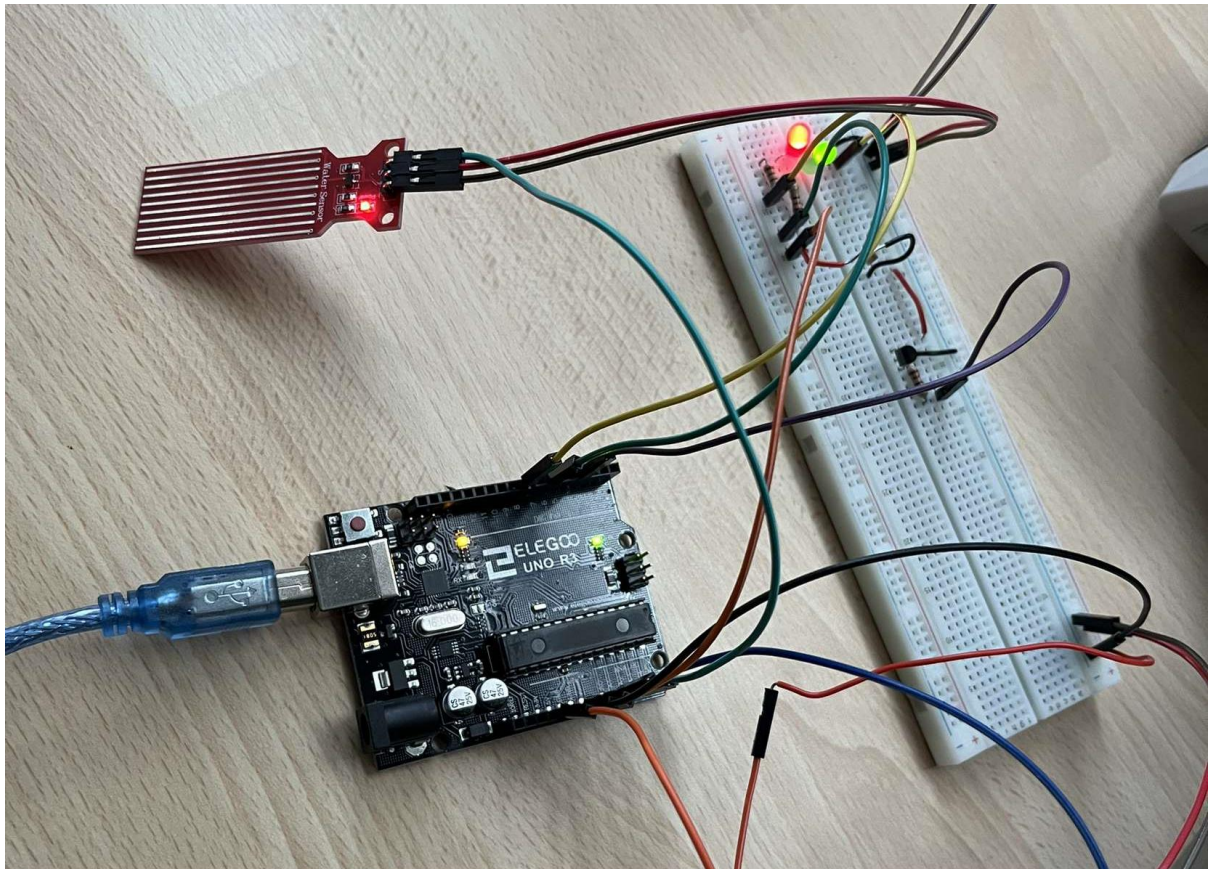


Figure 7

Final design

The group's final design largely remained the same as the initial design; however, there are a number of ways the group could have improved on their original idea, such as including an LCD display or an electronically controlled valve. However, due to the time constraints and added complexity extra features would bring, the group chose to keep the final design mostly the same as the original. There were, however, two main changes made, one of which was the decision to use a power supply rather than a 9-volt battery. This decision was made during prototyping as the group realised that the circuit would likely have too large a draw for a 9V battery, which would lead to a very short battery life. The second change made was that the Jug would no longer have an inner water container (see Figure 8), and instead the whole bottle would be used.

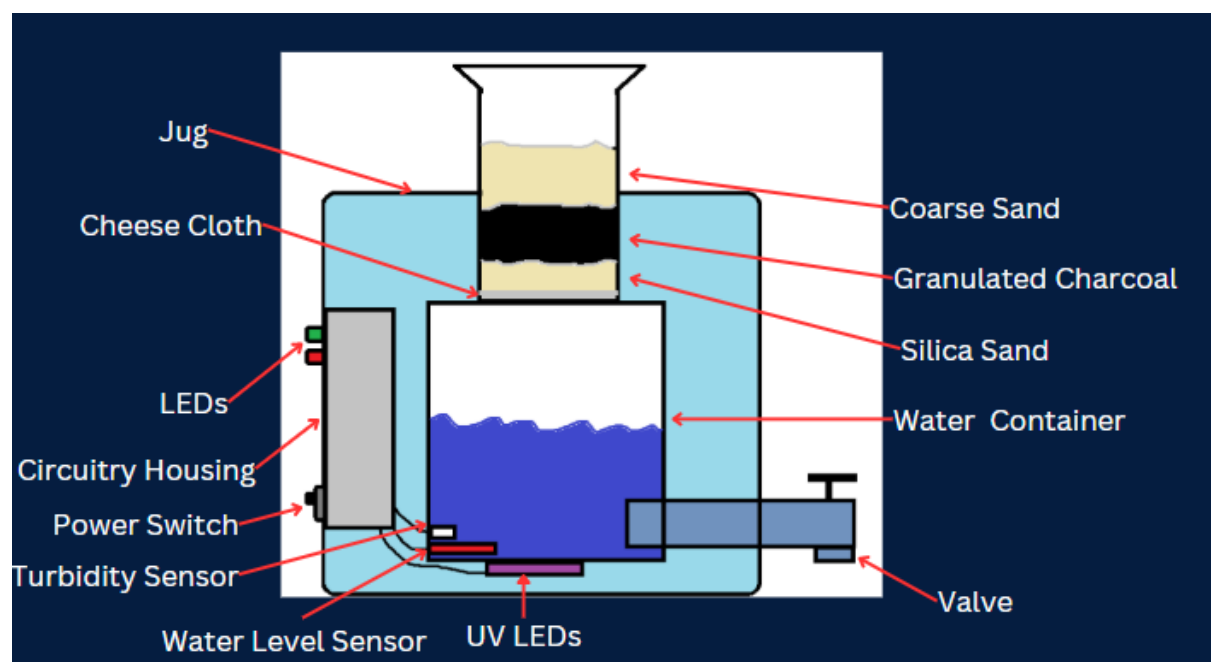


Figure 8

PCB design

The PCB design was an important step taken in order to finalise the project, as it makes the circuit more robust and gives it a more completed look. For the PCB design, Fusion 360 was used as it was a popular software and had high capabilities with advanced tools (g2, 2024).

This part of the project was overseen by Scott, as he was the person with the most experience in PCB design and Fusion 360 through previous competition work. The initial design of the PCB was made to be able to fit on top of the Arduino and plug into the pin headers (see Figure 9 for design). This was chosen as the group thought it would be a good use of space and allow for less wiring, which could lead to connection issues. The initial design of the PCB was completed on time; however, there were some issues that arose when getting the board milled.

One of these issues was that the board had to be made bigger as there was not enough tolerance between the pads and the edge of the board, leading to poor milling on the LPKF machine. So, in order to address this, the board was made 5 mm larger to allow for the clearance needed (see Figure 10).

Additionally, the original PCB design used both sides of the board; this was to allow the pin headers to be mounted to the underneath of the board so it could connect to the Arduino. However, when getting it milled, it could only be milled single-sided. In order to overcome these issues, the board was slightly altered by adding vias and jump leads so both sides of the board could be utilised (PCBWay, 2023). The use of vias was a time-effective solution as it did not mean significant modifications to the board layout. One issue the vias did not fix was the physical construction of the board, as components such as the pin header needed to be soldered on the same side as it was being mounted, which proved difficult as it was a through-hole component.

Improvements that could have helped this process would be more prototyping with the milling machine, which could have led to a better understanding of why the circuit was printing incorrectly. Another improvement for the final PCB design would be to send it off to be printed by an external company, as it could then be made with a film layer and printed dual-sided. This would allow for lower production costs and greater flexibility when designing the circuit and would have larger benefits should the water purifier need improving by adding more functions, such as an LCD screen (amitron, n.d.).

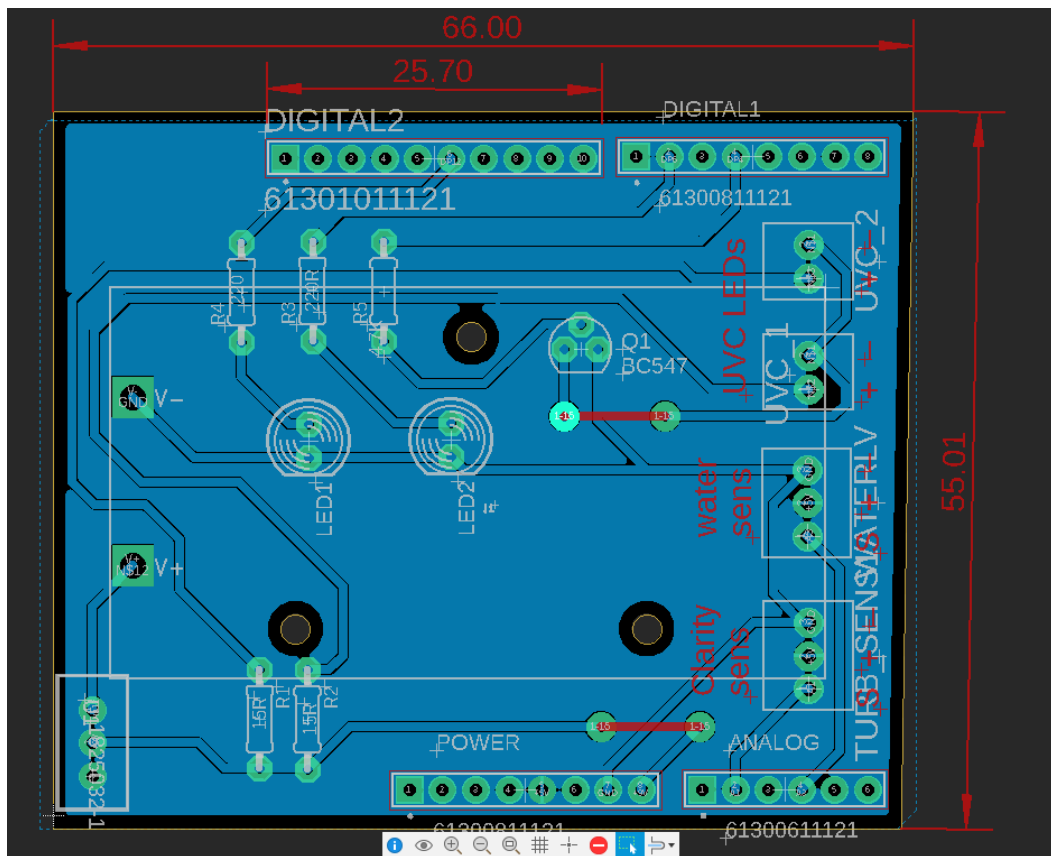


Figure 9



Figure 10

CAD design

Similarly to the PCB design, the CAD design is a big step that takes the project from prototype to product. The parts that needed 3D printing are as follows:

- A Box to hold the Arduino (see figure 11).
- A tube for the filter (see figure 13).
- An end cap to go on the valve (see figure 12).

Originally, Tommy was overseeing the CAD design as he had previous experience creating CAD designs. The original intention was to use the software Techsoft for the project; however, the only software available was Fusion 360. Despite this, after looking at reviews on Fusion 360, the software has good capabilities and is easy to learn and use (Mawson, 2020). Due to the time limitation that had occurred from not being able to use Techsoft, it was important to pick up the software quickly.

As Tommy had little experience with Fusion 360, this led to a large delay in the start of the CAD design, which further pushed back other parts of the project as a final print was only able to be made a day for the final product. To help with the lack of experience, Scott assisted in the CAD design.

The first issue occurred with the initial design not leaving enough tolerance. Leaving tolerance is an important part of 3D printing, as when a print cools, it will shrink slightly, leading to parts not fitting correctly (AnkerMake Official, 2024). For the design, a tolerance of 0.3 mm was left; however, this wasn't enough, which meant a second print had to be made with a 0.5 mm tolerance.

For the project, PLA plastic was used; however, if not for the delay, a better plastic could have been used, such as PP. PP is the preferred filament to use as it has a high chemical resistance as well as being less prone to swelling than PLA, which can cause the print to warp (ultimaker, n.d.).

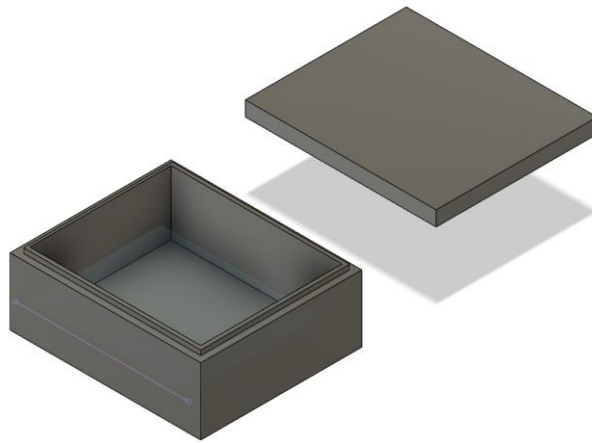


Figure 11

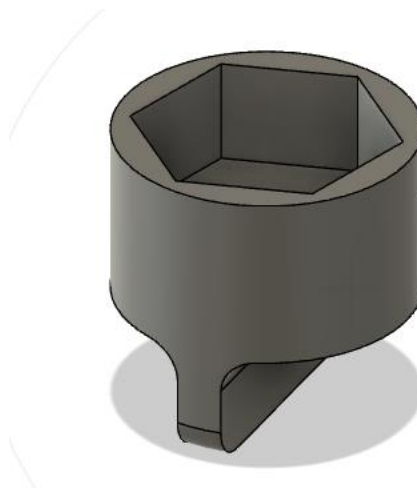


Figure 12

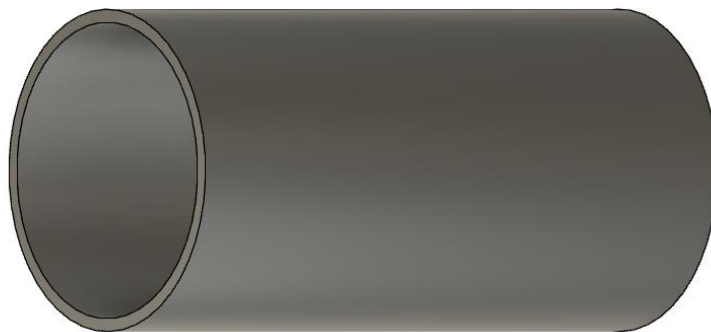


Figure 13

Finale build

For the final construction (see Figure 14) the group had a number of tasks to do. The first was to build the nozzle for the outer container. This involved cutting a 20 mm pipe to a length of around 50 mm and then hot glueing the end cap and screw to it (see Figure 16).

The second was to cut a bottle and layer the sand charcoal filter in it (see Figure 15). To do this, the cheesecloth was placed first, and layers of sand and charcoal, roughly an inch thick, were patted down to keep the layers densely packed. The cheesecloth was then tied up to keep the layers from falling out. A bottle ended up being used as there was not enough time to print the container to hold it.

The third was to glue all the components onto the filter (see Figure 17). For this, hot glue was used as the holes created in the bottle were rough, and the group felt the hot glue would seal up any large gaps due to its high viscosity. This did, however, cause an issue, as when trying to attach the Arduino housing, the hot glue, when put on the bottle, began to warp the plastic. To combat this, the glue was first put on the Arduino housing, as it was more rigid, and given a second to cool before being pushed onto the bottle.

To improve on the final design, more 3D-printed parts could have been used in areas like the filter. As well as that, for mounting the parts that would enter the water, like the water level sensor and turbidity sensor, a more appropriate glue like epoxy could have been used, as it forms a strong connection to plastics (gluegun, n.d.) and is food-safe (gluegun, n.d.).



Figure 14

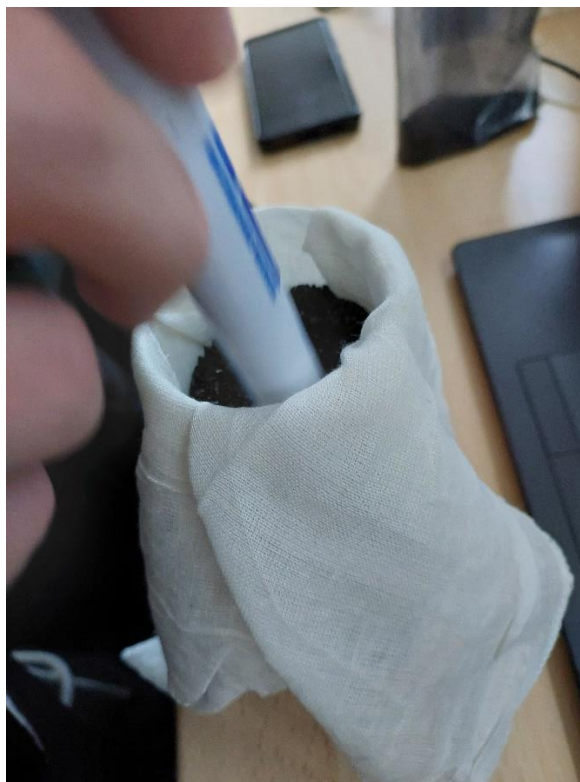


Figure 15



Figure 16



Figure 17

Conclusion

In conclusion, the group water purifier project, despite various challenges and delays, the group successfully produced a functional prototype showcased at a college event. The initial planning required adjustments due to unforeseen delays and for future projects, the group aims to better anticipate timelines, enhance communication, and organize coding and design tasks. Using higher-quality materials and external manufacturing for complex components could improve the process and final product. Overall, the project demonstrated the importance of adaptability, teamwork, and thorough planning, culminating in a successful water purifier prototype.

References

amitron, n.d.. *DOUBLE SIDED PCB*. [Online]

Available at: <https://amitron.com/printed-circuit-boards/double-sided>

[Accessed 22 May 2024].

AnkerMake Official, 2024. *The Ultimate Guide to Improve 3D Printing Tolerances 2024*. [Online]

Available at: <https://www.ankermake.com/blogs/guides/3d-printing-tolerances>

[Accessed 25 May 2024].

Bishop, O., 2001. From components to circuits. In: *Understand Electronics (Second Edition)*. Oxford: Newnes, pp. 154-155.

g2, 2024. *Top Free PCB Design Software*. [Online]

Available at: <https://www.g2.com/categories/pcb-design/free>

[Accessed 22 May 2024].

gluegun, n.d.. *Best Glue for Bonding Plastic*. [Online]

Available at: <https://www.gluegun.com/collections/best-glue-for-bonding-plastic>

[Accessed 26 May 2024].

industrialclear, n.d.. *IS EPOXY RESIN FOOD SAFE?*. [Online]

Available at: [https://industrialclear.com/blogs/learn/food-safe-](https://industrialclear.com/blogs/learn/food-safe-epoxy#:~:text=Yes%2C%20epoxy%20is%20considered%20food,either%20liquid%20or%20cured%20for)

[epoxy#:~:text=Yes%2C%20epoxy%20is%20considered%20food,either%20liquid%20or%20cured%20for](https://industrialclear.com/blogs/learn/food-safe-epoxy#:~:text=Yes%2C%20epoxy%20is%20considered%20food,either%20liquid%20or%20cured%20for)

[m](https://industrialclear.com/blogs/learn/food-safe-epoxy#:~:text=Yes%2C%20epoxy%20is%20considered%20food,either%20liquid%20or%20cured%20for)

[Accessed 26 May 2024].

Mawson, J., 2020. *Answer to question: What do you think about the Fusion 360 for 3D printing?*. [Online]

Available at: [https://www.quora.com/What-is-your-review-of-Fusion-](https://www.quora.com/What-is-your-review-of-Fusion-360#:~:text=I%20find%20it%20as%20a,all%20the%20tutorials%20out%20there)

[360#:~:text=I%20find%20it%20as%20a,all%20the%20tutorials%20out%20there](https://www.quora.com/What-is-your-review-of-Fusion-360#:~:text=I%20find%20it%20as%20a,all%20the%20tutorials%20out%20there).

[Accessed 25 May 2024].

MEARDON, E., n.d.. *What are Gantt charts?*. [Online]

Available at: [https://www.atlassian.com/agile/project-management/gantt-](https://www.atlassian.com/agile/project-management/gantt-chart#:~:text=Gantt%20charts%20help%20teams%20to,%2C%20milestones%2C%20and%20dependent%20tasks)

[chart#:~:text=Gantt%20charts%20help%20teams%20to,%2C%20milestones%2C%20and%20dependent%](https://www.atlassian.com/agile/project-management/gantt-chart#:~:text=Gantt%20charts%20help%20teams%20to,%2C%20milestones%2C%20and%20dependent%20tasks)

[20tasks](https://www.atlassian.com/agile/project-management/gantt-chart#:~:text=Gantt%20charts%20help%20teams%20to,%2C%20milestones%2C%20and%20dependent%20tasks)

[Accessed 16 May 2024].

PCBWay , 2023. *What is a PCB Via?*. [Online]

Available at:

[https://www.pcbway.com/blog/PCB Basic Information/What is a PCB Via PCB Knowledge ce45ad4e.html#:~:text=A%20via%20is%20a%20small,to%20establish%20inter%20layer%20connections](https://www.pcbway.com/blog/PCB_Basic_Information/What_is_a_PCB_Via_PCB_Knowledge_ce45ad4e.html#:~:text=A%20via%20is%20a%20small,to%20establish%20inter%20layer%20connections).

[Accessed 22 May 2024].

ultimaker, n.d.. *How to 3D print waterproof parts*. [Online]

Available at: [https://ultimaker.com/learn/how-to-3d-print-waterproof-](https://ultimaker.com/learn/how-to-3d-print-waterproof-parts/#:~:text=PLA%20can%20be%20used%20to,circumstances)%20it%20can%20be%20composted)

[parts/#:~:text=PLA%20can%20be%20used%20to,circumstances\)%20it%20can%20be%20composted](https://ultimaker.com/learn/how-to-3d-print-waterproof-parts/#:~:text=PLA%20can%20be%20used%20to,circumstances)%20it%20can%20be%20composted).

[Accessed 25 May 2024].