Ethical and Environmental Analysis

Year: 2023 Semester: Spring Team: 08 Project: Engineer’s Chess

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Assignment Evaluation:

| **Item** | **Score (0-5)** | **Weight** | **Points** | **Notes** |
| --- | --- | --- | --- | --- |
| **Assignment-Specific Items** | | | | |
| **Environmental Impact** |  | x6 |  |  |
| **Ethical Challenges** |  | x6 |  |  |
| **Writing-Specific Items** | | | | |
| **Spelling and Grammar** |  | x2 |  |  |
| **Formatting and Citations** |  | x1 |  |  |
| **Figures and Graphs** |  | x2 |  |  |
| **Technical Writing Style** |  | x3 |  |  |
| **Total Score** |  | | |  |

5: Excellent 4: Good 3: Acceptable 2: Poor 1: Very Poor 0: Not attempted

Comments:

*Comments from the grader will be inserted here.*

1. Environmental Impact Analysis

Our project contains many features that could pose environmental impacts, such as the use of printed circuit boards (PCBs), LCD screens, and a LED matrix. While the device does use power, it has no batteries at all. The exterior of our project is made from balsa wood. Due to the elements included in our project, the environmental effects from the products manufacturing, use, and end of life are very much present.

During the fabrication of PCBs, hazardous wastewater is produced and can have a very negative effect on the environment around the facility. The wastewater includes a large number of metal ions and complexes such as: Cu2+, Ni2+, Ag+, Au+, Sn2+/Sn4+, and Pb+ [1]. Not only are inorganic compounds found in the PCB wastewater, but a multitude of organic substances can also be found, including: surfactants, inks, resists, organic dispersants, brighteners, degreasers, as well as ammonia, cyanide, fluoride, phosphorus and other pollutants [1]. Due to the high concentrations of these compounds found, they pose many threats to the local ecology of the PCB fabrication plant, if the wastewater is not strictly controlled and prevented from being polluted into the environment. The wastewater is known to cause a variety of diseases in humans, proving that the problem is not limited to wildlife but also has significant importance to human wellbeing.

While the manufacturing of PCBs and their potential to be environmentally unfriendly was not forefront when designing our product, we still took some decisions to reduce some of the ways PCBs can be harmful. We ordered Lead-Free HASL PCB finishes, which can help greatly reduce the amount of lead used in production. As our product is only in the prototyping stage, the PCB could be made smaller and more efficiently for the final product, also helping to reduce the amount of waste produced per item.

Another component that our project includes is the use of two LCD screen panels. The waste from manufacturing LCDs can also be abundant in potentially harmful resources consisting of glass, plastics, metals, electronic circuitry, and liquid crystals[2]. Like with PCB manufacturing, if the waste is not handled properly the byproducts can be extremely harmful to the ecology around the manufacturing plant. One of the efforts our team can do when moving to produce our product on a large scale to help limit the waste caused from LCD manufacturing would be to purchase LCD’s from reputable companies that ensure proper handling of waste materials.

The main chess board display for our product uses a 64 by 64 LED matrix. In the production of LEDs aluminum, copper, gold, gallium, and other metals are used in various quantities [3]. As with any production of electronics, these elements can be released into the environment if not handled properly, causing serious problems if such a thing were to happen. As our team is not able to directly influence how cleanly LEDs are made, one of the only courses of actions we could take is to ensure that we purchase the LED matrix from a reputable source that promises to be as environmentally friendly as possible.

On the decision on what material our product's casing was to be made of, we were first looking for something that is aesthetically pleasing and is easy to construct. Eventually, our team settled on balsa wood as it fit these parameters. As it is wood, the balsa wood has to come from cutting down trees. On one hand, balsa trees have an extremely fast growth rate, allowing for balsa wood to be fairly sustainable in the long term. On the other hand, balsa wood is necessary for the survival of Amazonian rainforests [4]. Balsa trees will often grow wherever the top canopy is letting light through, which then produce their own shade to help keep the forest floor shaded [4]. Because of the importance of Balsa trees in the Amazon and other forests, when companies harvest balsa wood from their natural habitat rather than through farming, it can cause significant damage to the ecosystem. Knowing this, the best thing to do is to only purchase balsa wood from companies that farm it, and do not use the naturally grown balsa trees. This would be fairly sustainable, as balsa trees are very quick growing and this would help limit deforestation.

Through normal use of our product, there are a lot less concerns to be dealt with. If the electronic components operate as the manufacturers say that they do in their projected lifetime, the biggest environmental impact of our product would be the power usage required to play the game of chess. Fortunately, our game only uses a 5 volt, 2 amp wall socket outlet. This is a fairly low power device. At most the device will use 15 Watts, depending on efficiency. If used in a country with sufficient power generation, that often produces excess power in the day, 15 Watts will have minimal environmental impact. Another normal use environmental impact our team may have needed to consider was any possible lead components decaying during use, however, our product is lead free, eliminating such a problem.

When it comes to the end of life of our product, one of the largest considerations of what to do is how the PCBs will be disposed of. Fortunately, research and attempts to make recycling PCBs more worthwhile are ever present. Especially due to how many valuable resources are in the PCBs themselves. Unfortunately, even with the efforts made to make PCB recycling more efficient, approximately 50 million tons of electronic waste was disposed of in 2018 [5]. While ways to recycle PCBs exist, it is ultimately up to the owner of the product at the end of life to ensure that our product is disposed of properly. One way to help encourage proper disposal is by providing recommendations in the user manual or on the packaging itself.

The disposal of the LCD screens is also very important. LCDs are both harmful and reusable due to the variety of ingredients contained: the liquid crystal, panel glass, and precious heavy metals [6]. In this way, the LCDs must be disposed of properly. Like with PCBs, some local recycling centers will have days specifically allocated for electronic waste. As the manufacturer of our product, we do not want the LCDs used in our game to be exposed to wildlife and cause harm, but we can only encourage the end of life user to take the best course action and turn the electronics into a center that can dispose of the LCDs correctly. The disposal of the LEDs are very similar to LCDs and can be handled with the same level of care at end of life to ensure it is not disposed of incorrectly.

The packaging for our game is made of balsa wood, so this is a fairly environmentally friendly material at its end of life. Wood decays on its own, so if the game is taken to the proper recycling centers and the electronics are removed. The wood container left behind can be disposed of by many means, most of which have little harmful effects. This is especially true of balsa wood as it has no toxic properties that could be released as it decays.

1. Ethical Challenges

One of the issues that could arise in the use of our product is if a user has epilepsy or sensitive eyes. The LED matrix is very bright and can flicker at times. This could cause issues for those with epilepsy. This can be taken care of through either a warning on the packaging or in the user manual. The device does not have flickering normally, but this could arise after the product has been used for an extended period of time. If this happens, we want a warning so that someone who could be affected by flickering would be aware of this when they purchase the device. Another issue with the LED matrix is that LEDs are known to sometimes reduce melatonin levels when using before bed [7]. Thus, we may include a warning or suggestion to not use the device in low light levels before going to sleep or withhold from using the game within an hour or so before bed.

Another possible issue that could arise is when the user plugs in the device. Because we do not have a power switch, the device turns on as soon as it is plugged in. This is not a problem if the user does not touch either of the prongs on the plug. However, this problem is still very plausible. Fortunately, because our device is only 5 volts and 2 amps, any potential electrical shock will be low and would not cause any major injury. To help with ensuring the user is aware of this, we can put warnings on both the user manual and the power plug itself.

The buttons on our user interface have the ability to be pried off. This could cause complications if they were ever to be removed. The colors of the buttons are bright and colorful, which could look like candy to a small child. Due to this we will include a warning in the user manual that there would be a choking hazard if the buttons are pried off. The buttons are not easy to pull off, and require a tool to pry them off, but the possibility could still happen. Due to our packaging design and the buttons we used, if the button covers do come off the buttons can still be used and little to no actual PCB or wire will be shown, thus preventing any potential shock.

3.0 Sources Cited

[1] “Top 5 small and medium PCB design, manufacturing and Assembly Factory,” PS Electronics, 09-Dec-2022. [Online]. Available: <https://www.quick-pcba.com/pcb-news/wastewater-treatment-of-pcb-fabrication-process.html#:~:text=The%20wastewater%20produced%20by%20PCB%20fabrication%20process%20also%20contains%20plenty,fluoride%2C%20phosphorus%20and%20other%20pollutants> . [Accessed: 08-Apr-2023].

[2] W. Kang, J. C. Kim, J. H. Noh, and D. W. Kim, “Waste liquid-crystal display glass-directed fabrication of silicon particles for lithium-ion battery anodes,” *Korea University*, 16-Sep-2019. [Online]. Available: https://pubs.acs.org/doi/10.1021/acssuschemeng.9b02654. [Accessed: 08-Apr-2023].

[3] S. Borealis, “LEDs: The next e-waste stream,” *scienceborealis.ca Blog*, 09-Feb-2020. [Online]. Available: https://blog.scienceborealis.ca/leds-the-next-e-waste-stream/. [Accessed: 08-Apr-2023].

[4] “The green paradoxes of an Amazonian country,” *World Rainforest Movement*, 09-Jul-2021. [Online]. Available: https://www.wrm.org.uy/bulletin-articles/the-green-paradoxes-of-an-amazonian-country. [Accessed: 08-Apr-2023].

[5] Z. Chen, M. Yang, Q. Shi, X. Kuang, H. J. Qi, and T. Wang, “Recycling Waste Circuit board efficiently and environmentally friendly through small-molecule assisted dissolution,” *Nature News*, 29-Nov-2019. [Online]. Available: https://www.nature.com/articles/s41598-019-54045-w. [Accessed: 08-Apr-2023].

[6] “Environmental impact assessment on the recycling of waste LCD panels ...,” 22-Feb-2019. [Online]. Available: https://pubs.acs.org/doi/10.1021/acssuschemeng.9b00119. [Accessed: 08-Apr-2023].

[7] S. Moore, “The negative impact of leds on the environment and health,” *AZoCleantech.com*, 21-Sep-2022. [Online]. Available: https://www.azocleantech.com/article.aspx?ArticleID=1616#:~:text=LEDs%20are%20a%20significant%20source,to%20their%20impact%20on%20melatonin. [Accessed: 08-Apr-2023].