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Exploring the potential benefits of 3D printing technology in laboratory equipment: case studies on custom lab equipment and components

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ABSTRACT

Although 3D printers are becoming more common in households, they are still under-represented in many laboratories worldwide. However, this paper highlights the potential benefits of 3D printing technology in laboratory equipment. Researchers and scientists may need to learn about the potential benefits of 3D printing technology. It is essential to note that 3D printers are not just toys. They can be valuable tools for laboratory equipment, creating custom lab equipment and components, which can be difficult or expensive to obtain through traditional means. 3D printing can save time and money while increasing research efficiency. Also, 3D printers can create complex structures and models that help visualize and understand scientific concepts and create prototypes of new inventions and ideas. This study explores two examples of using 3D printing techniques, including a 3D printer-created pipette tip sorting device and a specific mold for sand samples in biocementation. The application and errors, mistakes, and challenges in materials control, with suitable solutions, were also discussed. Although 3D printers may still need to become as standard in laboratories as other types of equipment, their potential applications make them a valuable addition to any research or development team.

1. Introduction

While it is true that 3D printers are becoming more common in households, they are still relatively under-represented in many laboratories worldwide. This situation is partly because many researchers and scientists may not know the potential benefits of 3D printing technology for their work. However, it is essential to note that 3D printers are not just toys. They can be precious tools for laboratory equipment. For example, 3D printing can be used to create custom lab equipment and components, which can be difficult or expensive to obtain through traditional means. Moreover, 3D printers can also be used to create complex structures and models that help visualize and understand scientific concepts. They can also be used to create prototypes of new inventions and ideas, enabling researchers to quickly test and refine their concepts before committing to expensive production runs. Overall, while 3D printers may not yet be as standard in laboratories as other types of equipment, their potential applications make them valuable to any research or development team. Therefore, professors and educators must understand the potential benefits of 3D printing technology in the laboratory setting. Here are a few reasons why investing in a 3D printer could be an intelligent decision:

(i) Customization: create custom lab equipment and components tailored to specific experiments or research projects, which can save time and money, as well as increase efficiency.

(ii) Prototyping: quickly and easily create prototypes of new inventions and ideas, enabling researchers to test and refine their concepts before committing to expensive production runs.

(iii) Visual aids: create complex structures and models useful for visualizing and understanding scientific concepts, which can be especially helpful for teaching and learning.

(iv). Innovation: constantly evolving, and investing in a 3D printer for the laboratory can encourage innovation and experimentation among students and researchers.

Once users are familiar with the 3D printing process, they can begin to print valuable items for the lab. 3D printing allows for the creation of customized lab equipment tailored to specific experiments and research projects. For example, one everyday use of 3D printing in the lab is to create holders for vials, tubes, and cuvettes. These holders can be designed to fit specific types of equipment and can be customized to hold a certain number of samples, which can help to organize and streamline the lab workflow, making it easier to access and use samples. Other valuable items that can be 3D printed for the lab include [1–6]:

(i) Adapters and connectors: create custom adapters and connectors for lab equipment, allowing researchers to connect different components.

(ii) Lab jigs and fixtures: create jigs and fixtures for holding samples or components in place during experiments, improving the accuracy and reproducibility of experiments.

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(iii) Microfluidic devices: create microfluidic devices for manipulating small volumes of fluids. These devices can be customized to fit specific experiments and are much cheaper and faster to produce than traditional methods.

The ability to design and produce custom parts that are not commercially available is a significant advantage of 3D printing, called rapid prototyping, and it's helpful for researchers and scientists who need to iterate and test new ideas quickly. With 3D printing, researchers can design and produce parts in-house without needing specialized equipment or expertise, which is especially useful for older equipment that may no longer be manufactured or replacement parts that are difficult to find. In addition, by 3D printing replacement parts, researchers can extend the lifespan of their equipment and save money on costly replacements. Two separate topics, medicine and building materials, were mentioned as real-scale examples of using and owning a 3D printer. With knowledge about materials, researchers can create valuable tools and testing devices.

2. Materials and Experiments

In this study, the Ender 3 S1 Plus manufactured by Creality, a leading company in the 3D printing industry, was used. It is an upgraded version of the popular Ender 3 series with several new features and improvements. The chosen material for printing was PLA+, which is a type of polylactic acid (PLA) filament. PLA+ is an advanced form of traditional PLA, providing several advantages over the standard material. The improved strength and flexibility of PLA+ compared to traditional PLA likely contributed to the printed components' enhanced durability and resistance to wear and tear.

3. Results and discussions

3.1. Pipette tip sorting device

The pipette tip sorting device is a specialized piece of laboratory equipment that automates the sorting and dispensing of pipette tips [7, 8]. These small, disposable plastic tips are used with pipettes to transfer precise volumes of liquid in the lab and come in various sizes and shapes for various applications. Creating a custom pipette tip sorting device requires exceptional design expertise and knowledge of laboratory equipment and workflow. Researchers may need to collaborate with specialized designers or engineers to optimize the device for their needs. The chosen material must be compatible with the lab environment, withstand repeated use, and be easily sterilized. Also. researchers may need to experiment with different materials to determine the best fit for their requirements. Ensuring accuracy and reliability in the pipette tip sorting device is crucial for lab experiments. Researchers must establish quality control measures to ensure the device functions properly and produces precise results.

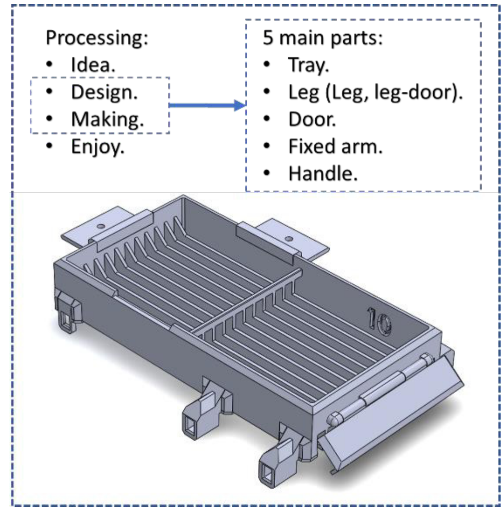


Figure 1. Strategy for the high-effect printing process.

The focus of this discussion pertains to the concept of "Leg-door" and its ability to address the issue of "Fixed arm" slipping in a particular direction (Figure 3). Precisely, "Leg-door" is positioned near the door and has proven to be more effective than the utilization of "Leg" in mitigating this problem.

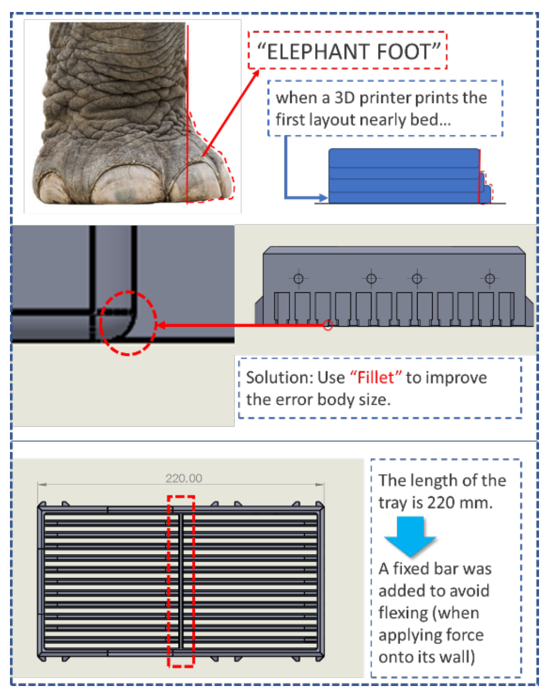
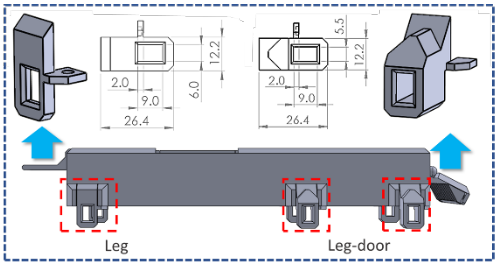
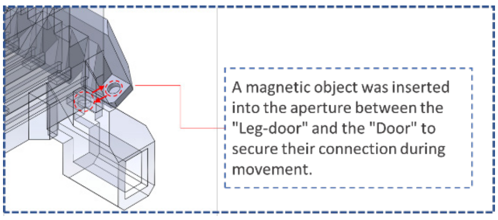


Figure 2. Problems and solutions.

Utilizing "Leg-door" would be advantageous for all parties involved, as the "Leg" component serves a dual purpose of providing stability to the sample while facilitating cost savings (Figure 4a). A magnetic object was inserted into the aperture between the "Leg-door" and the "Door" to secure their connection during movement (Figure 4b).



(a)



(b)

Figure 3. The specific design of "Leg-door" and "Leg".

In many situations, a researcher's skills, knowledge, and experience are essential. To design a lab device, one can start with a free drawing or an idea from literature. However, to create a device that is truly suitable and ready to use, specific revisions, modifications, or even significant changes may need to be made. It takes careful consideration and expertise to create a lab device that meets the requirements.

3.2. Specific mold for sand samples in biocementation

Biocementation involves treating sand samples with microorganisms to bind the sand particles together and create a more stable material. Previous studies developed mold but met problems with the sample removal step [9–11]. Specific characteristics and requirements must be considered to create a suitable mold for the sand samples: (i) The mold material should be compatible with the sand and biocementation process; (ii) The mold should be designed to the specific size and shape of the sand sample, which may require a custom mold design to ensure a perfect fit; (iii) The mold surface should be treated to be smooth to prevent the sand from sticking during biocementation by polishing or coating the mold with a release agent; (iv) The mold should include vents or channels to allow air to escape and prevent the formation of air pockets, ensuring the even distribution of the sand throughout the mold.

Utilizing a 3-part plastic mold (Figure 4) for sand sample preparation can effectively address several issues related to friction and the extraction of molds. First, using a 3-part mold facilitates rapid and precise compression of sand samples into the mold without requiring excessive force or encountering friction. This enhancement is critical in ensuring the sand is uniformly distributed and compacted, which is fundamental to obtaining consistent and accurate outcomes.

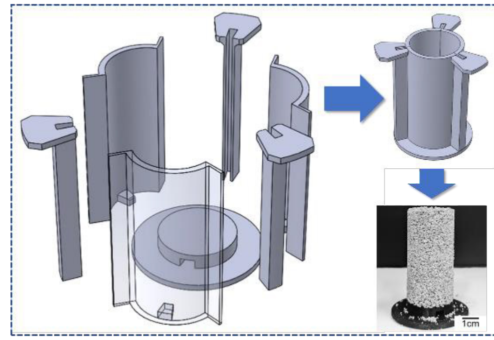


Figure 4. The 3-part plastic mold for sand sample preparation.

4. Conclusion

While there are challenges associated with using 3D printing for creating custom lab equipment such as pipette tip sorting devices, the benefits can outweigh these challenges when the device is properly designed, tested, and implemented. Similarly, a 3-part plastic mold for sand sample preparation can help improve the sand samples' accuracy and consistency while making removing the samples easier and less prone to damage. These experimental results in specific research topics demonstrated the benefits of using 3D printing effectively in academic and engineering fields.

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