

速報

Current Implementation of 3D Printed Prototyping in STEAM Education at ICT Hakusanroku Campus

Davis EVANS

An essential component of project-based education at ICT is prototype creation and fabrication. One of the key fabrication technologies used is 3D printing. This article discusses the current utilization of 3D printing facilities in both classes and extracurricular activities at the ICT Hakusanroku campus, and how this could be expanded and improved upon in the future.

Keywords: 3D Printing, Prototyping, Project-based Education

1. Introduction

In recent years 3D printers have become ever more present in both industry and educational institutions. Particularly, Fused Deposition Modeling (FDM) 3D printers that use cheap and widely available plastics, have become a cost-effective, easy to implement solution to the need for rapid prototyping solutions for both engineering and non-engineering design applications. The ability to take an idea from a concept on paper, to an actual tactile part that can be tested, evaluated, and iterated upon in a short time span has wide applicability to any project-based curriculum.

As an institution with a large focus on hands-on engineering design education, International College of Technology, Kanazawa (hereafter referred to as ICT) has many programs and activities that utilize 3D printing to facilitate student project-based curriculum as well as extracurricular activities. Year 1 and 2 students in the Science and Technology Department (respectively referred to as S1 and S2) spend their first two years at ICT's Hakusanroku Campus, which has its own onsite fabrication facilities, including an array of 10+ FDM 3D printers of various make and models. These printers are available to students year-round to facilitate not only classwork and assignments, but also extracurricular projects and design competitions.¹⁾

2. Survey Results

To evaluate the current state of 3D printer usage at ICT Hakusanroku campus, two voluntary response surveys were conducted, one was sent to faculty teaching courses at Hakusanroku during academic year 2024, and another was sent to academic year 2024 S1 and S2 students. In total 3 faculty and 5 student responses were recorded. The following commentary is based on the results of the above survey.

2.1 Faculty Responses

Based on provided faculty responses, there is at least one class in each year of curriculum that incorporates 3D printing as part of class activities, in particular both S1 and S2 Engineering Design courses. In regard to extracurricular activities, faculty also reported use of 3D printing resources for club and competition work. One use case given was custom part creation for a robot created for the NHK Robocon contest. Furthermore, all faculty respondents also indicated that they also make use of available 3D printing resources for personal projects and research.

2.2 Student Responses

Of the student responses, the majority were from students in the S2 class. All students reported having at least one class that included 3D printing as part of class activities, with the median response being two 3D printed items per school year created as part of class activities. Student responses also corroborated faculty responses regarding use of 3D printing in club and competition activities.

Of particular interest from the student survey results is the amount of faculty assistance used when students utilize 3D printing facilities.

When using the 3D printers, what method below best describes how you use them?

5 responses

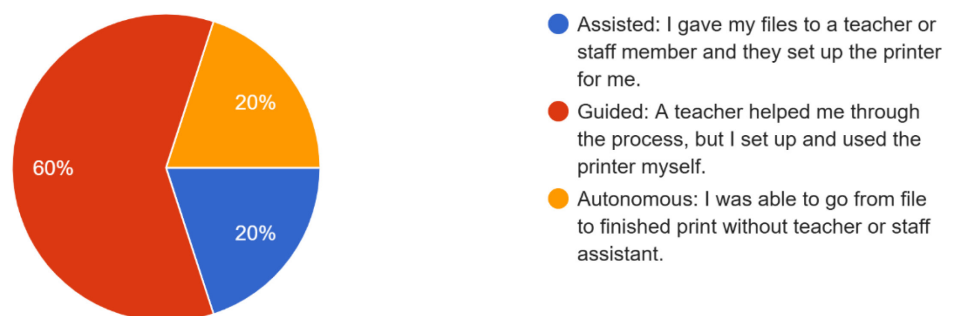


Fig. 1: Pie chart of student responses regarding method of 3D printer use

As seen in Fig. 1, the majority of students self-reported that while they had teacher guidance, they were the ones to set up and operate the 3D printer. As the goal at ICT is to raise autonomous innovators, while students are not fully autonomous at the S2 level according to this survey, they are not completely reliant on faculty to facilitate the fabrication process. Ideally most if not all students should be able to autonomously carry out part fabrication tasks by the end of ICT's 5-year program, if not sooner.

3. General Commentary on 3D Printing in Design Education

3.1 Advantages

The greatest advantage of utilizing 3D printing for design education or project courses is the simplification of the idea to physical object pipeline. Traditionally engineering design

education would require a significant amount of fabrication time to be allocated if a physical final part was desired. During this time students would need to spend several hours per part using manual shop tools such as lathes, mills, and table saws. While manual fabrication skills are still desirable and incorporated into ICT curriculum, the time limitations of a busy schedule heavily restrict the amount of manual labor that can be expected of students. With the incorporation of 3D printing, along with other automated fabrication techniques, parts and designs can be produced and used for iterative design and evaluation for many more courses, while minimizing the impact on busy student schedules.

While the above is applicable to all automated fabrication techniques, including laser cutting and CNC milling, the advantage of 3D printing in this category lies in ease of use and low barrier to entry. Laser cutting machines and CNC mills are sensitive to workpiece alignment and machine calibration. Mistakes in either category can lead to wasted time and resources or worse, user injury and/or damage to fabrication machines. FDM 3D printers are comparatively robust and resistant to user error. Modern machines are generally self-calibrating, parts and maintenance are cheap and easy to carry out, and plastic filaments are affordable and widely available. The inherent risk from 3D printers is also relatively low, with the most common injury being minor burns from contact with hot components. Thus, students can be allowed to use 3D printing resources with minimal training and supervision at low risk of injury or damage to facilities.

3.2 Disadvantages

While convenient for many use cases there are limitations to where and when 3D printing should be used in a design and manufacturing context.

One of the most important considerations is that while FDM 3D printing is well suited to rapid prototyping, it is normally not a good option to create finished parts for most use cases. The layered manufacturing process leads to seams that cause structural weakness compared to other processes such as injection molding, as well as rough, ridged surface textures that require further treatments to smooth or coat properly. 3D printing is also not well suited to producing large batches of parts as print times can take up to a day to produce a single large part.

3D printing is best utilized for asynchronous design work, where time is available to allow for printing while users work on other parts of a project or relax. In contexts where a part is needed within a few hours, one should consider faster processes such as laser cutting instead.

4. Future Expansion

To further the usefulness of 3D printing resources in ICT design education there are a few areas where offerings may be reasonably expanded.

4.1 Expansion of 3D Printing Machine Types

While FDM 3D printers are the most widely available and generally cheapest type of 3D printers on the market there are other types of 3D printers not currently available at ICT Hakusanroku campus.

Stereolithography (SLA) 3D printers developed from a different branch of 3D printing processes that predate the currently ubiquitous FDM machines. SLA printers use a laser to cure

photosensitive resin to create a solid shape in a liquid resin bath.²⁾ SLA printers generally have a faster printing speed than FDM printers but have a higher cost per print volume and are more difficult to maintain. The faster turnaround time of SLA printing may offer some advantages to time-limited design processes and competitions over current FDM printers.

Selective Laser Sintering (SLS) 3D printers also use a laser, but instead fuses a layer of plastic, metal, or ceramic powder to create a solid part. SLS printed materials tend to be much more mechanically sturdier than FDM or SLA created objects with a similar low material cost to FDM printing, but comes at a significantly increased initial cost per machine.²⁾

While budget and space for new 3D printing machines are limited, alternatively a method for ICT Hakusanroku students to take advantage of the wider selection of fabrication processes at the Kanazawa Institute of Technology (KIT) “Yumekobo” fabrication facility could also be considered. For example, a remote fabrication request form that could be filled out on a student computer at ICT Hakusanroku, the part fabricated at KIT Yumekobo, and then sent via internal mail to ICT Hakusanroku. Such a process would expand student access to fabrication facilities without a significant capital investment in new machinery.

4.2 Expansion of Material Selection for Existing Printers

Another area where improvement can be considered is in the offering of more specialized materials for currently available FDM 3D printers. Currently general-use plastics such as PLA and PETG are stocked unless otherwise requested. These material types are the most generally applicable, print cleanly with low chance of jamming, and are reasonably low cost. However, more specialized filaments such as flexible, rubber-like TPU, or low weight foaming filaments, which are particularly useful for lightweight drone parts, would expand the range and variety of parts that could be created with the currently available 3D printing facilities.

In conclusion, 3D printing is a useful technology to facilitate project-based learning and allows for far greater integration of hands-on prototyping than traditional manual fabrication techniques would provide in a busy and time-limited curriculum. Moving forward, expansion of 3D printing fabrications spaces with more variety in printer types and material selection would give students more opportunities in their projects both inside and outside the classroom.

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Davis EVANS

講師
国際高等専門学校
国際理工学科

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