BUILDBASE - A STUDENT LED FACILITY FOR ADDITIVE MANUFACTURING

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ABSTRACT

This paper reports on the development of a student driven facility for additive manufacturing. It addresses several issues observed with undergraduate engineering programs, particularly in Irish higher education institutions - namely a difficulty with providing access to fabrication equipment, a pattern of rote learning (often reinforced at third level!) leading to a reluctance in many students to experiment, development of an iterative, prototyping mentality and resources required to manage facilities.

A small space (i.e. room) was identified, and a modest investment made in equipment - five 3D printers (Ultimaker 2), some light hand tools, some storage cabinets and a display cabinet, as well a stock of consumable materials.

A management and training structure was designed - with an emphasis on sustainability and self-management. A small number of volunteer students were provided with training on how to use the machines and how to handle basic technical issues such as replacing spools or performing simple servicing.

In consultation with staff, the volunteer students designed an operating and management structure for themselves, and the facility was opened to a wider cohort of students.

The 'proof of concept' exercise has been very successful, and will be extended to a larger group of students in the next academic year. A summary of the approach taken, lessons learned and future development plans is given.

KEYWORDS: Additive Manufacturing, Engineering Education, Rapid Prototyping.

1. INTRODUCTION

Providing engineering students with open access to useful fabrication facilities enables them to synthesise their engineering science knowledge into producing constructed objects. Designing, making, testing, analysing, reflecting, gaining insights and iterating based on their findings, results in students building new knowledge. [1–3]

From Dewey's "Education and Experience" to CDIO and Design Thinking methodologies used in teaching today, progressive educational tenets highlight the importance of facilitating students in ways that enable them to gain useful experience and allow them to experiment. [2,4,5]

However, the advantages of providing students with access to such facilities are weighed against budgetary, planning, administrative and implementation considerations; upkeep, training, supervision, machine and material costs, and safety and liability issues. Whilst hardware and software developments such as the availability of affordable and user friendly CAD packages and 3D printers can now allow low cost access to enabling technologies, these advances have not stripped away the bureaucratic complications inherent in large educational institutions that can impede and stunt providing students access to such facilities, particularly in a timely, agile, open manner. [6]

A solution proposed here is to enable the students to develop, lead and manage such a resource themselves, allowing them to direct all operational and development aspects of an additive manufacturing facility. They build in the process an empowered community from the student body that gains a sense of ownership and engagement through a facility that promotes peer-based, cooperative, experiential learning. This additive manufacturing facility is then provided by the students as a service to the department as a place for project based, inquiry based or self directed learning.

2. APPROACH TAKEN

In July 2015 two Professors and the Chief Technical Officer in the Department of Mechanical and Manufacturing Engineering in Trinity College Dublin tasked and guided students working as summer interns with planning and implementing a small onsite facility. The Mission Statement was: Encourage innovators through a student driven, student led additive manufacturing facility.

An unused basement storage room in the department was chosen for the project. The room required minimal work to prepare it as a workshop, primarily basic electrical work, and countertop installation. Storage and workspace related items were added to make efficient use of the room, and to provide safe storage for tools and supplies. A display cabinet was bought to showcase notable works produced. Five Ultimaker 2 Fused Filament Deposition 3D printers and consumables, some post processing tools and maintenance equipment were purchased.

Before enrolling the first users, key development goals were to ensure a working operational structure was in place and that the system could be operated and scaled efficiently. Training and organisational structures were developed and implemented by the interns, and a website constructed that contained user guides and FAQs sections, a scheduler and booking system, a blog and information about the facility.

Now called BuildBase, the facility was provisionally launched as a year long pilot scheme in September 2015. The main intake of initial users were 90 students enrolled across four modules, with design based projects forming a part of their assessment. Around 20 users involved in masters and postgraduate research also obtained access through their Principal Investigators. A liaison administrator was appointed by the department to coordinate training requests, and the facility was operated and managed by students.

All incoming users were trained to beginner level, where they could print but not perform maintenance or calibration of the printers. A small number of users were then trained to an intermediate level, usually a member of each project group of 4-5 users, and they could then aid the beginners if any issues arose. The beginner and intermediate users would then begin to move up to more advanced user levels after gaining experience and showing competence.

The initial expert users who could train users, aid both beginners and intermediates, and manage the facility were the summer interns who developed and implemented BuildBase. The beginner, intermediate and expert levels were called Bronze, Silver and Gold respectively within BuildBase

3. CONCLUSION

The primary lessons learned from the pilot scheme were that such a facility can be implemented successfully. Along with the heavy utilisation of BuildBase, student and staff feedback was overwhelmingly positive, and the coming academic year is expected to bring growth and further development of the facility. Tracking the usage of the facility from the booking system data shows that by mid-June 2016 the facility had 116 trained and registered users.

Group	Total Hours Booked	No. of Members	Ave. Hours per User
Bronze	635	51	12
Silver	4494	51	88
Gold	2783	14	199
Totals:	**7912**	**116**	**18.5**

Table 1 BuildBase User Groups Statistics

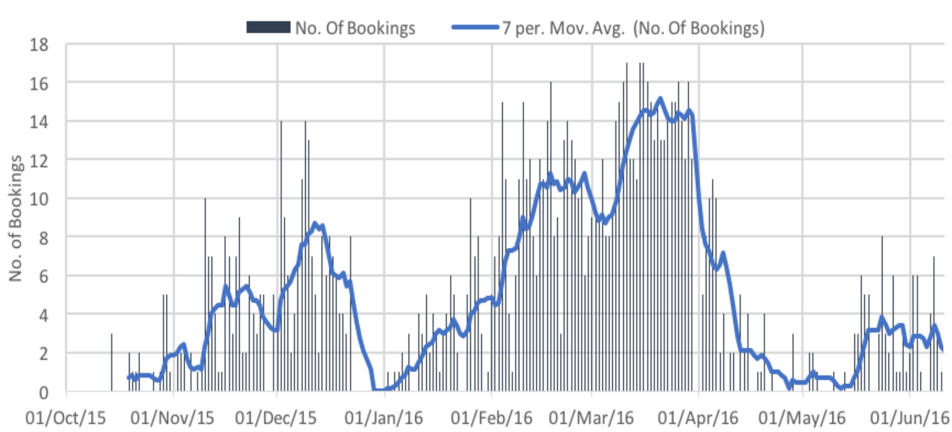

Figure 1 BuildBase Usage, October 2015 – June 2016.

In a survey sent to BuildBase members after the academic year end:

- 88% of students rated BuildBase as having a highly motivational effect towards engagement with their module/project work.

- 56% of users used it primarily for module work, 32% used it for research work and 12% used it for personal projects.
- All respondents found the facility to be useful; 76% found it to be extremely useful.
- 88% felt it was student led and student run.

In conclusion the pilot scheme can be considered a success, and the focus for the future will be on growing and developing BuildBase further according to its Mission Statement.

4. FUTURE PLANS

As the facility is expected to multiply its membership in the coming years as more students are given access developing the community, communicating BuildBase and its philosophy effectively, and balancing budgetary and demand considerations are key concerns. BuildBase is expected to grow rapidly, at least doubling in membership this coming year, and planning and controlling that growth so that it does not impact on the quality of service and the philosophy of BuildBase are key considerations.

Regards physical growth the design of a rack based system for the printers is being developed to maximise space and introduce easily implemented modularity, and new printers are likely to be purchased.

A more developed structure is being formally put in place for managing the facility, taking over from the initial intern implementers of the scheme. A council with individuals responsible for different areas will now lead BuildBase. The main operational roles are Chief Technical officer, Chief IT officer and Chief Community officer, with a chair and a treasurer filling the other council seats.

These officers will be responsible the operation and development of their sections, including developing understudies to be able to take over once their term finishes, ensuring smooth handovers year to year. Elections will be held for council positions from next year onwards.

The development of the community as a social and driving hub for BuildBase will be a larger focus this coming year. The community will develop and manage the competitions, sponsorship, outreach and member engagement side of BuildBase, with an aim to helping the facility achieve greater autonomy and financial independence.

To better communicate the differences between BuildBase and normal departmental services, the BuildBase liaison role has been adapted to more fully engage with the department and the limits of module-based engagement versus full membership of the facility are now formalised.

The training procedures have been adapted to bring all users up to point where they can calibrate and perform routine maintenance and configuration, and solve common printer issues. User levels have been simplified and now place greater weight on BuildBase membership; two of the printers are now for membership use only.

Regards the larger outreach of the concept there are plans to document the BuildBase approach in the manner of a comprehensive guide and set-up procedure to enable others to implement similar facilities elsewhere.

5. REFERENCES

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