



Establishment of an Academic Makerspace at the Bataan Peninsula State University: Prospects and Challenges

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Abstract. Makerspaces are now fixtures in smart cities and universities in advanced countries. Many universities, especially in the United States, have Academic Makerspaces serving students and faculty, helping them with their projects. At Bataan Peninsula State University, we have recently established an Academic Makerspace called the BPSU MakerLab, as part of our Additive Manufacturing Research Laboratory (AMReL). Our goal is to have an Academic Makerspace with services and facilities at par with international standards. This Academic Makerspace is a place where our students can ideate, conceptualize, build and manufacture their projects, either academic projects, or just extracurricular projects they are interested in. The goal is to promote invention, innovation, creation and making. This study summarizes the best practices of some Academic Makerspaces in the United States and in the Philippines including their facilities. With this study, we have identified what facilities are needed, which equipment to purchase, and what kinds of programs should be made available in an Academic Makerspace. This study specifically provides insights for the short- and long-term programs of BPSU's MakerLab, and could be used to recommend future facilities/services in BPSU. The prospects and challenges of establishing an academic makerspace have also been briefly discussed.

Keywords: Makerspaces, Academic Makerspace, STEM Education, Innovation

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1. Introduction

Makerspaces are increasingly becoming an integral part in academic institutions. Universities, colleges, and even high schools establish these spaces to boost collaboration, creativity, critical thinking and innovation. These spaces promote hands-on and experiential learning to users. Graduates, especially those from the Science, Technology and Engineering courses need to be prepared as they enter the work force. They need to be able to quickly adopt recent technological developments, be more creative, and work with a team. Also, effective communication is very important to be successful at work. [1, 2]. Makerspaces promote creativity and collaboration among users, which essentially serve as a playground or training ground to future engineers and technologists. Makerspaces allow them to harness their

creative and critical thinking skills and be relevant and competitive in today's job markets. [1, 3, 4]. Makerspaces provide the necessary tools for students to create their own design ideas, which contribute to the development of their critical thinking skills as well as provide a rich and satisfying learning experience [1]. This is because in makerspaces students are provided with hands-on and collaborative experiences in addressing real-world problems using advanced manufacturing technologies [1, 5]. Makerspaces support the development of technopreneurs [1, 6, 7, 8] and are usually open to the community, and thus promote richer and stronger ties among stakeholders [1, 9, 10]. At Bataan Peninsula State University, we have recently established an Academic Makerspace we call as the BPSU MakerLab, as part of our Additive Manufacturing Research Laboratory (AMReL). The goal of opening an Academic Makerspace inside BPSU's main campus is to provide the necessary facilities to students as well as to improve their design experience. BPSU's academic makerspace hopes to foster collaboration among different disciplines. The study aims to let the researchers understand the important considerations in setting up and operating an academic makerspace, specifically BPSU's MakerLab. This will be done by benchmarking best practices of makerspaces in other parts of the globe and in the Philippines. The prospects and challenges of establishing BPSU's Academic Makerspace is also assessed. BPSU's faculty and students, as well as the local community will benefit from this study. The insights from this study will also benefit other universities/colleges that are planning to set up an academic makerspace.

1.1. Academic Makerspace: Balanga City's Missing Link

The City of Balanga in the Philippines hopes to become the Silicon Valley of the country, i.e. to have thriving and successful technology and startup businesses contributing to the local economy as well as providing employment to its citizens in high tech industries. The city has very aggressive leadership towards the attainment of its goals, however, due to some reasons, the formation of technology businesses in the city remains to be seen. The programs toward the attainment of such vision is presented in Figure 1, together with the support mechanisms provided by educational and government institutions nearby, as well as the efforts being made by the private sector to this end. The city government actually previously supported the operation of a Makerspace which caters to the needs of tech enthusiasts in the city. The figure below shows the representative situation in the City of Balanga in 2017 with regards to establishing an ecosystem for technology startups. One important component missing identified then was the existence of academic makerspaces in the city.

2. Methodology and Materials

The study was divided into four phases namely: (1) Preliminary Meetings / Brainstorming (2) Literature Search (3) Writing/Research and (4) Consolidation of Research Works. In the first phase, the coverage of the whole study was determined, and the tasks and topics were distributed to all members. The goal was to compile the best practices and frameworks of academic makerspaces in the United States and the Philippines. The second phase included readings through many publications and web sources related to Makerspaces and in particular, Academic Makerspaces. Specifically, keyword search using the following keywords: [makerspace], [academic makerspace], etc. have been used. Interviews to administrators of makerspaces, academic makerspaces, and innovation centers in the Philippines were also conducted. Users of makerspaces were not interviewed. No statistical treatment was employed in this study. The third phase included writing of the research paper. Regular meetings were conducted to discuss more ways to enhance the study. Important insights were consolidated and the findings in the study were compared to existing experiences and practices in BPSU.

3. Results and Discussion

Wilczynski et al [11] classified the makerspaces based on the scope of the makerspace, accessibility, target users and number of users, management structure and staffing [11]. Further, Galaleldin et al presented several issues in organizing an academic makerspace including the following: Facilities, Programs, Target Clientele and number of users, Financial / Business model, Partners, Accessibility and Operating Hours, and Administrative Structure and Staffing. Also, decisions have to be made such as [1]: Should the makerspace be located within an academic campus? Should the staff belong to an academic institution? What equipment should it have (e.g. laser cutters, 3d printers, CNC machines, etc)? Should it provide training programs / instruction? What should be the guidelines when it comes to using the facility for personal business purposes? Should the academic makerspace generate profits from the operation?

It should be noted that 3d printers, aside from laser cutters, lathe/milling machines, and 3d scanners, are widely used in Makerspaces due to applications in a wide range of applications such as health [12, 13], electronics [14], prototyping and small production runs [15, 16], water filtration and desalination [17, 18], power generation [19], and others [20, 21, 22]. BPSU has also recently established the Philippines' very first Additive Manufacturing Research Laboratory [23], with the MakerLab as an integral part of the facility. It would be good to know how the facilities in BPSU's MakerLab compare with other local and foreign Academic Makerspaces. The insights and ideas generated from this research would contribute in the crafting of operational manuals, as well as in addressing access issues (to make the facility available to faculty, students and the community).

3.1 Best Practices in Academic Makerspaces in the United States

This section presents some overview of the makerspace facilities in the United States and in the Philippines. These examples provide insights on the operation and sustainability of academic makerspaces, and other similar facilities such as fabrication laboratories (fablabs), tech workshops, and others.

3.1.1 Georgia Institute of Technology Invention Studio

The Georgia Institute of Technology Invention Studio is an academic makerspace managed by students. The facility is available to the entire university [24,25]. Their makerspace provides access to equipment as well as training. It also serves as a hub for the maker community within the campus, and supports design instruction (curricular and extra-curricular) to promote collaboration in problem-solving. A student organization manages this makerspace and are assisted by a professional staff and faculty members for logistics support, oversight, and equipment maintenance. The Studio also offers guidance, trainings and workshops as well as outreach activities. The goal is to teach skills and serve as a link for the GA Tech community through design and problem-solving collaboration. [24,25].

3.1.2 Yale Center for Engineering Innovation and Design

The Yale Center for Engineering Innovation and Design (CEID) is a makerspace open to all university faculty, students and staff [24, 25]. The facility offers training sessions, workshops, and design classes that help users translate ideas into functional devices. With lecture space, meeting rooms, machine shops, an open studio, and a wet lab, the facility promotes design-based collaborations among its users to support faculty and student projects and activities (curricular, co-curricular, and extra-curricular). The center has also played an important role promoting engineering as an academic consideration for other disciplines. A director and 2 design faculty members and 2 design fellows, student assistants, provide guidance, teach skills, and oversee operations in the makerspace. [24, 25]

3.1.3 Case Western Reserve University Sears think[box]

Case Western Reserve University's Sears think[box] supports making and building, promotes innovative thinking, facilitates multidisciplinary collaboration, and advances product development and venture creation. The facility is open to all faculty and students as well as the local community (~20% of visitors). The facility combines collaboration programming, makerspace equipment, startup guidance, and incubation facility in one building and under one organizational structure. The 7 floors of the facility

were designed to support rapid prototyping, advanced manufacturing, assembling, meeting and brainstorming, collaborating, commercialization and entrepreneurship with one floor dedicated to each step of the process. There is an intellectual property section, an incubator and accelerator. Think[box] is managed by a faculty director and an executive director [24, 25]

3.2. Best Practices of Makerspaces in the Philippines

3.2.1 Saint Louis University TechHub

The Saint Louis University (SLU) in Baguio City recently established its Technopreneurship Hub (SLU TechHub). The TechHub is a joint project of the Department of Science and Technology (DOST), the Department of Trade and Industry (DTI), and the Commission on Higher Education (CHED). The TechHub provides an ecosystem starting from immersion and creativity to innovation and technology, and then towards knowledge creation and intellectual property, and eventually commercialization. SLU is among the first five tech hubs in the Philippines offering design consultancy, prototyping, fabrication, trainings and workshops, mentoring, co-working space, networking and business planning. [26, 27]. Table 1 summarizes the facilities inside SLU’s Tech Hub [26, 27].

Table 1. Facilities at SLU’s Tech Hub

SLU Incubator for Research, Innovation, and Business (SIRIB Center) *SIRIB is an Ilocano word which means “intellect”.	This facility aims to support research and development initiatives. This is where students are taught and guided through ideation and design thinking.
Fabrication Laboratory (FabLab) *This is a DTI Shared Service Facility	This facility is where MSMEs together with SLU faculty and students collaborate and realize their designs.
SLU-DOST Convergent Resilience Technology Business Incubator (ConRes TBI)	This facility provides technology incubation, and potentially become business ventures - commercialized. Business support, coaching, mentoring and Intellectual Property Rights advising is provided in this facility.

3.2.2 Miriam College

THE SM group has donated an innovation center (makerspace) to Miriam College. The innovation hub is located near the entrance of Miriam College campus in Quezon City. The facility was envisioned to immerse its students and faculty in a new model of teaching and learning focusing on the following: design, robotics, engineering, entrepreneurship, arts and mathematics (DREAM). It is expected that this facility will help bring improvement to current instruction practices in the institution [28]. It has a fabrication laboratory (fablab) among other facilities, which serves as a digital manufacturing hub to its students. Table 2 summarizes the facilities inside their innovation center [28].

Table 2. Summary of Facilities at Miriam College’s Innovation Hub

Fabrication Laboratory (FAB LAB)	This is a creative workshop which has several computer-controlled equipment and tools. In this facility, students can turn their ideas into prototypes as they have access to advanced digital manufacturing technology.
Electronics Laboratory (E-LAB)	This facility has the latest programming resources and building materials to learn coding and robotics. This is a venue for collaboration providing a fun atmosphere to create systems to improve lives.
Multi-Media Laboratory (MULTI-MEDIA LAB)	This facility enables students to work collaboratively using web authoring equipment and software. Tools for animation, software development web design, graphic design, video manipulation and digital audio are provided here.
Instrumentation	This facility has several hand-held tools, building materials and sensors. This

Laboratory (INSTRUMENT LAB)	is an ideal space for STEM (science, technology, engineering, and mathematics) students.
PERFORMANCE LABORATORY	This 21 st -century model classroom features interactive projectors which could be used in remote learning, developing digital art skills, and collaborative learning. This facility can be converted into a free space for group meetings, and also into a conference room and art exhibition room.
MAKERS' CAFÉ	This is a dining facility as well as a food business simulation and incubation area. Students and teachers may use this facility to explore new trends in the food industry.
INNOVATRIUM	This facility is basically a theater, where people can perform. It can also be a pitching area where students can discuss their ideas and innovative concepts.

Academic Makerspace at the Bataan Peninsula State University

The available equipment at BPSU's MakerLab are as follows: Stereolithography 3d Printer, Fused Deposition 3d Printers, UV Curing Apparatus, Injection Molding Machine, Filament Extruder, Filament Winder, Ultrasonicator, Microscope, and 3d Scanner. The MakerLab has already catered to numerous faculty and student research projects, and is a major facility being utilized by the various research units and projects related with 3d printing (Additive Manufacturing). To be a world-class facility and be at par with other Academic Makerspaces in this study, BPSU needs to provide more facilities/equipment similar to the other Academic Makerspaces mentioned in this paper. BPSU MakerLab has been jointly established by BPSU and DOST's Philippine Council for Industry, Energy, and Emerging Technology Research and Development (DOST-PCIEERD). BPSU may also consider tapping other fund sources such as the Department of Trade and Industry (DTI), Commission on Higher Education (CHED), and other divisions of the Department of Science and Technology (DOST). Access policies (including pricing of services) to the MakerLab may be provided by the authors upon request.

4. Prospects of establishing an academic makerspace

The following are some compelling reasons why Academic Makerspaces are needed in academic institutions.

1) Access.

- There are many students needing facilities that an Academic Makerspace can offer which includes ideation, prototyping, mentoring, collaboration [29].

2) Research Facility.

- An Academic Makerspace will be a valuable facility for faculty and student researchers. Collaborative research projects may be explored in academic makerspaces where faculty and student projects can be conducted [30]

3) Promotion of 21st Century Learning Skills.

- An Academic Makerspace promotes the 21st Century Learning Skills (namely, critical thinking, collaboration, communication and creativity), and thus would be a vital component for an academic institution for its creative/design programs and activities. [31, 32].

4) Industry Linkages.

- The industry could benefit from the prototyping facilities provided by innovation laboratories such as an Academic Makerspace. An Academic makerspace could be a venue where the industry can bring up problems in design and packaging, and where faculty and students can help solve these problems. [6]

5. Challenges of establishing an academic makerspace

1) Funding.

- The cost of the needed equipment and materials could be prohibitive. High Tech equipment which includes 3d printers, laser cutters, milling/turning machines, etc. could be quite expensive. This will depend on the size, quality of output, brand name, and other factors.

2) Limited Access.

- Access could be an issue, as the facility is primarily available for use of BPSU faculty and students. Also, the operating hours is limited to the operating hours of offices (i.e. usually only open on weekdays, 8-5pm).

3) Monitoring.

- Monitoring the use of equipment, tools and materials could be a challenge, given the diverse nature of equipment and materials found in the makerspace.

4) Operation.

- Managing the day-to-day operation of the academic makerspace could be a challenge as a full-time staff is needed in order to properly manage all the activities in the makerspace (e.g. training, repair, use of equipment/tools, inventory of materials and supplies, etc).

6. Summary and Conclusion

This study summarizes the best practices of some Academic Makerspaces in the United States and in the Philippines. With this study, the facilities and equipment needed, and the kinds of programs that should be made available in an Academic Makerspace have been identified. Fund source, possible partner agencies, and other important details have been discussed in passing. This study provides insights for the short- and long-term programs of BPSU's Academic Makerspace, and could be used to recommend future facilities/services in BPSU. Lastly, the prospects and challenges of establishing an academic makerspace have also been briefly discussed.

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